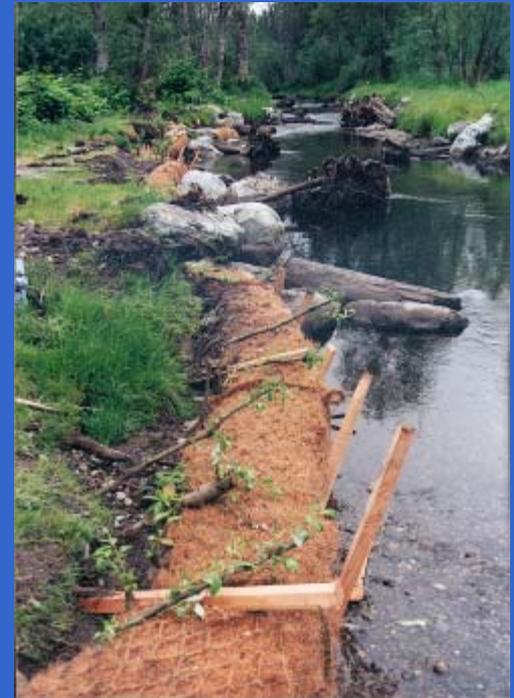


Geomorphic and Ecologic Consequences of Hydrologic Changes in Urban Streams – Examples from the Pacific Northwest

Christopher Konrad
USGS Washington Water Science Center

9 February 2005

Efforts to restore and protect urban streams must address many different stressors.

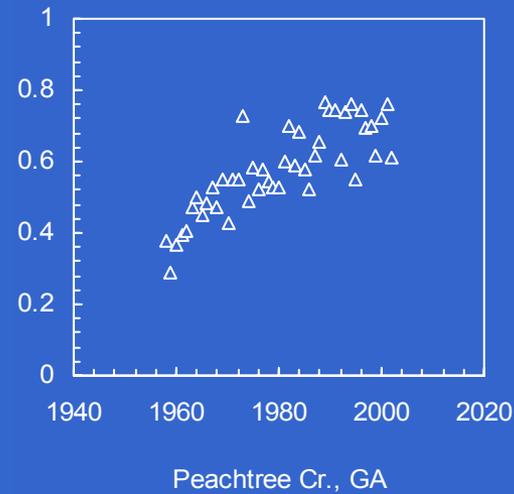
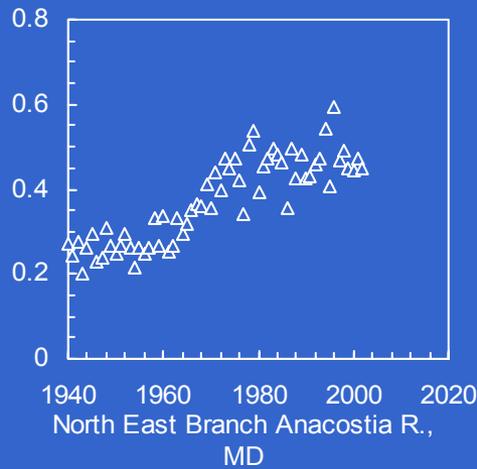
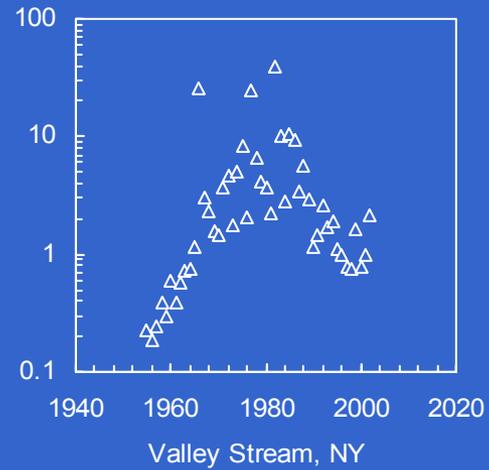
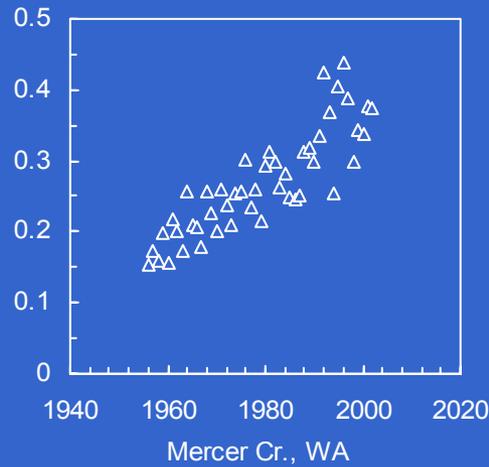


The hydrologic effects of urban development should be considered among them.

