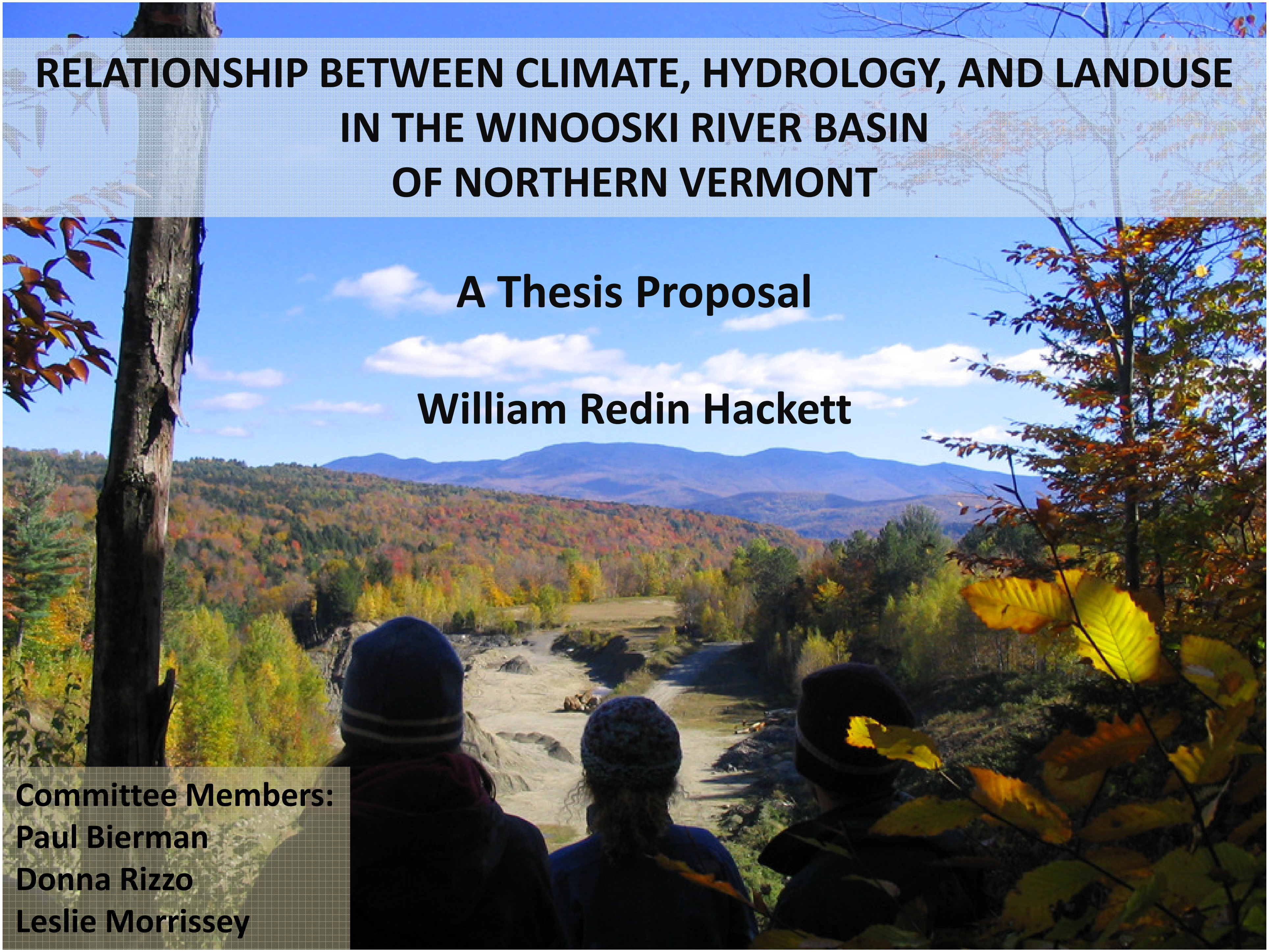
RELATIONSHIP BETWEEN CLIMATE, HYDROLOGY, AND LANDUSE IN THE WINOOSKI RIVER BASIN OF NORTHERN VERMONT



A Thesis Proposal

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Committee Members:
Paul Bierman
Donna Rizzo
Leslie Morrissey

Outline

-Objectives
-Study Area
-Background
  -Climate
  -Natural Oscillations in climate
  -Hydrology of landuse
-Methods
  -Preliminary analysis
  -Further Analysis
-Putting it all together
-Timeline

Study Objectives

-Determine the nature of changing trends in discharge and weather data

-Have precipitation, discharge, and temperature changed over time?

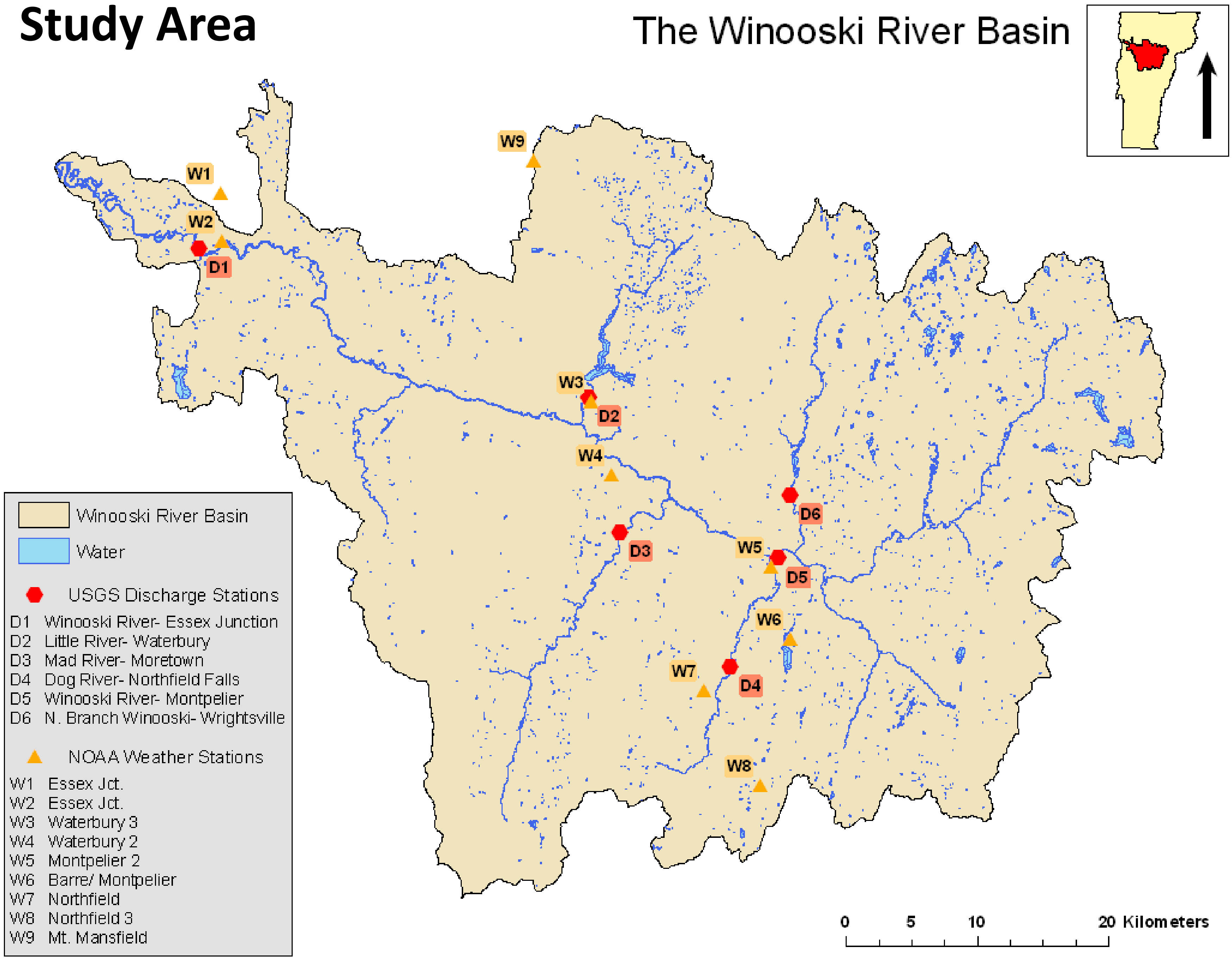
-Identify changing trends in storm frequency and intensity

-Has storm intensity changed over the past 50 years? Has their frequency changed?

-Analysis of relationship between climate and discharge over time by establishing landuse and climate signatures in the record

-Have precipitation and discharge changed in equivalent amounts over time or has this relationship changed? Can this be linked to landuse?

Study Area



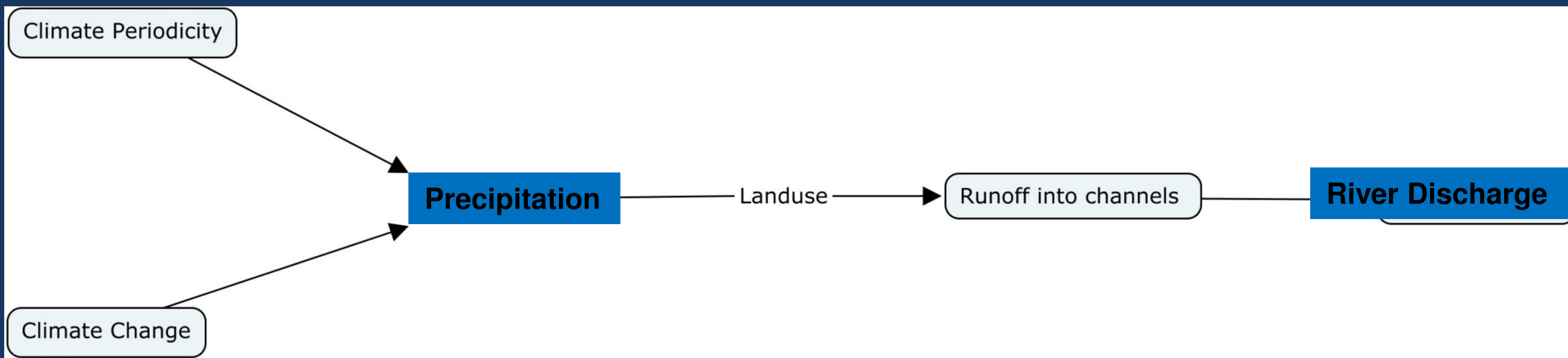
The Winooski River Basin
W1
W2
D1
W9
W3
D2
W4
D6
D3
W5
D5
W6
W7
D4
W8
Winooski River Basin
Water
USGS Discharge Stations
D1 Winooski River- Essex Junction
D2 Little River- Waterbury
D3 Mad River- Moretown
D4 Dog River- Northfield Falls
D5 Winooski River- Montpelier
D6 N. Branch Winooski- Wrightsville
NOAA Weather Stations
W1 Essex Jct.
W2 Essex Jct.
W3 Waterbury 3
W4 Waterbury 2
W5 Montpelier 2
W6 Barre/ Montpelier
W7 Northfield
W8 Northfield 3
W9 Mt. Mansfield
0 5 10 20 Kilometers

Stations

Weather Station	Years of Coverage	Elevation (m)
Essex Junction	1937-1960	104
Essex Junction	1971-2007	73
Waterbury 3	1941-1958	143
Waterbury 2	1958-1992	232
Montpelier 2	1999-2007	162
Barre Montpelier AP	1948-2007	343
Northfield	1923-1974, 1994-2007	204
Northfield 3	1974-1994	429
Mt. Mansfield	1954-2007	1204

Discharge Gage	Years of Coverage	Basin Area (km^2)	USGS Station ID
Winooski River at Essex Jct.	1929-2005	2,704	04290500
Winooski River at Montpelier	1915-1922 & 1929-2005	1,028	04286000
Winooski River at Wrightsville	1934-2005	179	04285500
Little River at Waterbury	1936-2005	287	04289000
Mad River at Moretown	1929-2005	360	04288000
Dog River at Northfield Falls	1935-2005	197	04287000

Concept


Climate Periodicity
Climate Change
Precipitation
Landuse
Runoff into channels
River Discharge


WINOOSKI, VT. PONTOON BRIDGE.

