A Changing Climate: Some Implications for Riparian Wetlands Restoration

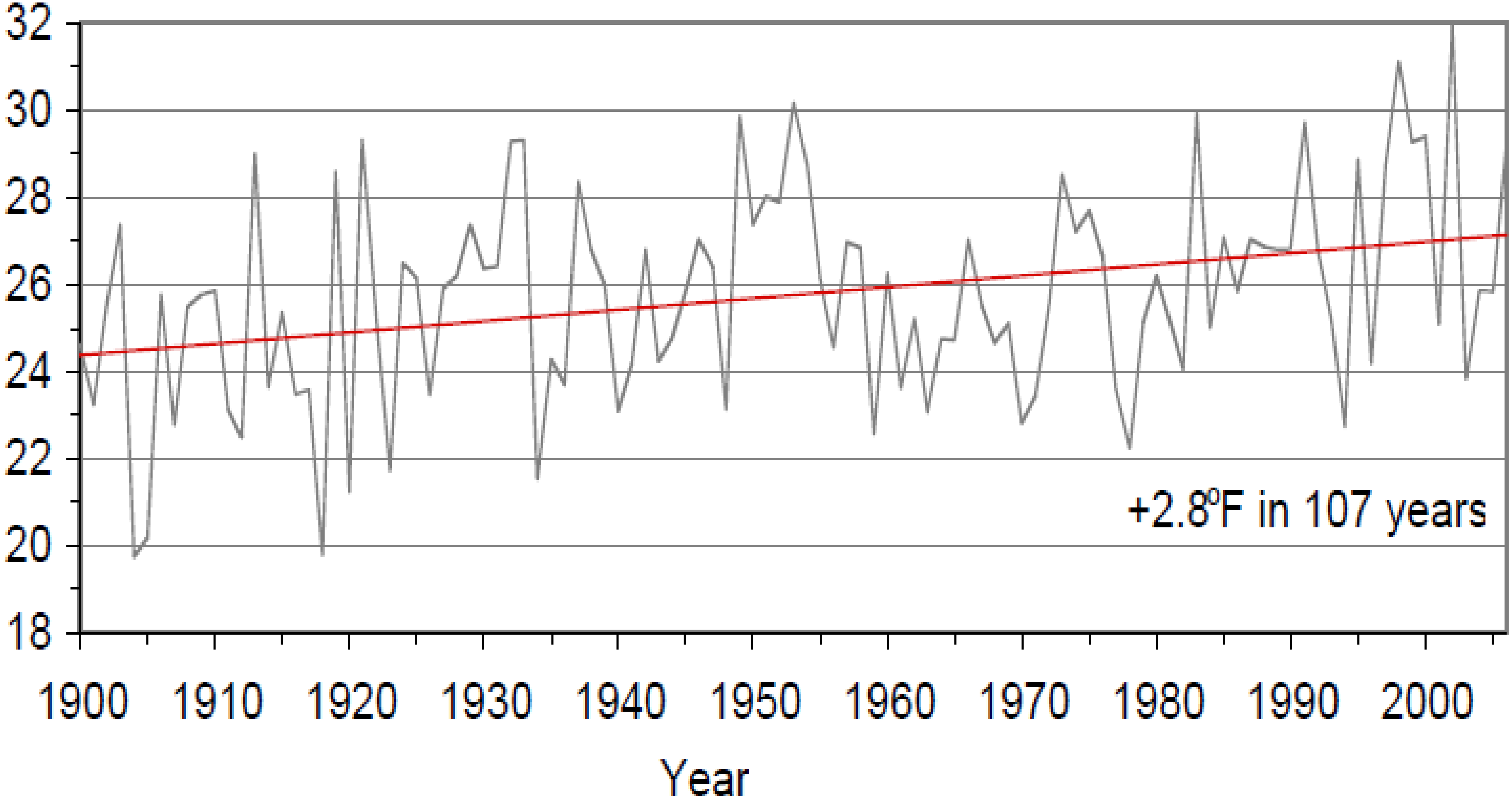
- What is Happening
- What to Expect
- Some Implications for Wetlands Associated with Riparian Corridors

Michael Simpson,
Environmental Studies Dept.