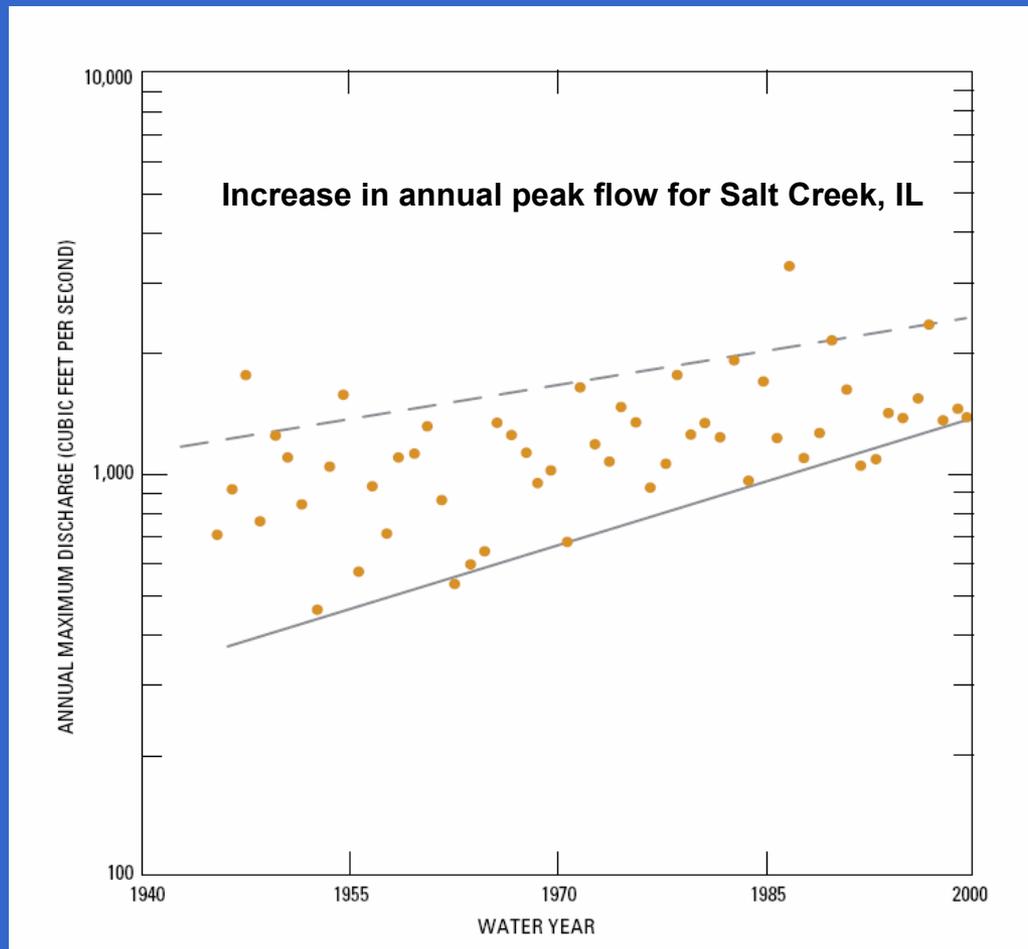
Difficulties in connecting hydrologic change to ecological response in urban streams

- Urbanization modifies streamflow in complex ways
- Streamflow is affected by urbanization at many time scales
- Multiple, co-varying stressors act on urban streams

Median daily percent change in streamflow

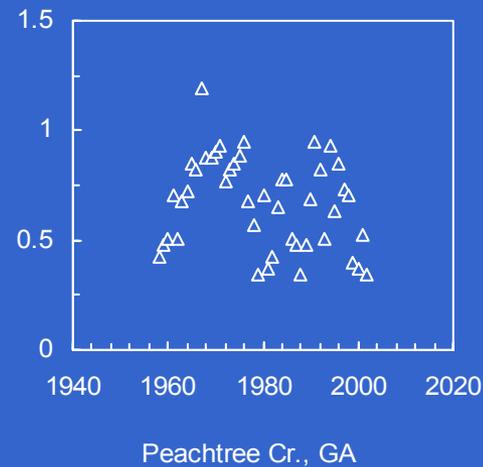
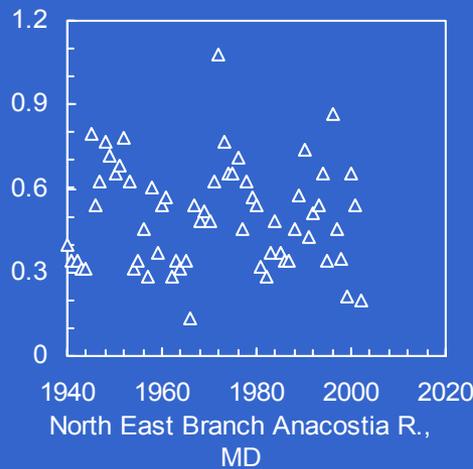
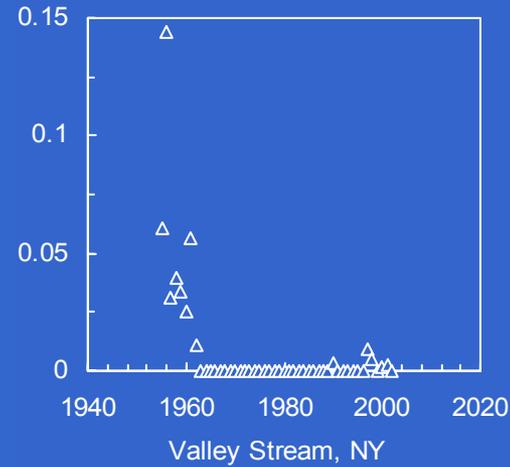
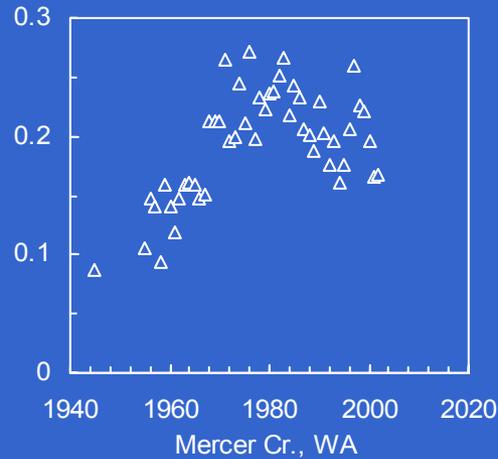