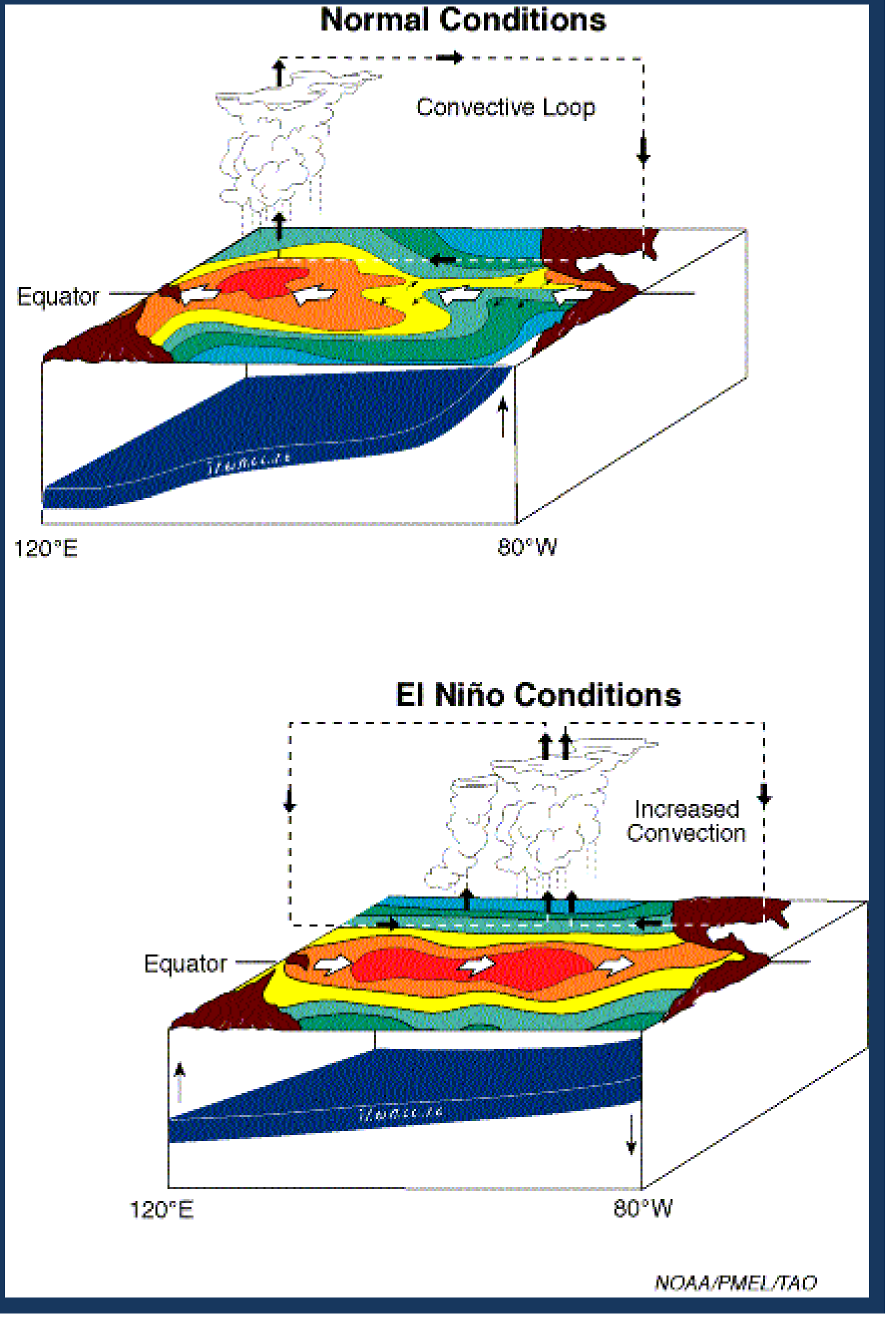

WILLISTON RAILROAD BRIDGE, VT.

Climate

Average annual/monthly/daily: precipitation, snow, rain, temperature, wind, humidity, solar energy

Short term periodicity in climate can effect the weather: El Nino

-Sea surface temperatures in the Pacific can bring mild and wet winters to northeastern U.S.



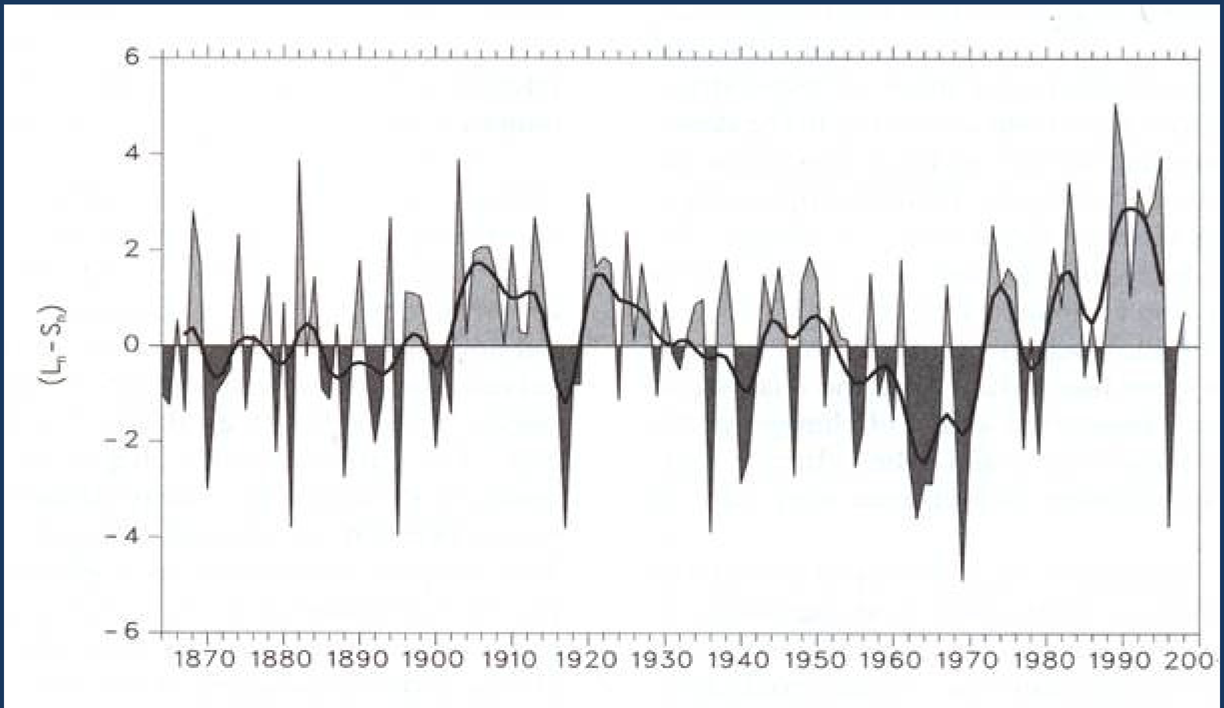
http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html

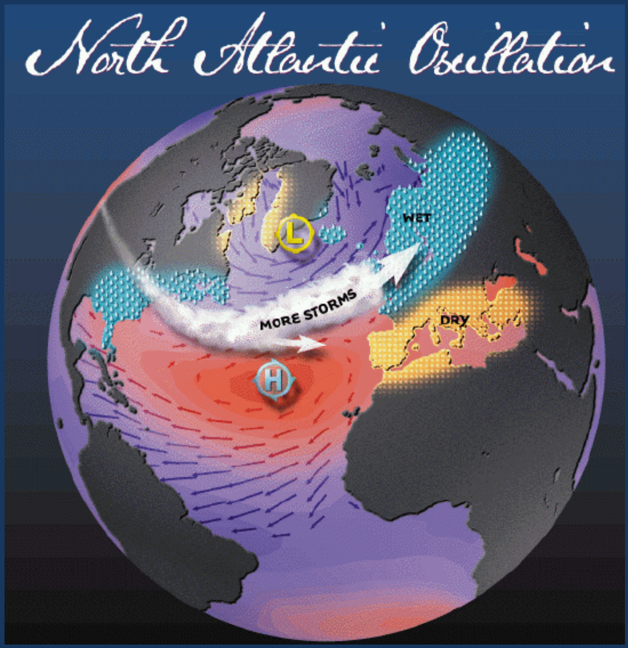
North Atlantic Oscillation (NAO)

-NAO signal fluctuates and can drastically effect winter weather.

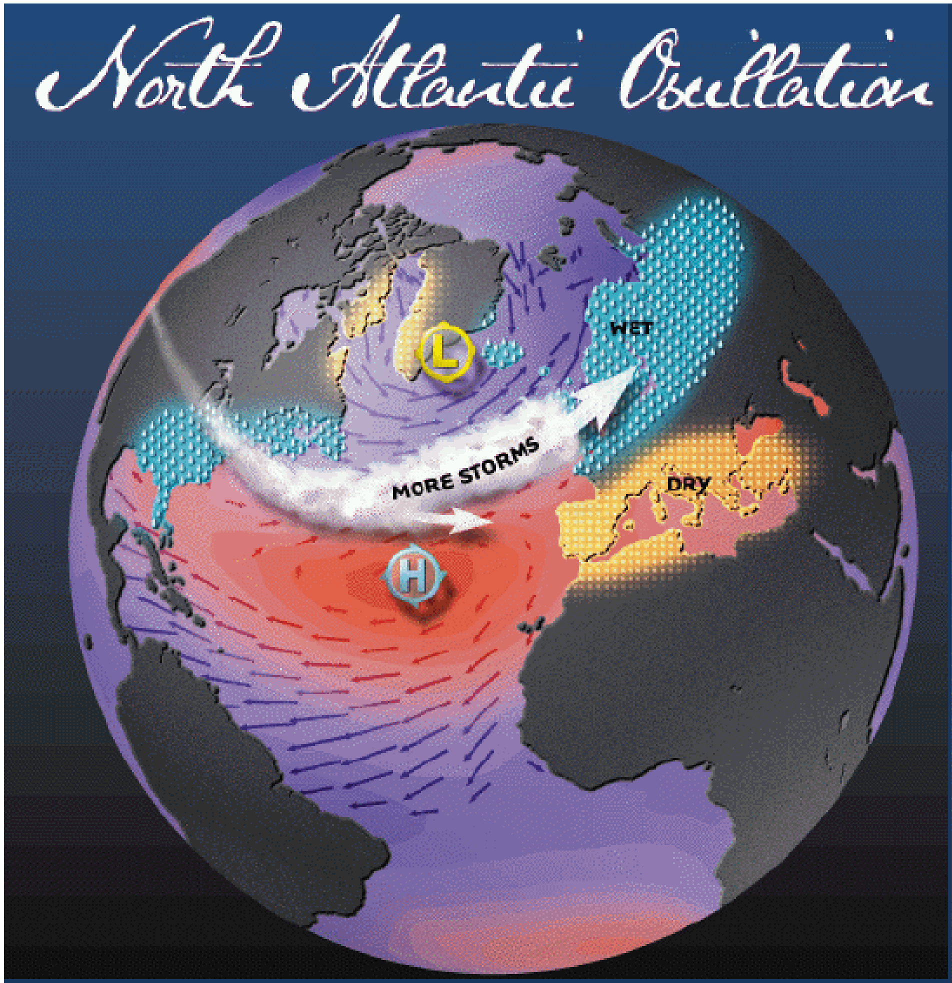
-Difference between Azores High and Icelandic Low.