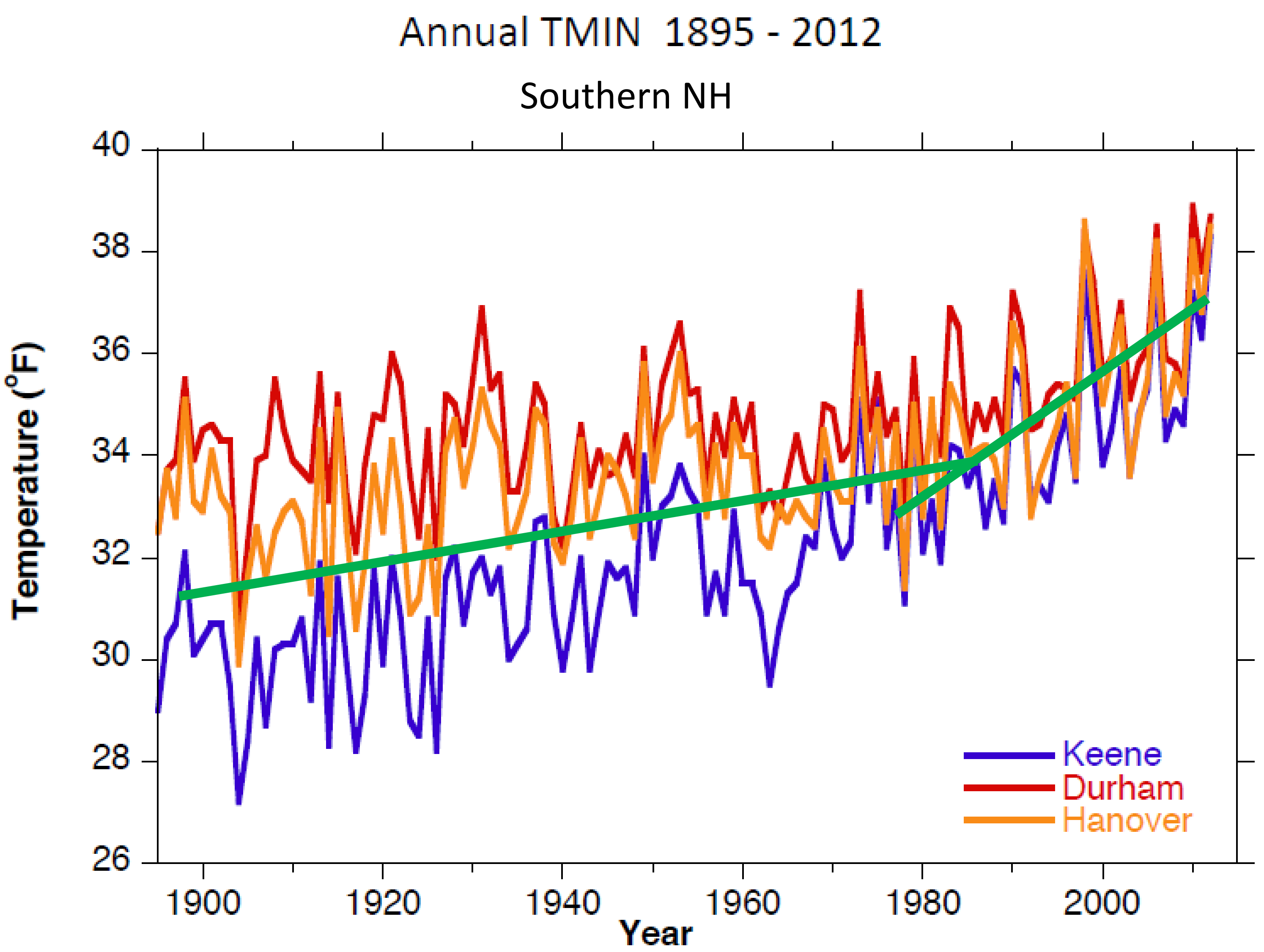
ANTIOCH UNIVERSITY
NEW ENGLAND

What Is Happening

Annual US Average Temperature 1900-2008

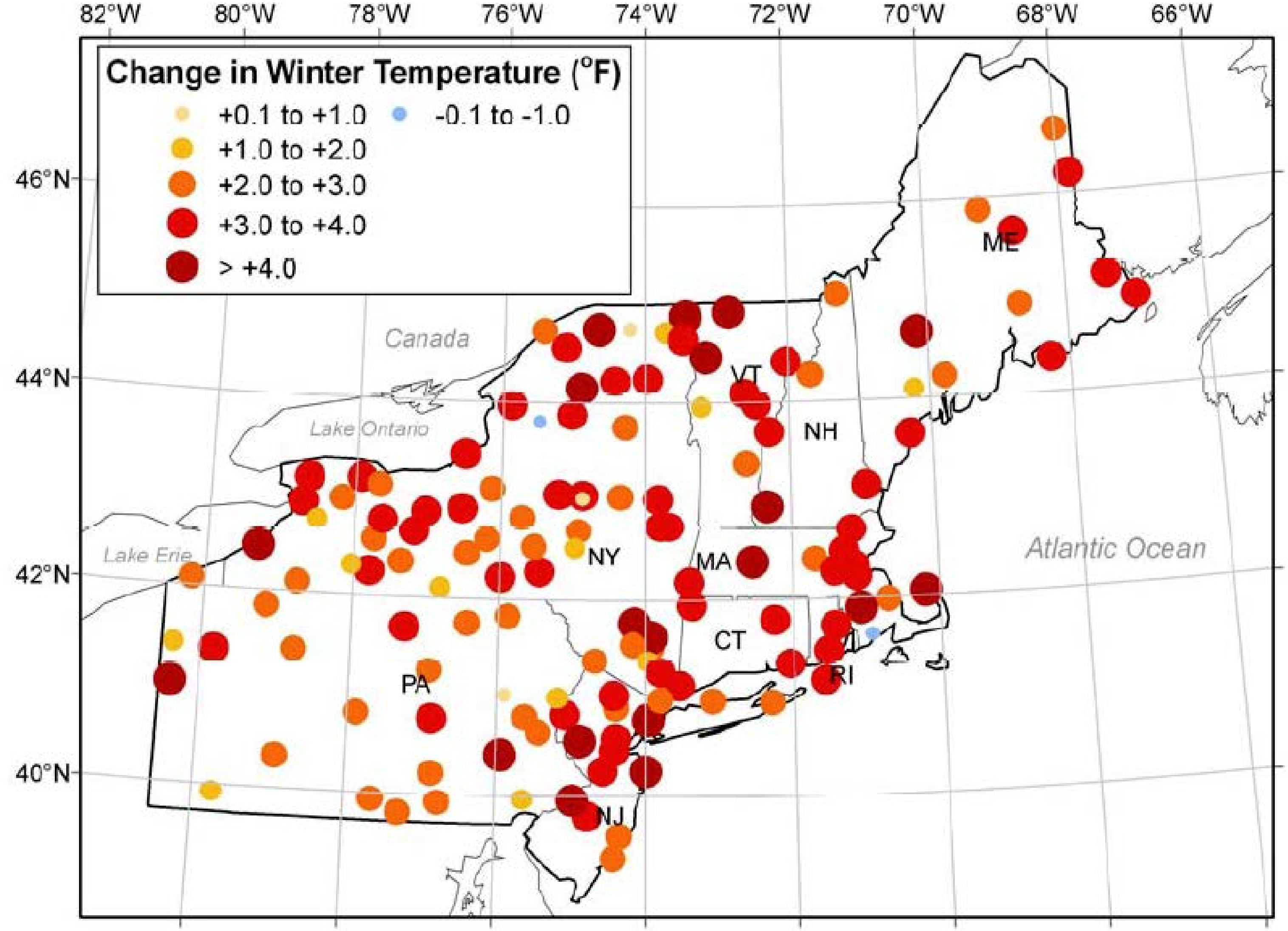


Burakowski & Wake 2008


Annual TMIN 1895 - 2012
Southern NH
Temperature (°F)
40
38
36
34
32
30
28
26
1900
1920
1940
1960
1980
2000
Year
Keene
Durham
Hanover