Urbanization modifies streamflow
patterns over time



Hydrologic changes from urban development are complex

Daily streamflow exceeded
90 percent of the year



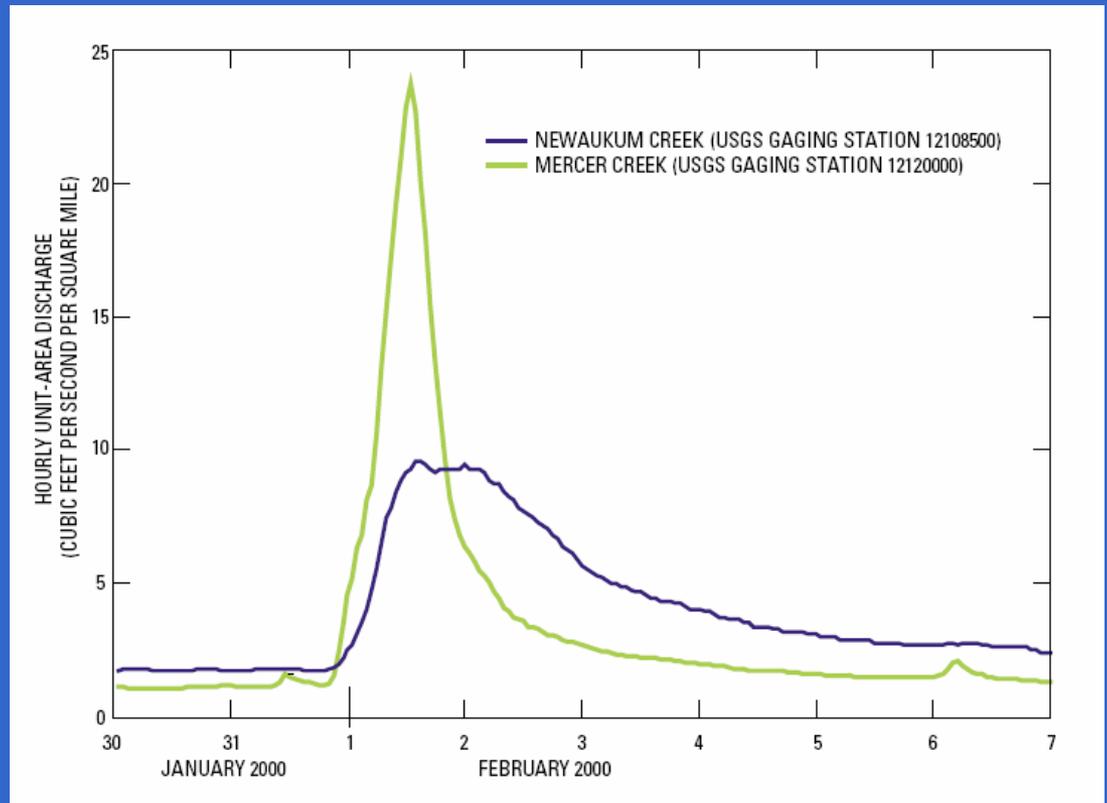
Some hydrologic effects of urbanization
are inconsistent

Difficulties in connecting hydrologic change to ecological response in urban streams

- Urbanization modifies streamflow in complex ways - **WHICH HYDROLOGIC CHANGES ARE IMPORTANT?**
- Streamflow is affected by urbanization at many time scales
- Multiple, co-varying stressors act on urban streams

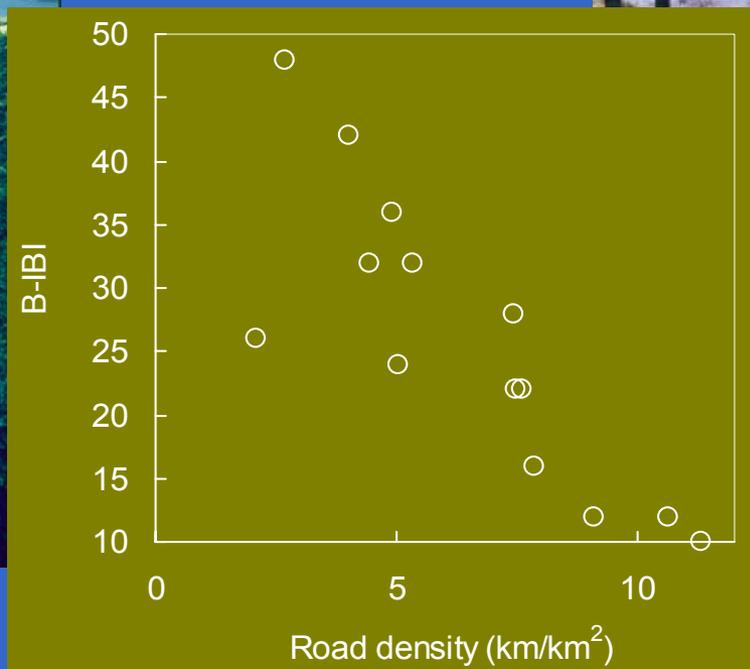
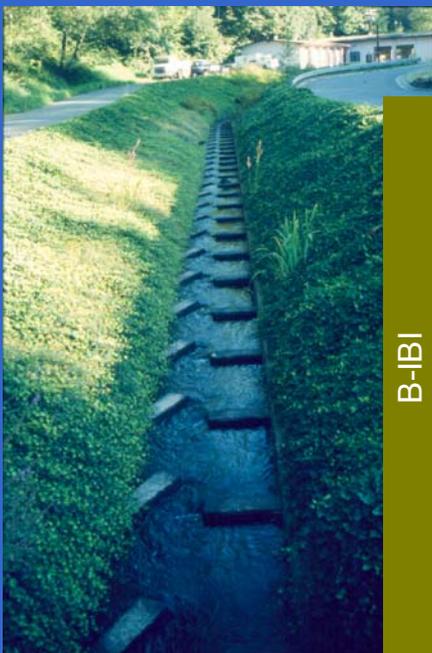
At the storm scale,

the effects of urban development are obvious, but lotic communities are resilient and recover rapidly.