-More of an effect in Europe, but US winters can be mild and wet during positive NAO winters, and colder during negative winters.





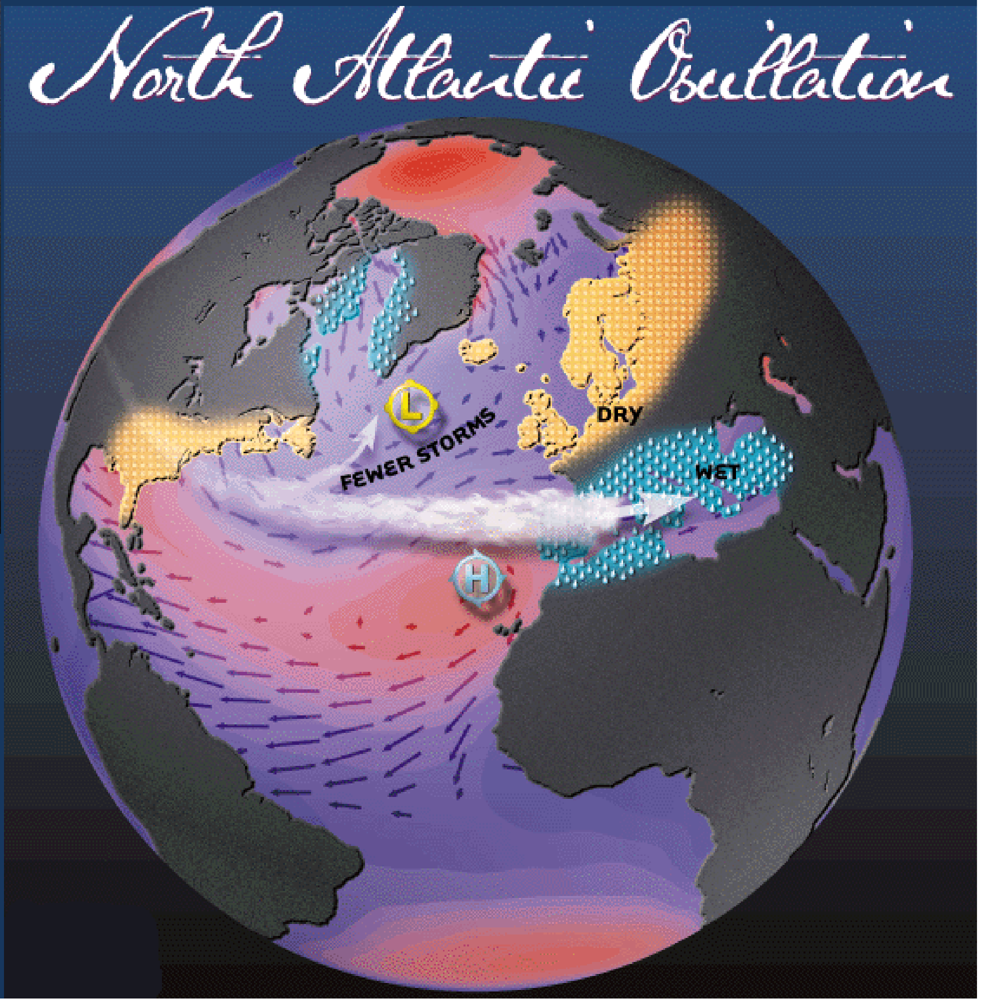
Decade-to-Century-Scale Climate Variability and Change, 1998.