Difficulties in connecting hydrologic change to ecological response in urban streams

- Urbanization modifies streamflow in complex ways - **WHICH HYDROLOGIC CHANGES ARE IMPORTANT?**
- Streamflow is affected by urbanization at many time scales - **WHAT TIME SCALE REPRESENTS STREAMFLOW CHANGES WITH ECOLOGICAL CONSEQUENCES?**
- Multiple, co-varying stressors act on urban streams



Multiple stressors affect the biological conditions of urban streams

Difficulties in connecting hydrologic change to ecological response in urban streams

- Urbanization modifies streamflow in complex ways - **WHICH HYDROLOGIC CHANGES ARE IMPORTANT?**
- Streamflow is affected by urbanization at many time scales - **WHAT METRICS REPRESENT STREAMFLOW CHANGES AT ECOLOGICAL TIME SCALES?**
- Multiple, co-varying stressors act on urban streams – **HOW CAN STUDIES CONTROL FOR OTHER STRESSORS?**

Solutions for connecting hydrologic change to ecological response in urban streams

WHICH HYDROLOGIC CHANGES ARE IMPORTANT?

Pose hypotheses regarding how streamflow affects stream ecosystems

WHAT METRICS REPRESENT STREAMFLOW CHANGES AT ECOLOGICAL TIME SCALES? Use statistics that represent annual and inter-annual streamflow patterns

HOW CAN STUDIES CONTROL FOR OTHER STRESSORS? Look for patterns between streamflow and biologic conditions outside of an urban context

A geomorphic link between hydrologic change and ecological responses in urban streams

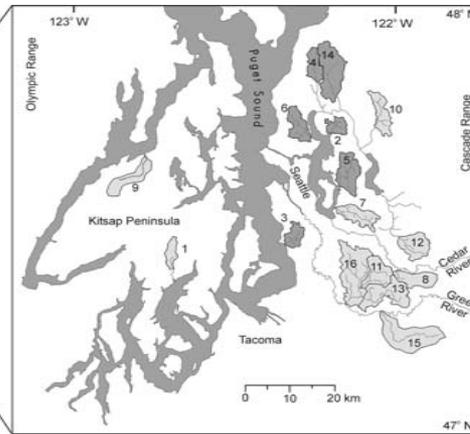
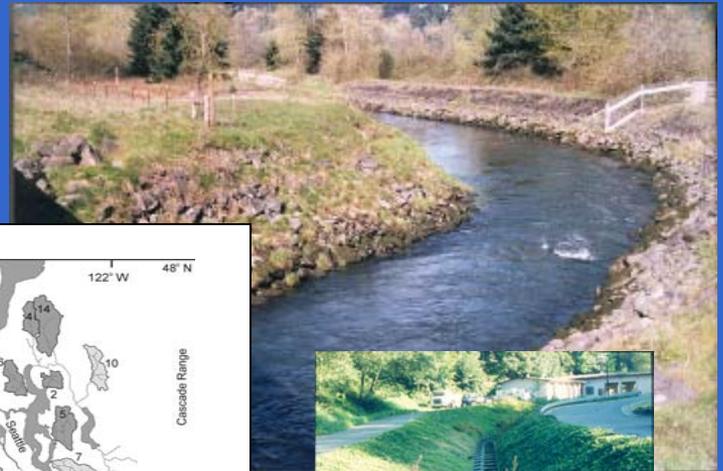
Hypothesis:

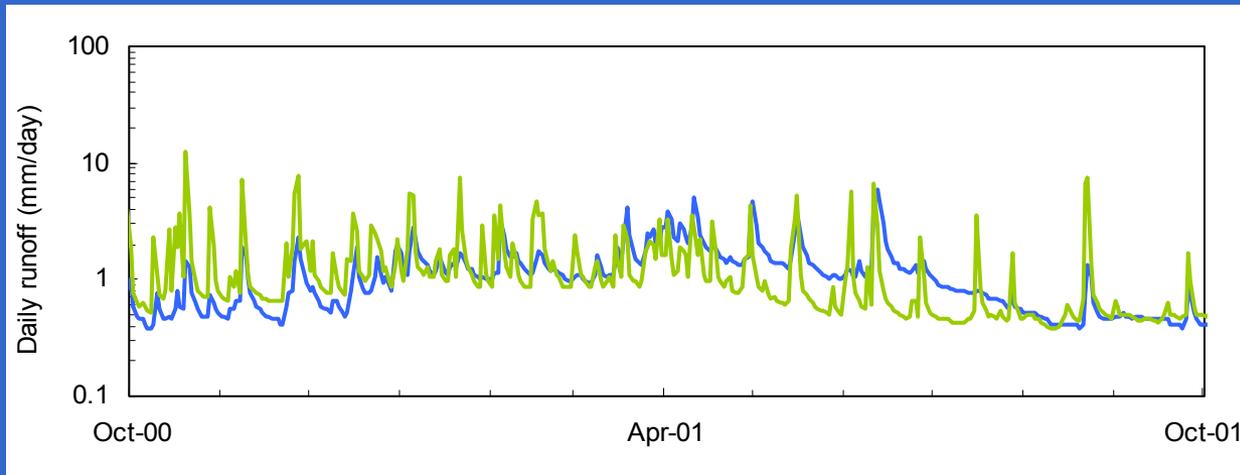
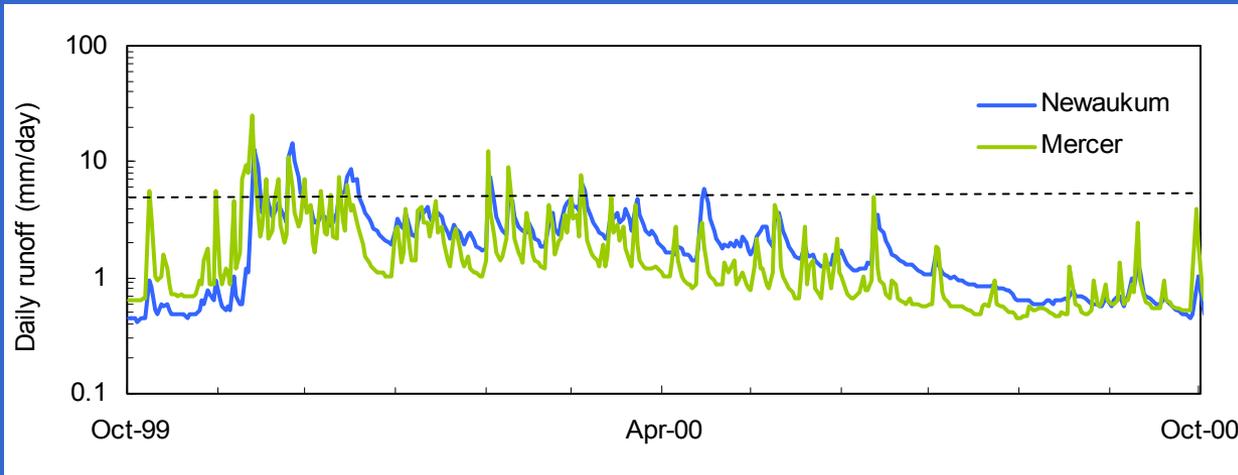
Urban development modifies the relation between streamflow frequency and duration.

Frequent but brief periods of high flows in urban streams cause persistent streambed disturbance

Similar streamflow patterns should produce biological responses outside the context of urban streams.

Hydro-geomorphic analysis of stream spanning an urban gradient in the Pacific Northwest



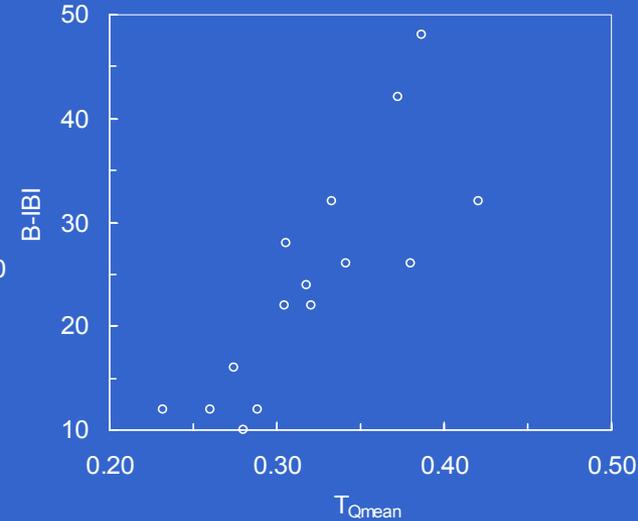
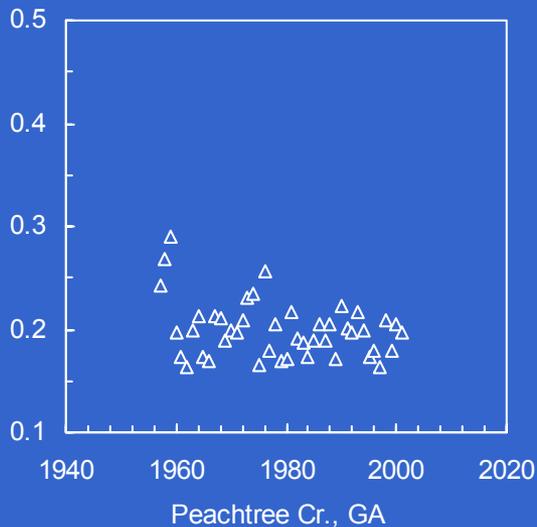
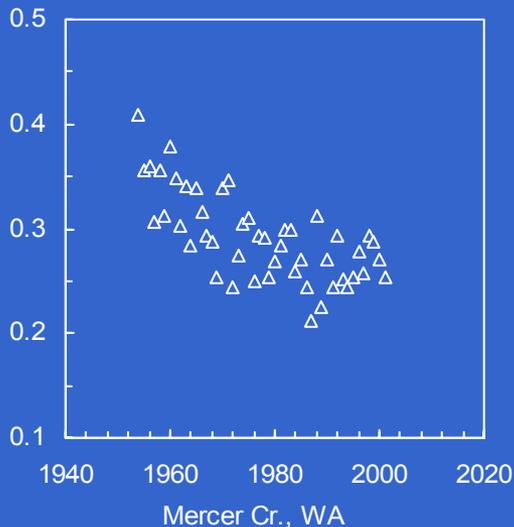
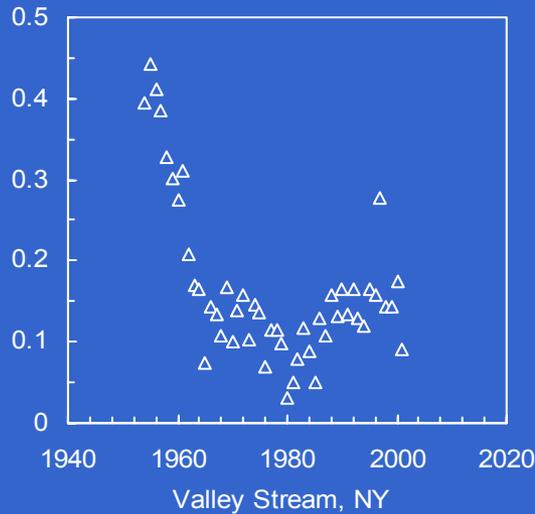
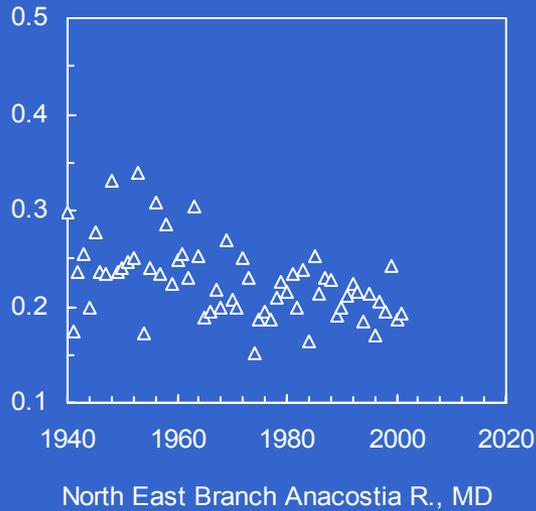