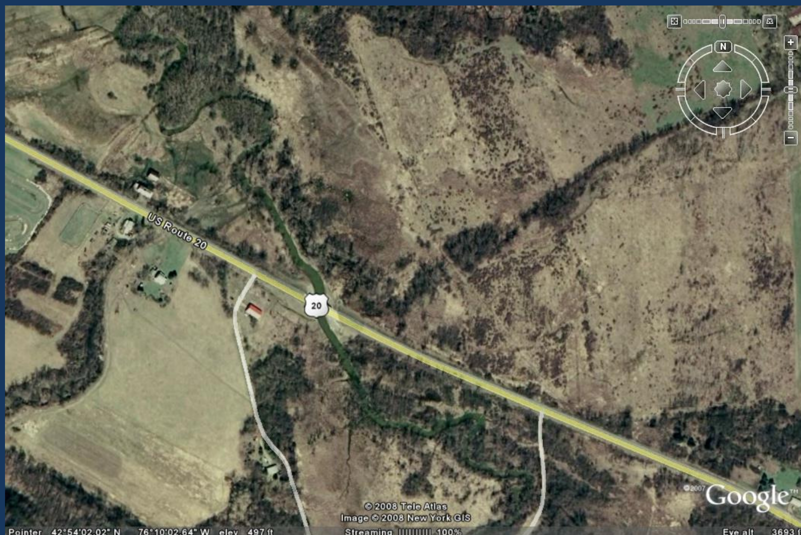
+ NAO

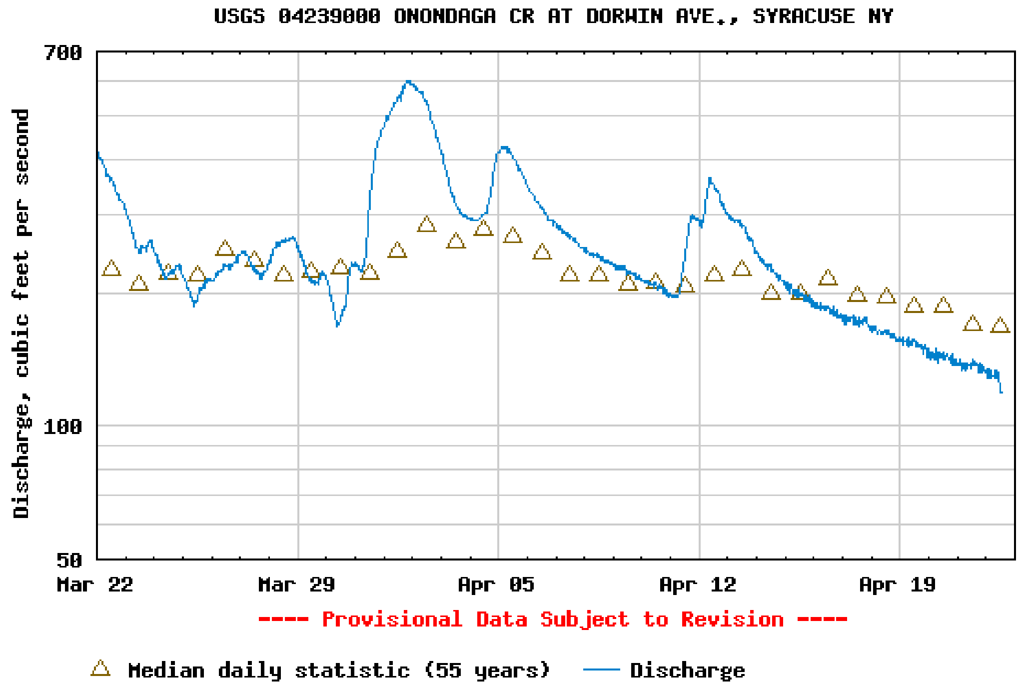
www.ldeo.columbia.edu/NAO

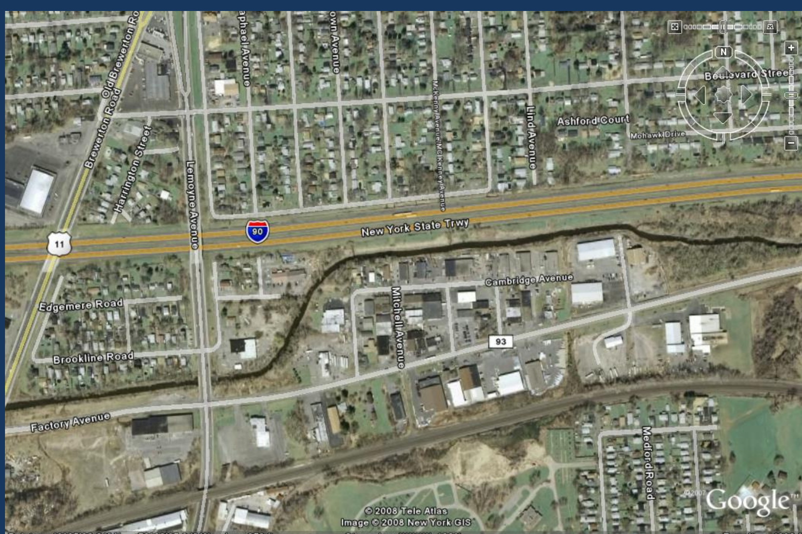
- NAO

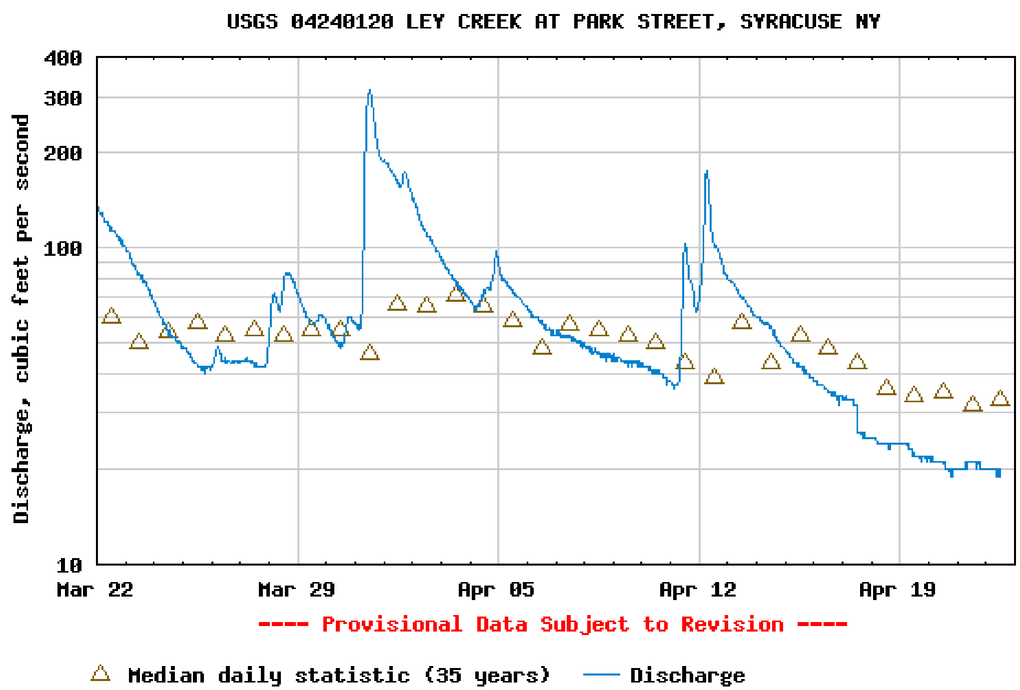


Hydrology of Landuse









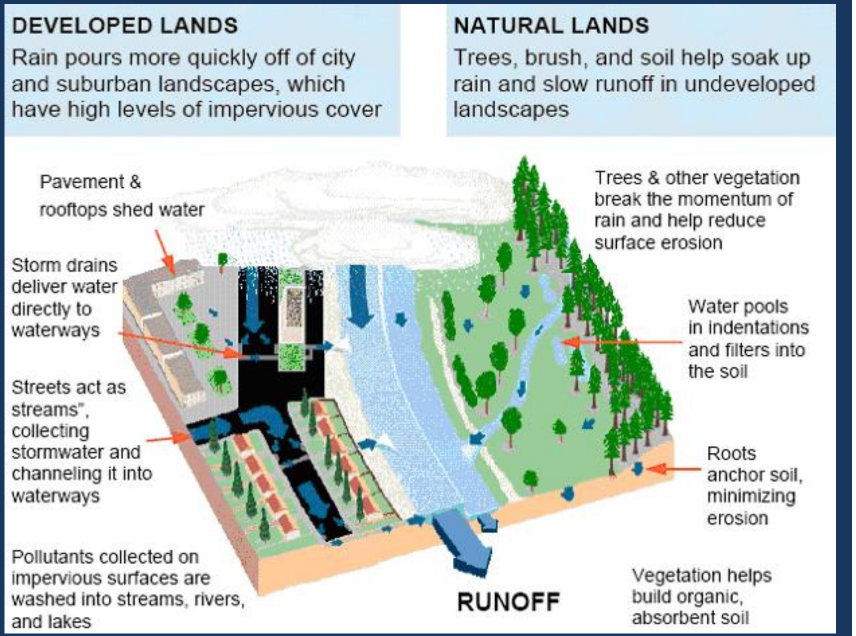
Images: google earth, Discharge data: USGS

Hydrology Continued

-Increasing agriculture in sub basins of the Mississippi have seen increased runoff compared to forested areas.

-Increasing urbanization in CA has led to increased discharge

-Contaminant transport, erosion and sediment transport



http://envplan240.pbwiki.com/Urban+Land+Use+Management+

Compounding Variables

-Spatial variability of microclimate: elevation

-Landuse changes can interact or coincide with changes in climate

-Solution: treat each sub Basin independently and Test for variables one at a time (landuse, climate, etc.)

Methods

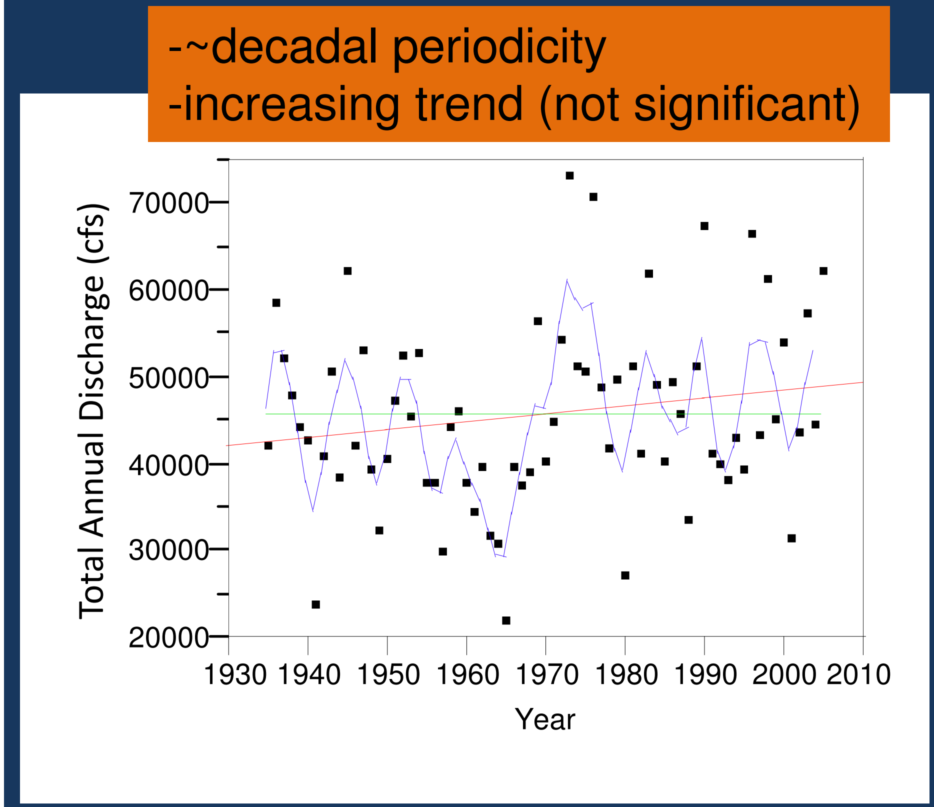
-Analyze yearly, monthly, daily data by station:

- -Discharge
- -Precipitation
- -Temperature
- -Wind speed; direction
- -Relative Humidity
- -Solar Input

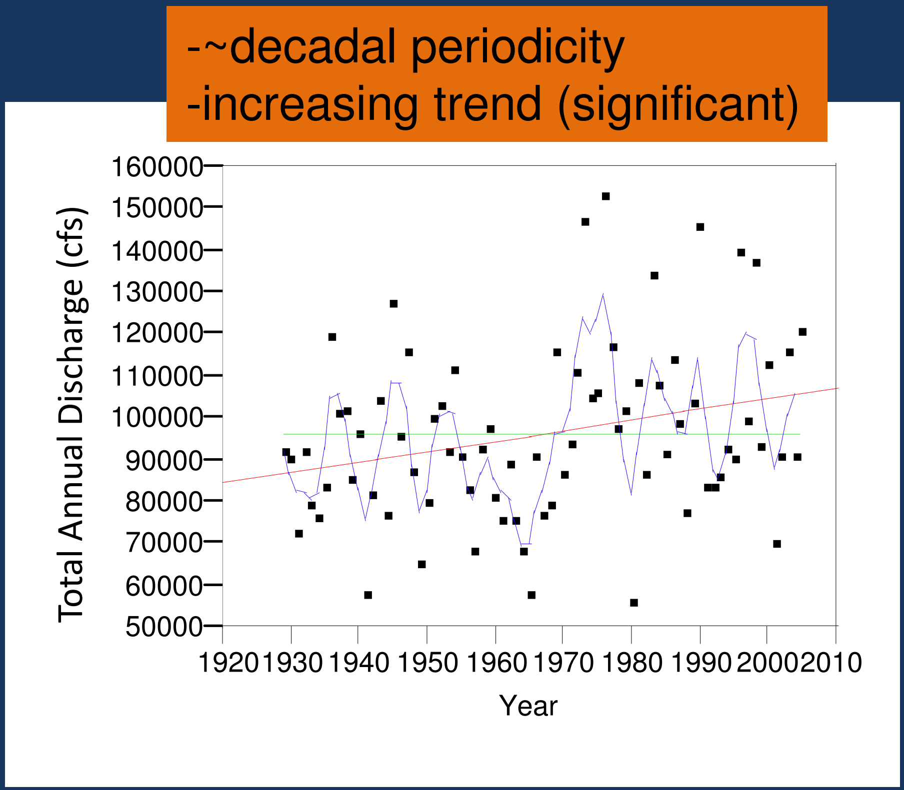
-Analyze discharge and precipitation for storms and base flows

-look for relationships between these using Spectral Analysis and ANN

Preliminary Analysis

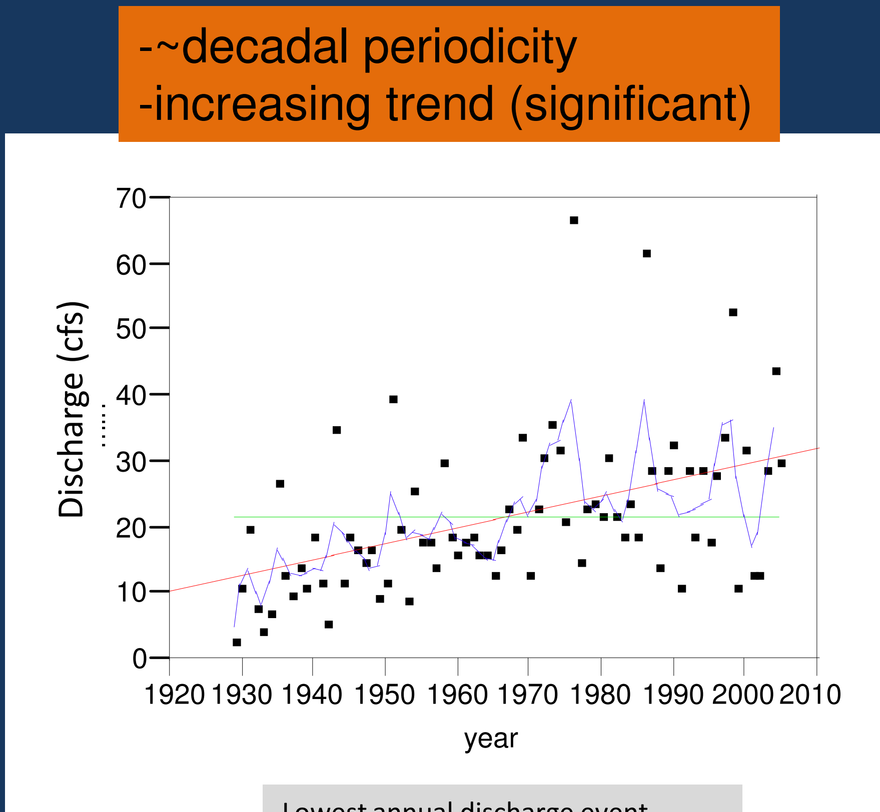


Dog River annual discharge 1935-2005
Linear r^2= 0.034, Spline r^2= 0.616
P value= 0.124