Higher frequency but not longer duration of storm events in Mercer Creek.

Annual and inter-annual streamflow statistics

- Fraction of time that daily streamflow exceeds mean streamflow
- Fraction of time that streamflow exceeds a $\frac{1}{2}$ - year flood ($T_{0.5}$)
- Frequency that streamflow exceeds the 10th percentile flow

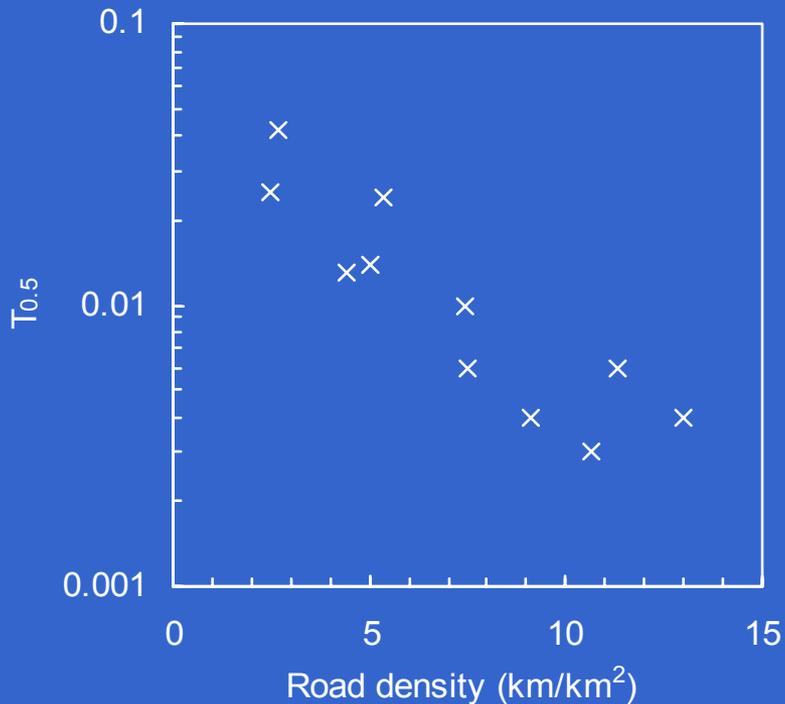
Fraction of time that daily streamflow exceeds mean streamflow (T_{Qmean})



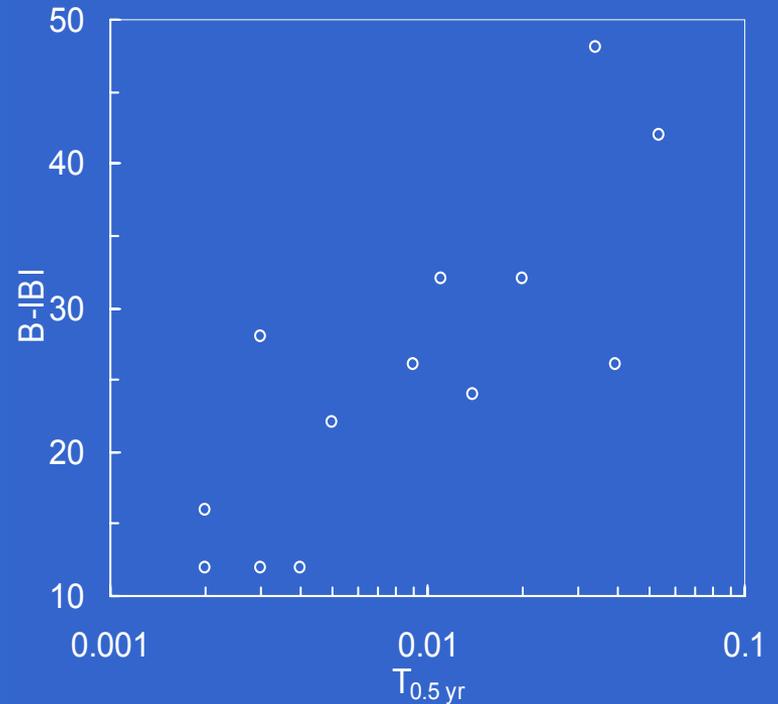
Diversity and structure of benthic assemblages decrease with T_{Qmean} in western Washington streams

T_{Qmean} decreases in response to urban development

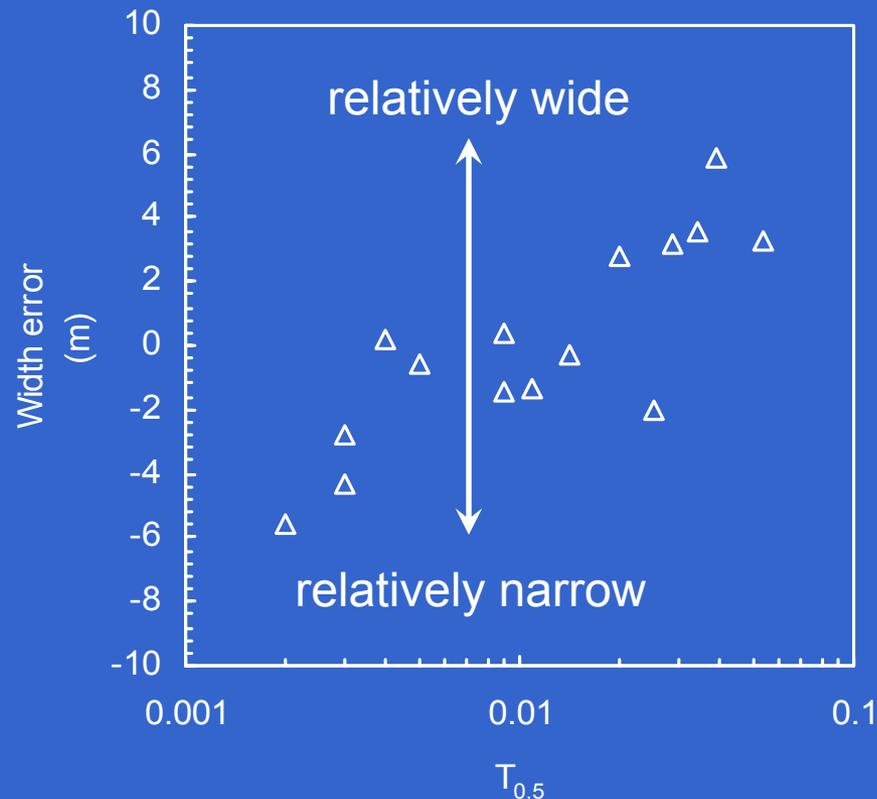
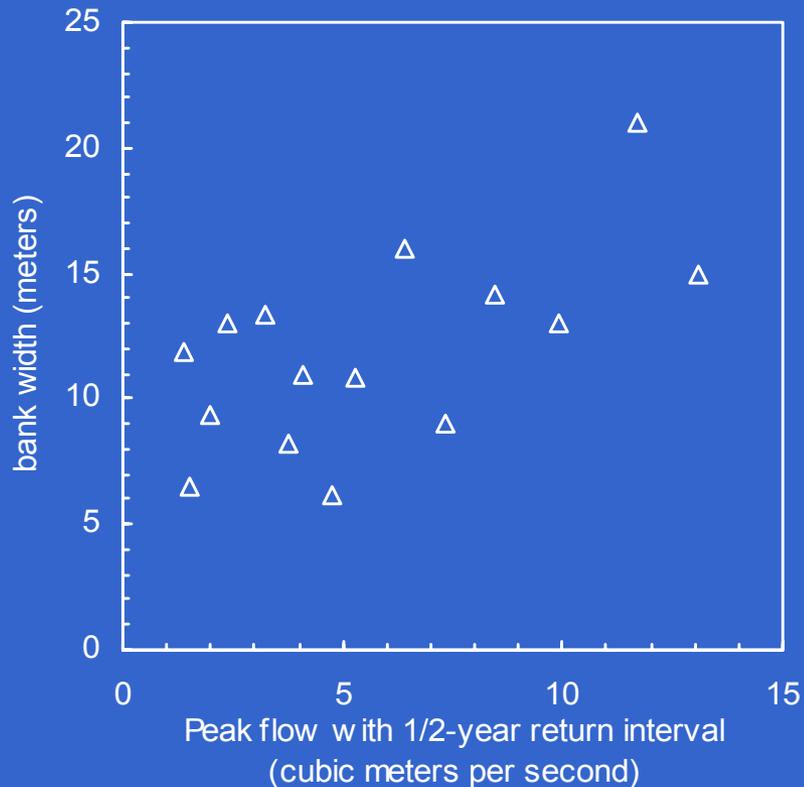
Fraction of time that streamflow exceeds a $\frac{1}{2}$ - year flood ($T_{0.5}$)