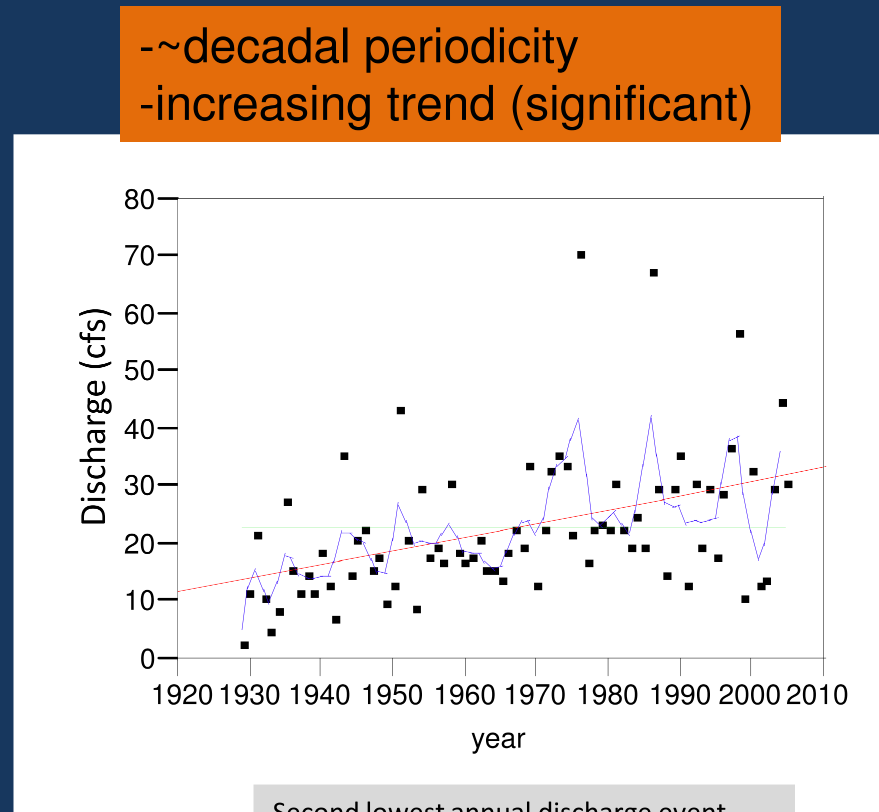


Mad River annual discharge 1929-2005
Linear r^2= 0.075, Spline r^2= 0.611
p value= 0.016

Preliminary Analysis



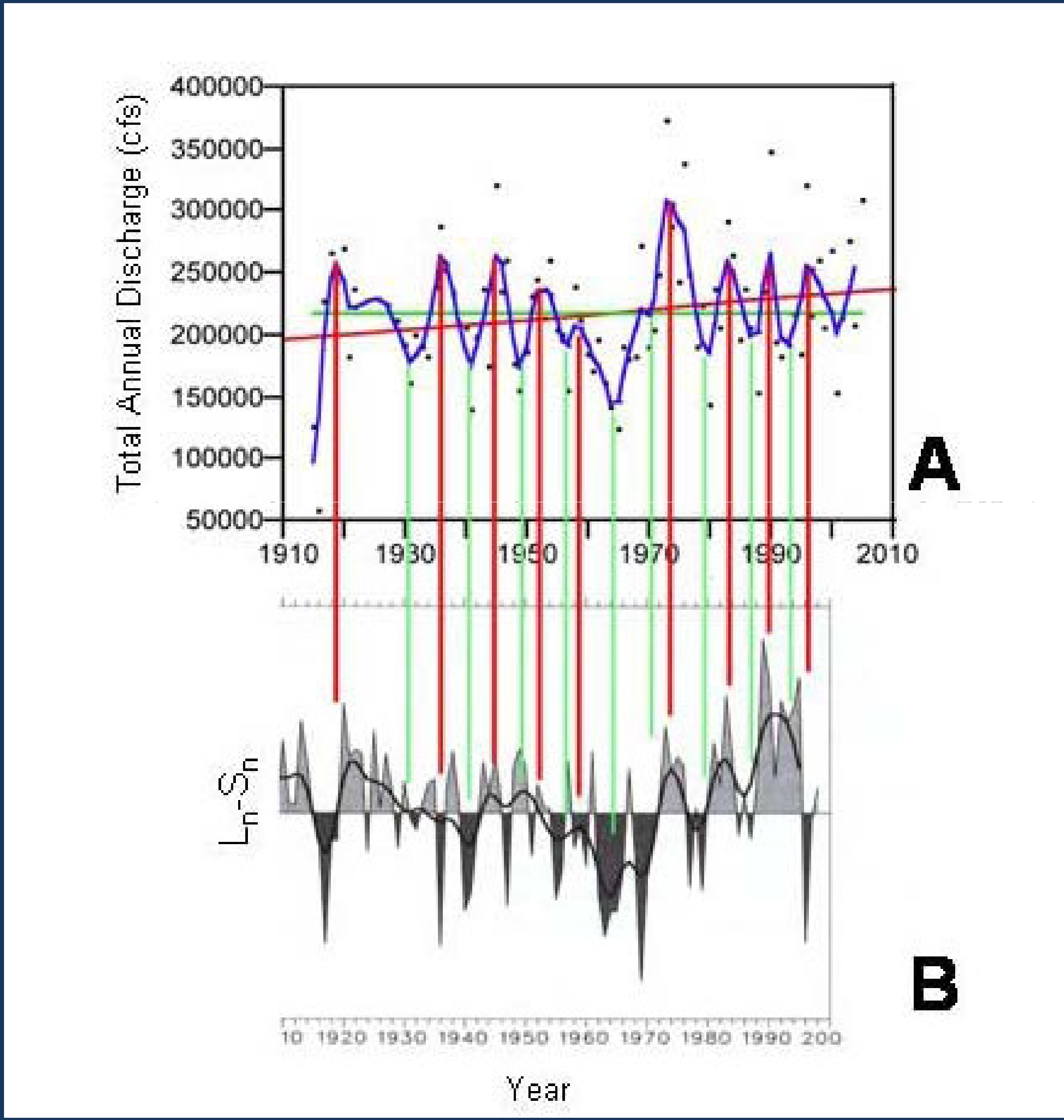
Lowest annual discharge event
Mad River
1929-2005
Linear r2= 0.214, spline r2= 0.561
P value= <0.0001



Second lowest annual discharge event
Mad River
1929-2005
Linear r2= 0.188, spline r2= 0.555
P value= <0.0001

Natural Oscillations and Periodicity

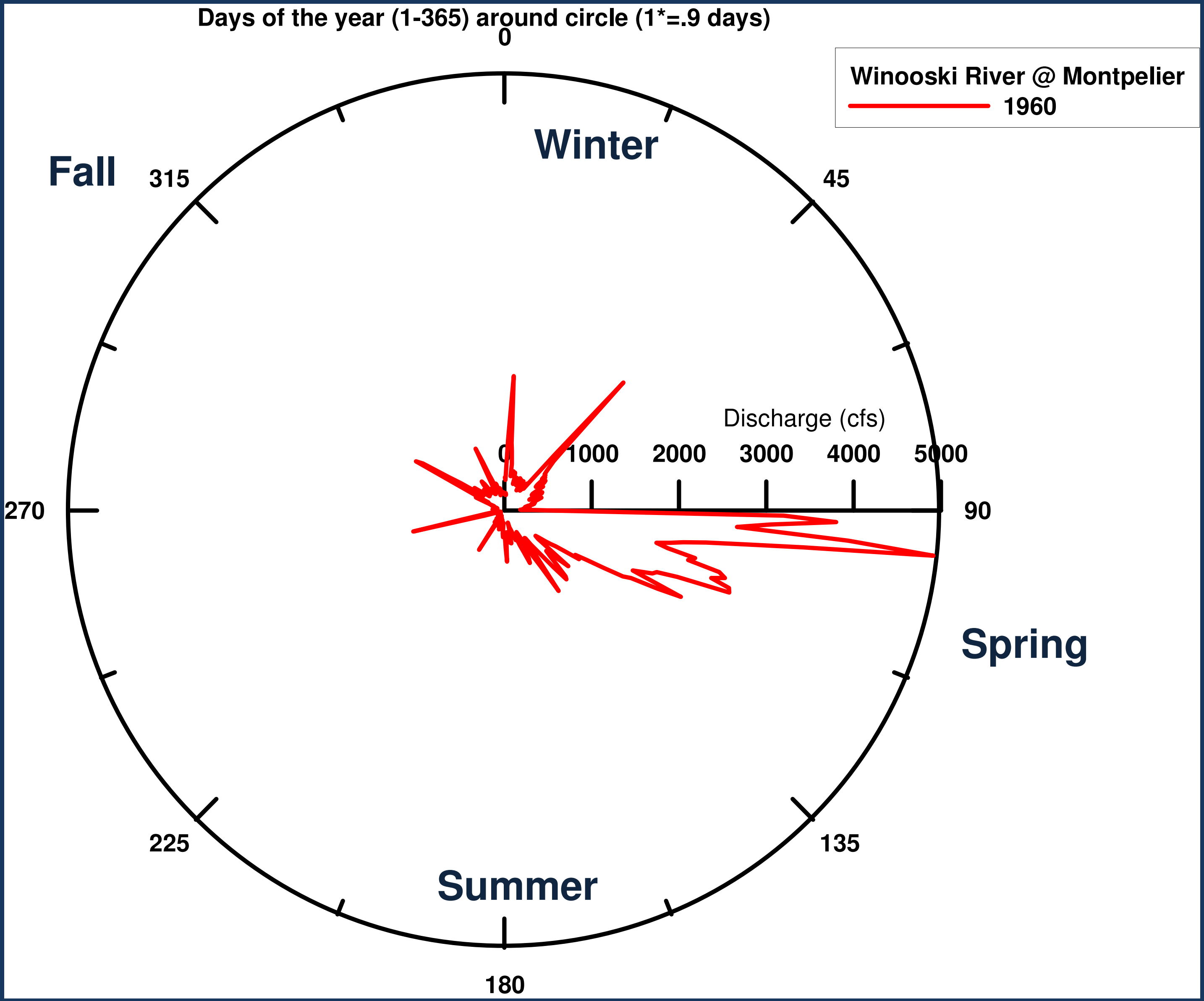
Correlate peaks and troughs in discharge Record with those Of the NAO signal over the same period



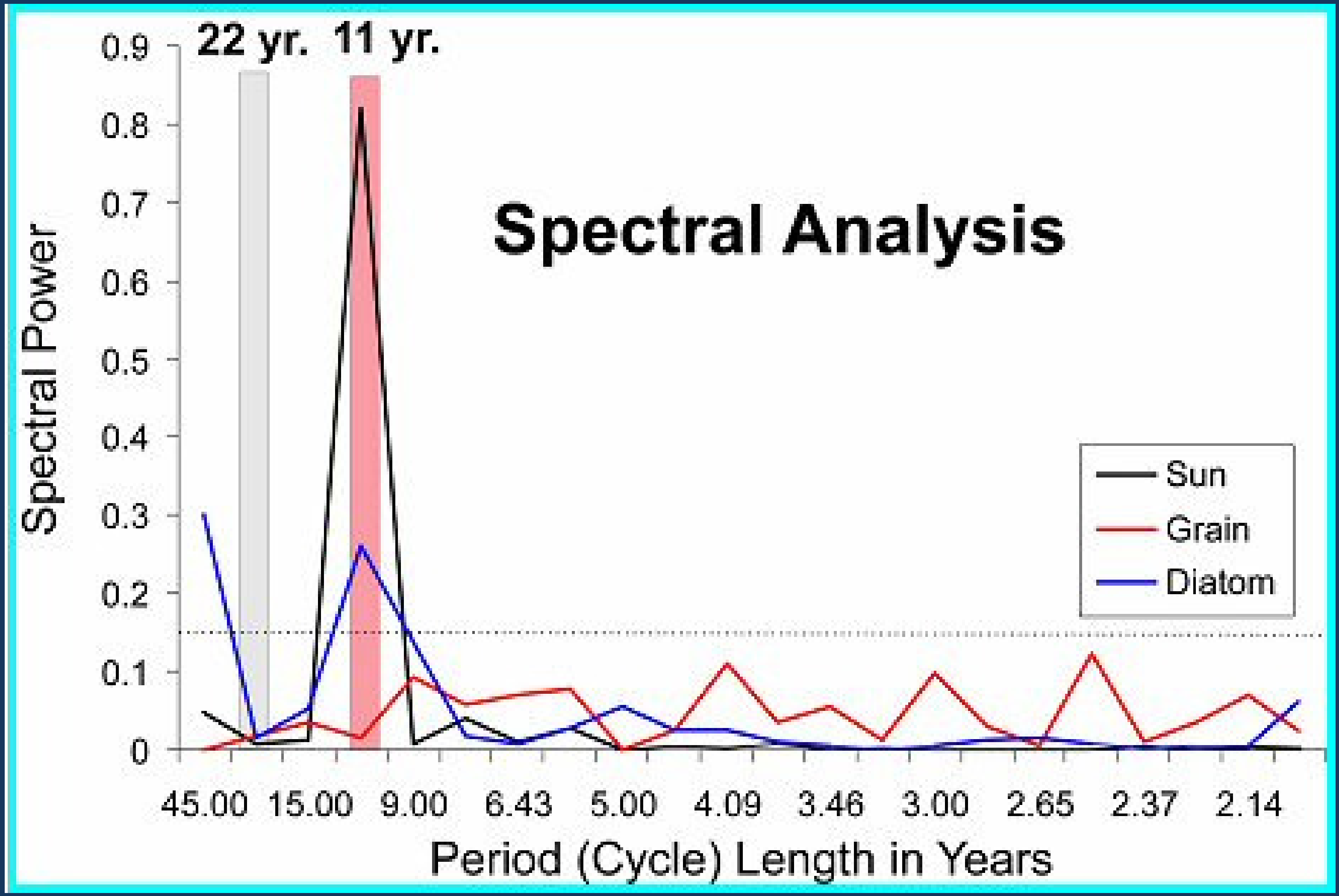
Adapted from *Decade-to-Century-Scale Climate Variability and Change*, 1998.

Further Analysis

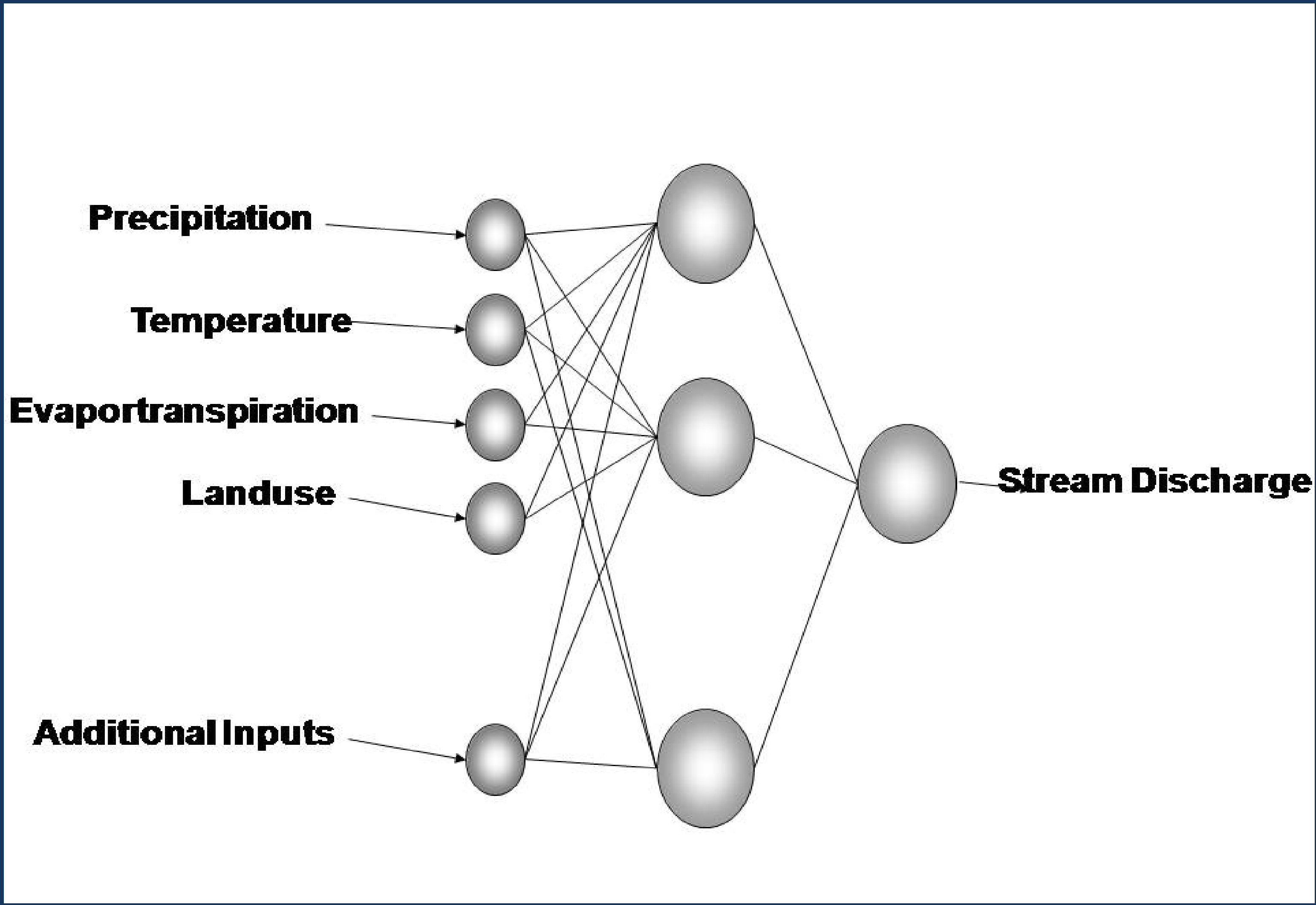
Directional Statistics



Spectral Analysis



Artificial Neural Network



Analysis of Landuse

Methods:

-Point sampling of entire basin to choose sites

  -Randomly select from uplands and lowlands

-At each point, 4 km^2 subset of sample points

-Identify each point as road/structure, field, forest, or developed.

-Total percentages for each image set (year)

Analysis of Landuse

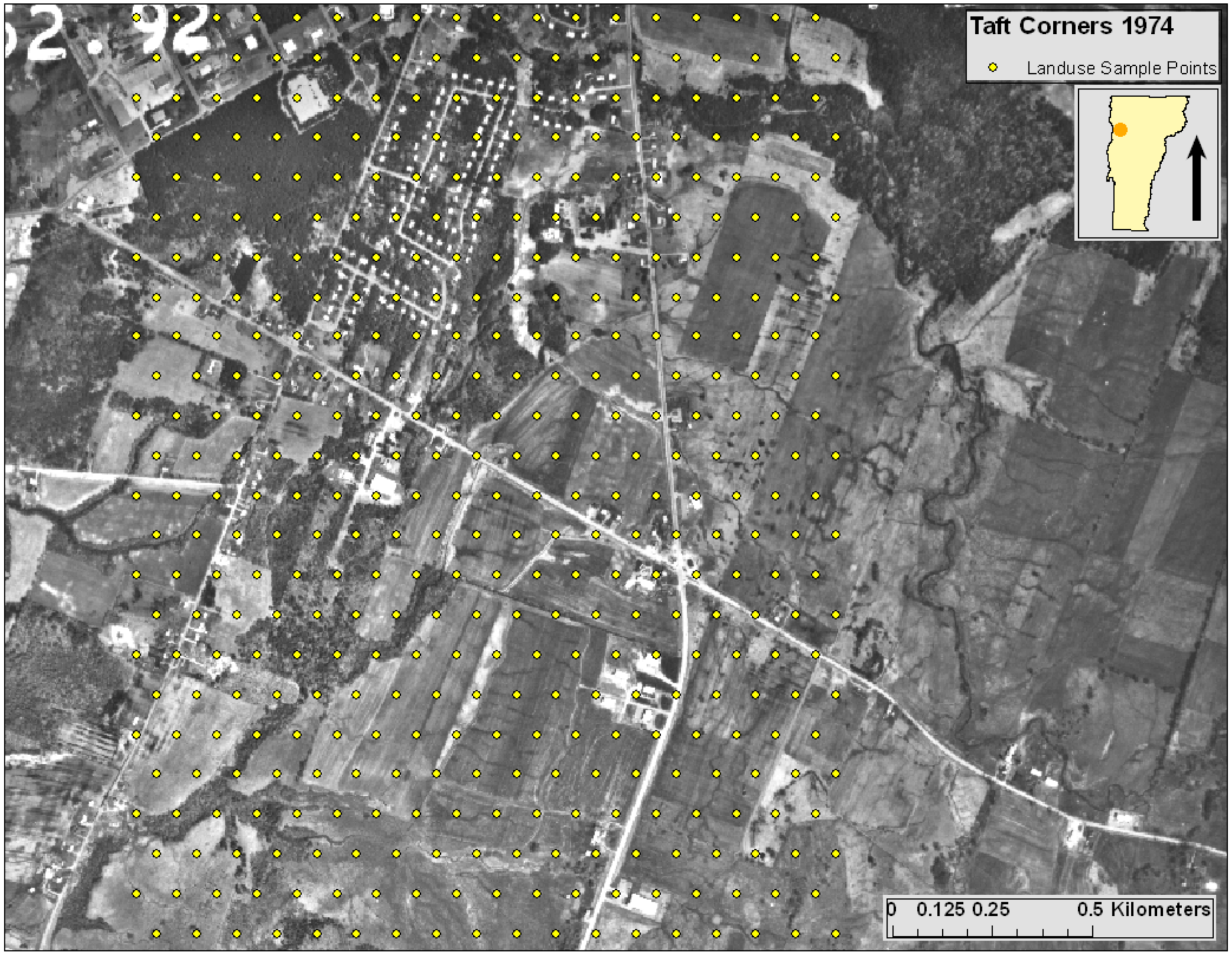
Taft Corners, Williston, VT:

Analysis of Landuse

Taft Corners, Williston, VT:

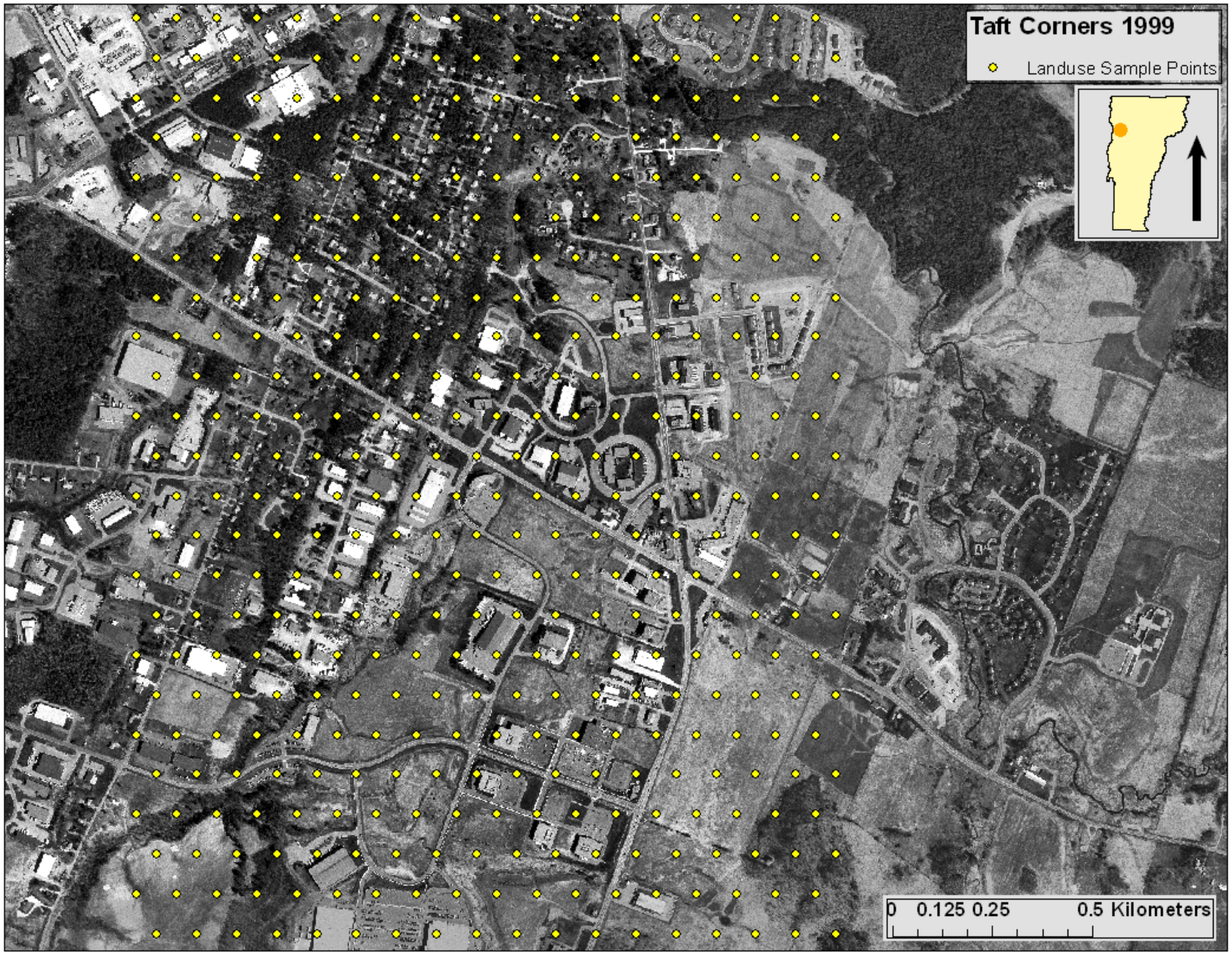
Analysis of Landuse

Taft Corners, Williston, VT:



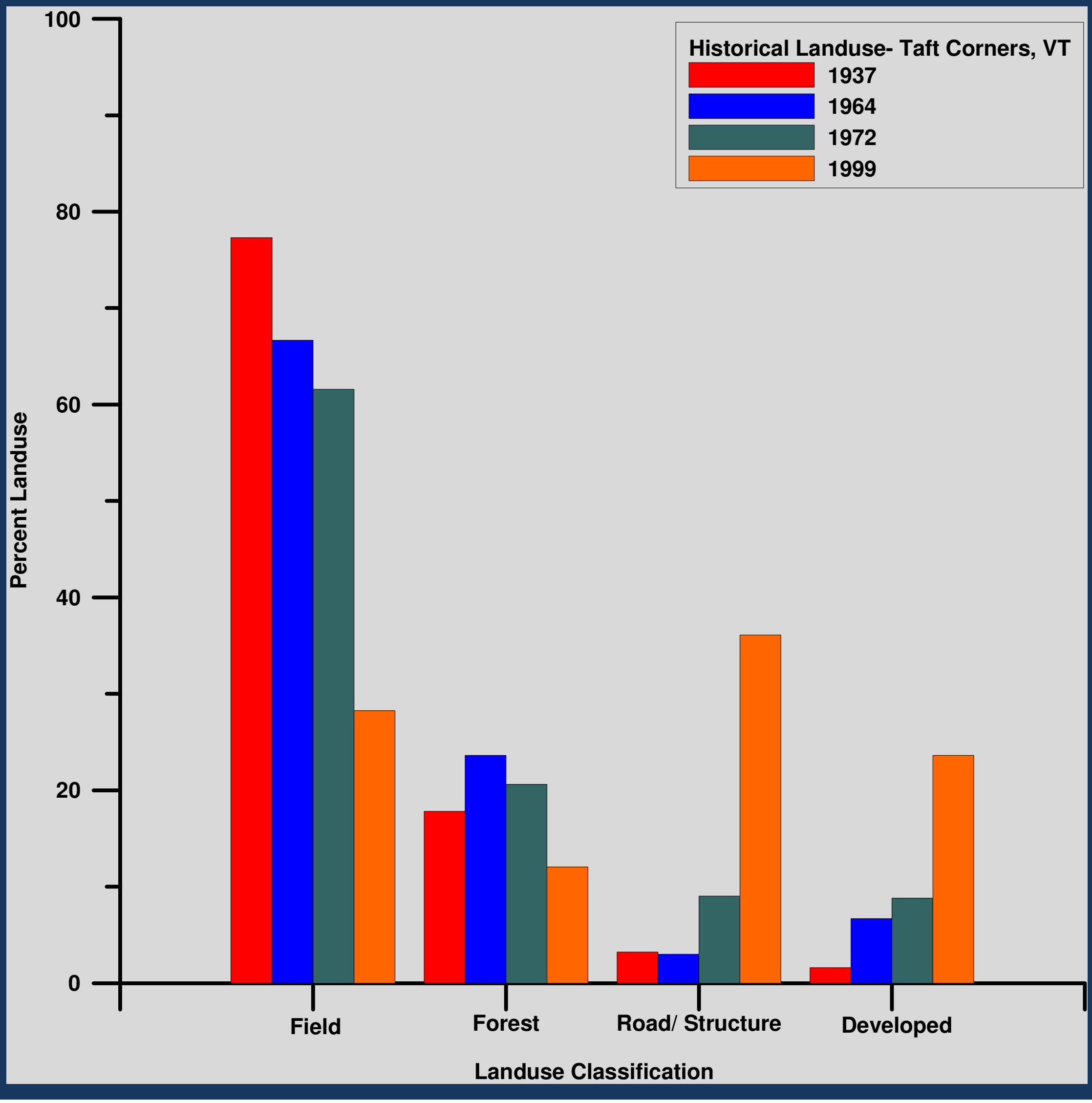
Analysis of Landuse

Taft Corners, Williston, VT:



Analysis of Landuse

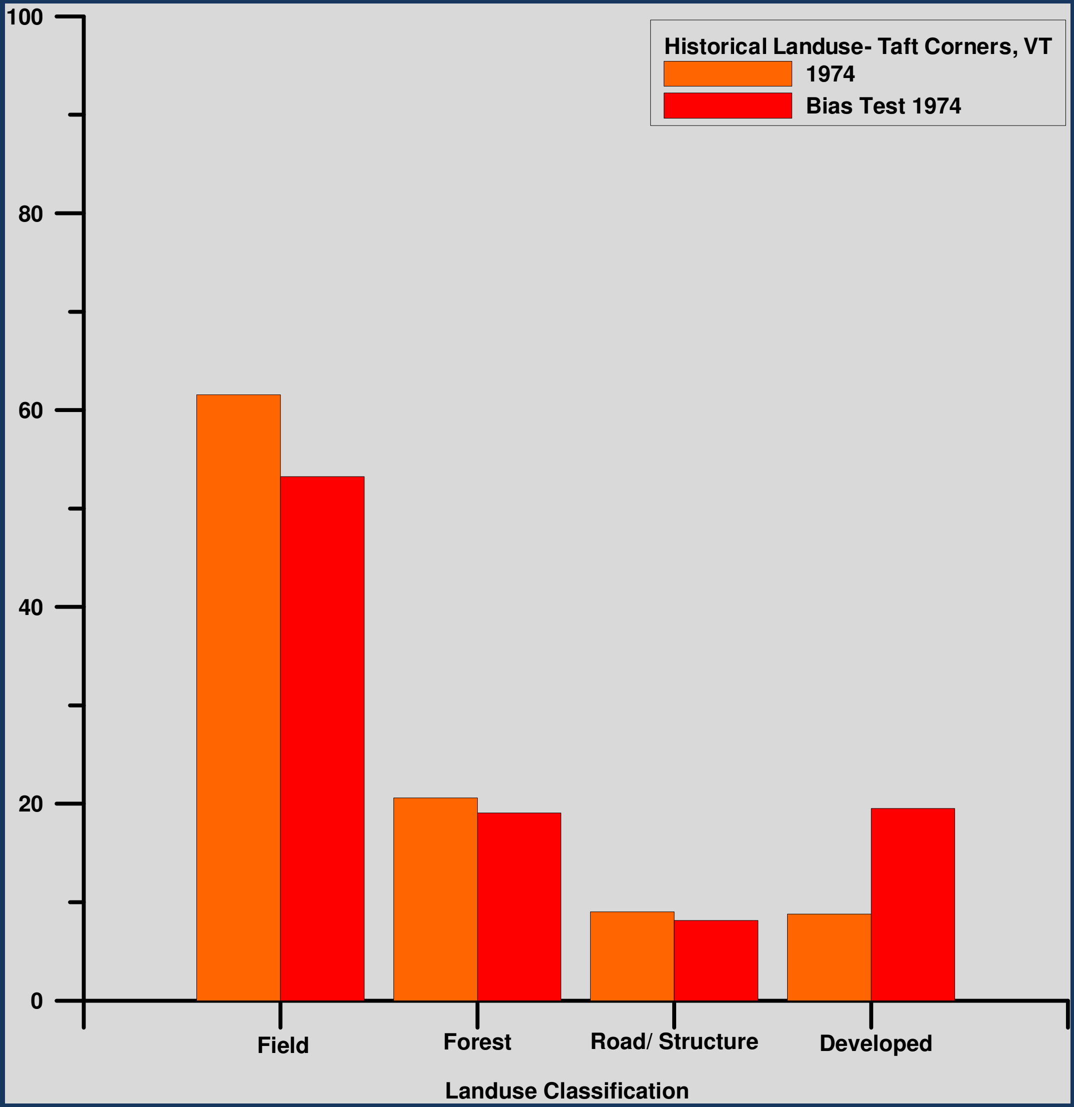
Taft Corners, Williston, VT:



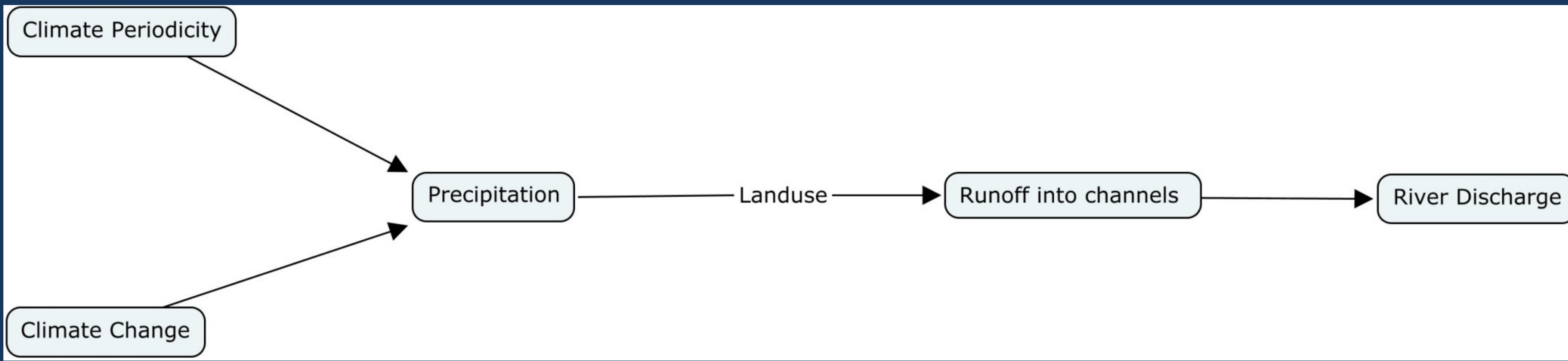
Sampling Bias

Test subject: Matt Jungers

Category	1974	MCJ test
Field	62%	53%
Forest	21%	19%
Road/Structure	9%	8%
Developed	9%	20%



Summary



-Overall climatic trends
-Climatic oscillations ie: NAO, el nino

Data:
-Precipitation
-Wind
-Solar Input
-Temperature

-Landuse
-Evapotranspiration
-Runoff

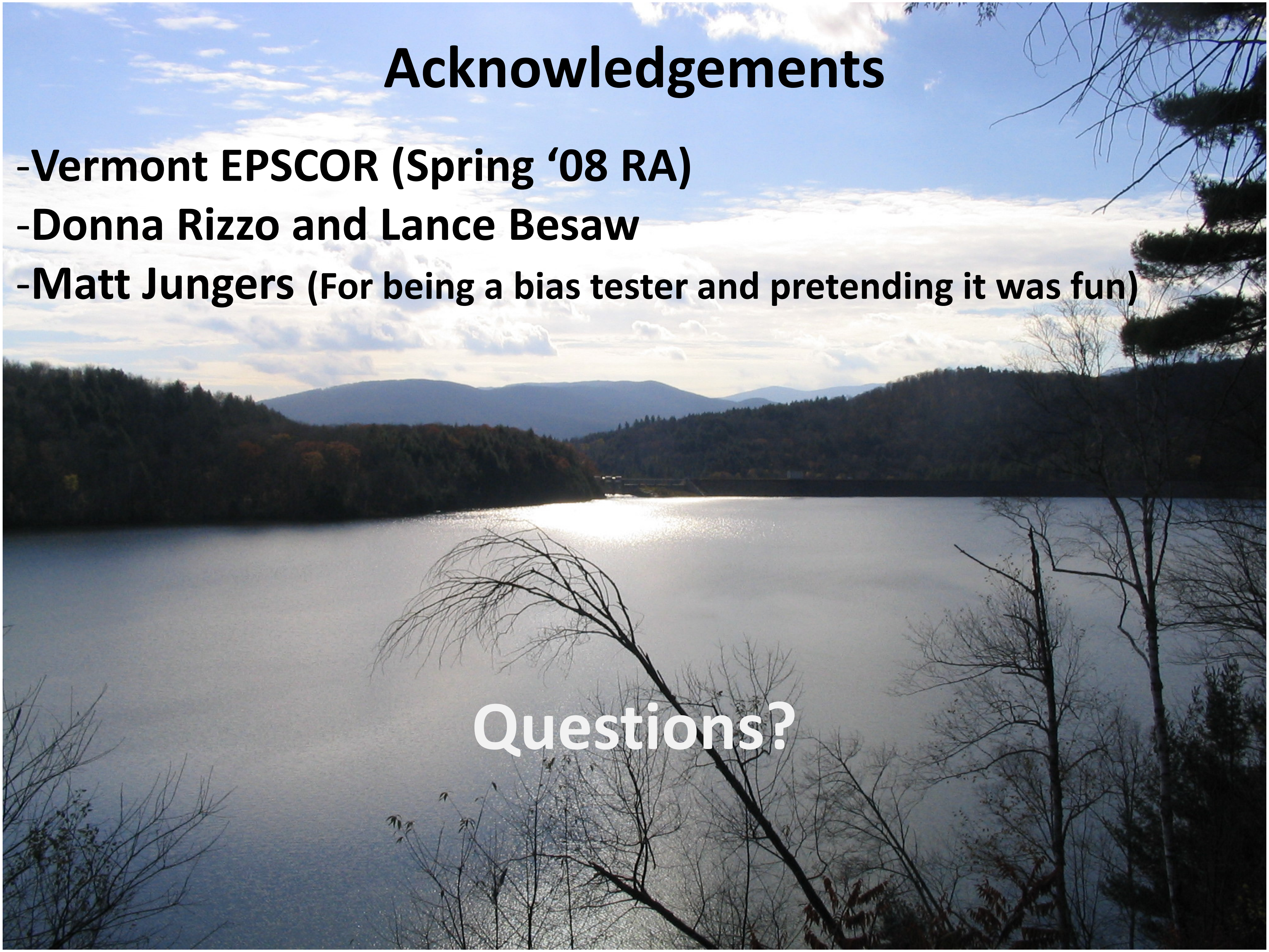
-Discharge Data

-Identify climate signals within the weather and discharge data

-Then, attempt to correlate landuse changes (and timing) with data

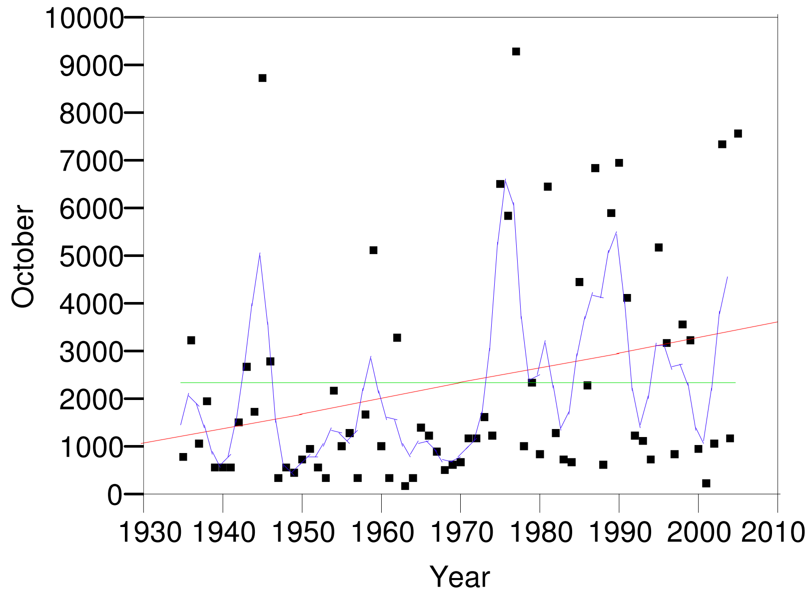
Timeline

Task	Timing
Discharge and weather data analysis	Spring 2008
Thesis Proposal	Spring 2008
Landuse/historical imagery analysis, additional data analysis and model creation, paper writing	Summer- Fall 2008
Progress Report, GSA Talk/Poster	Fall 2008
Write Thesis	Spring 2009
Thesis Defense	Spring/Summer 2009


Acknowledgements
-Vermont EPSCOR (Spring ‘08 RA)
-Donna Rizzo and Lance Besaw
-Matt Jungers (For being a bias tester and pretending it was fun)
Questions?

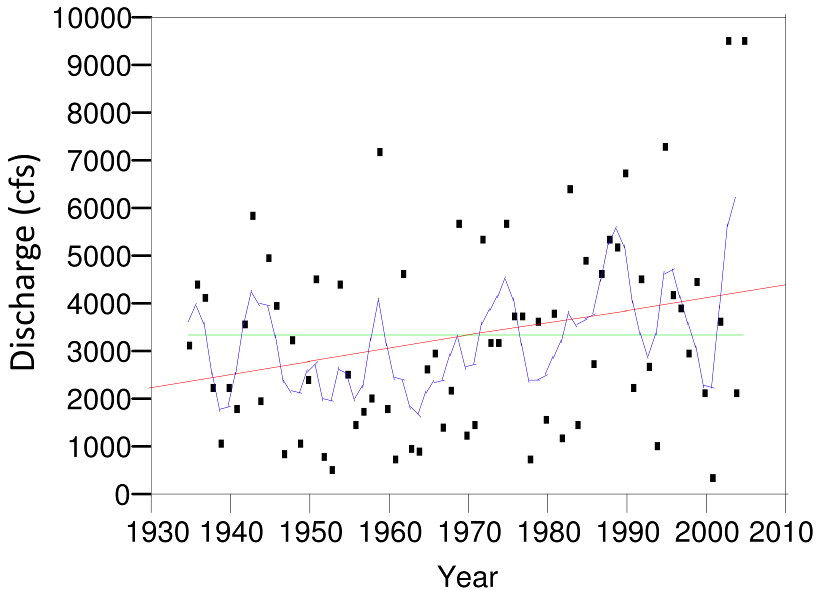
Preliminary Analysis

-~decadal periodicity
-increasing trend (not significant)



Dog River October discharge
1935-2005
Linear r^2= 0.081, Spline r^2= 0.622

-~decadal periodicity
-increasing trend (not significant)



Dog River November discharge
1935-2005
Linear r^2= 0.076, Spline r^2= 0.493