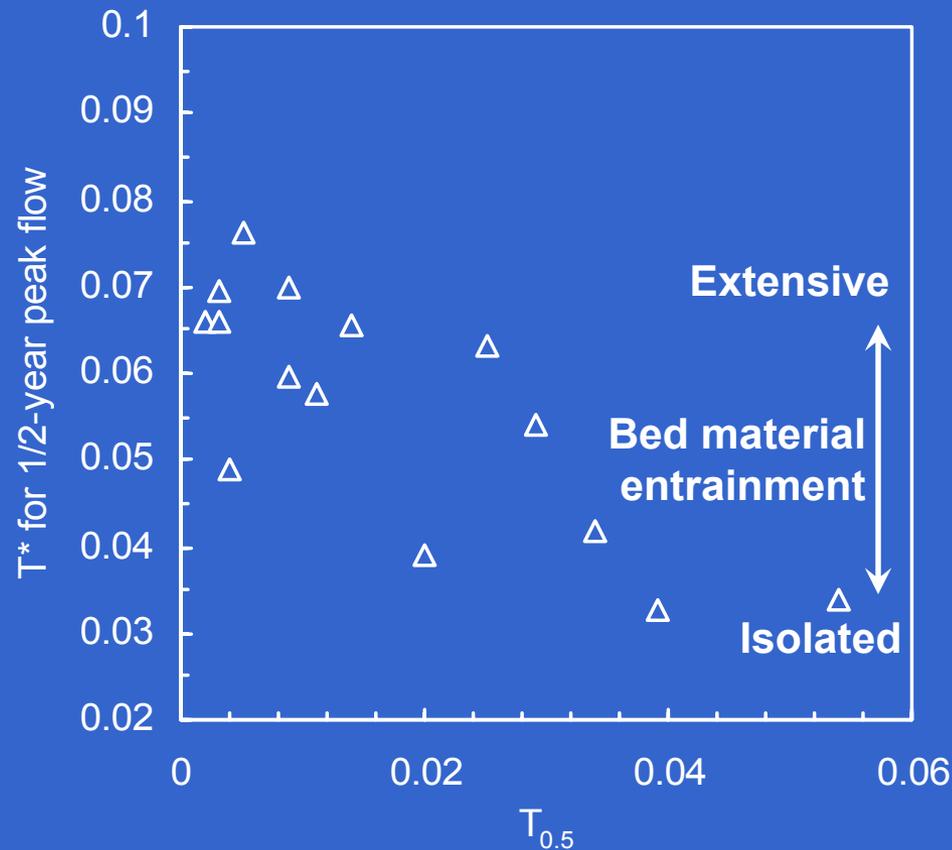
Hydrologic variation with urban development



Biological variation with streamflow

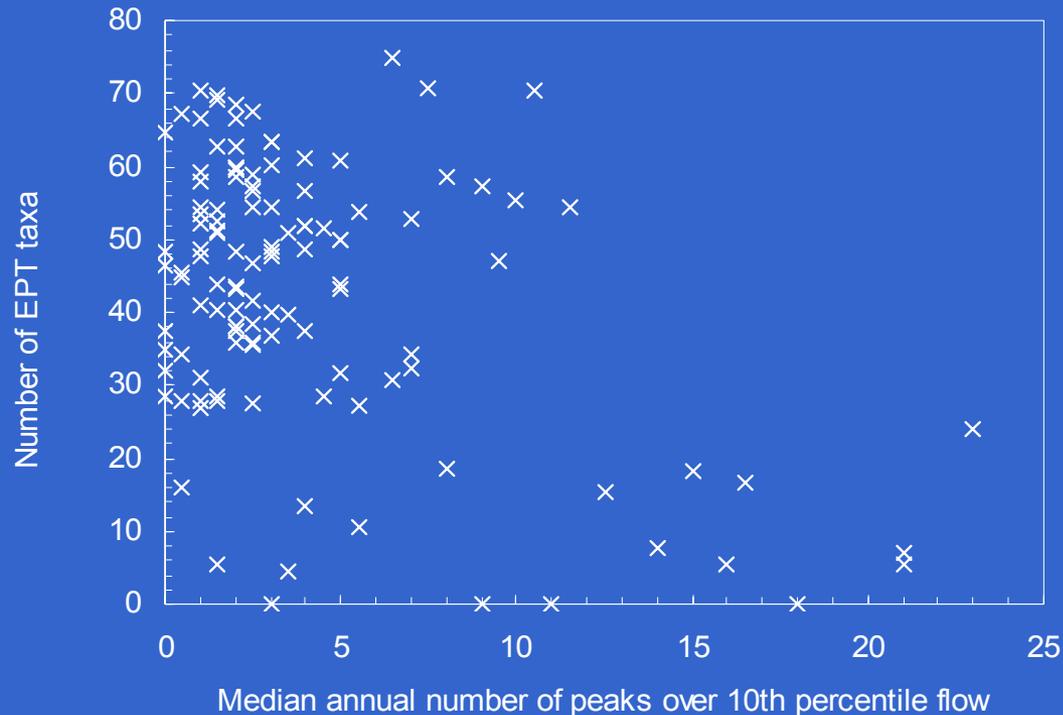


Adjustment of bank width to a 1/2-year flood varies with the cumulative duration that the flow was exceeded over the previous years



Streambed disturbance during a 1/2-year flood varies with the cumulative duration of the flow over the previous years

Using the broad ecological response to streamflow patterns to assess the effects of hydrologic changes in urban streams



Benthic invertebrate data compiled by Jason May, USGS as part of the NAQWA inter-regional assessment of benthic invertebrates and landscape/hydrologic alteration in the western U.S.

Summary

- Geomorphology provides a mechanism for linking streamflow changes to ecological response in urban streams.
- Streamflow changes must be assessed at time-scale of years.
- Urban stream ecosystems respond to multiple stressors, but altered streamflow is likely an important one.