Wake 2013

Northwest Winter Temperature Trends 1965-2008



Burakowski & Wake 2008

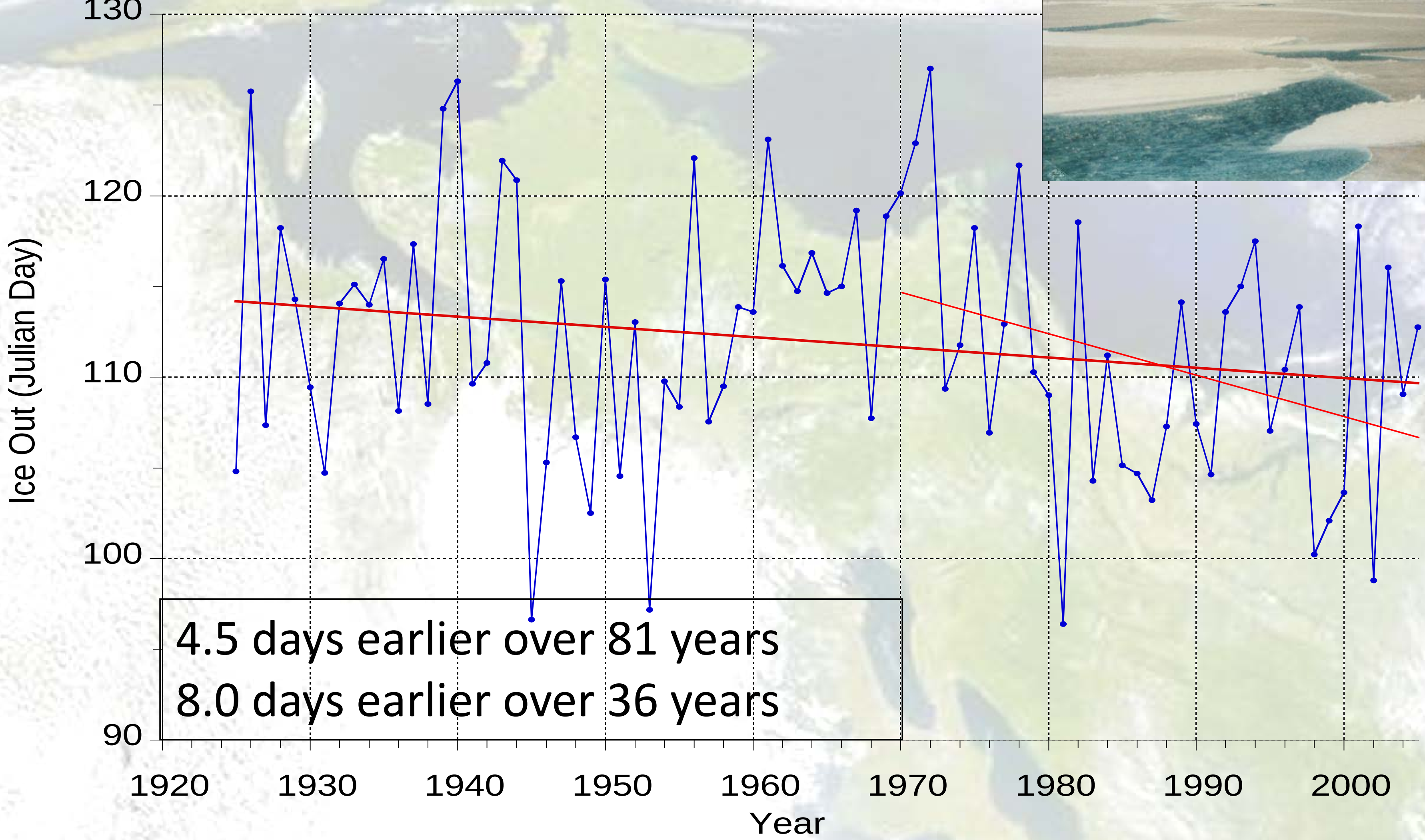
Trends in Winter Climate in the Northeast US

Mean Temperature	+ 2.5 ^{o}F
Max Temperature	+ 2.7 ^{o}F
Min Temperature	+ 2.3 ^{o}F
Snowfall	- 9 inches
Snow on Ground	- 9 days

Burakowski et al., 2008

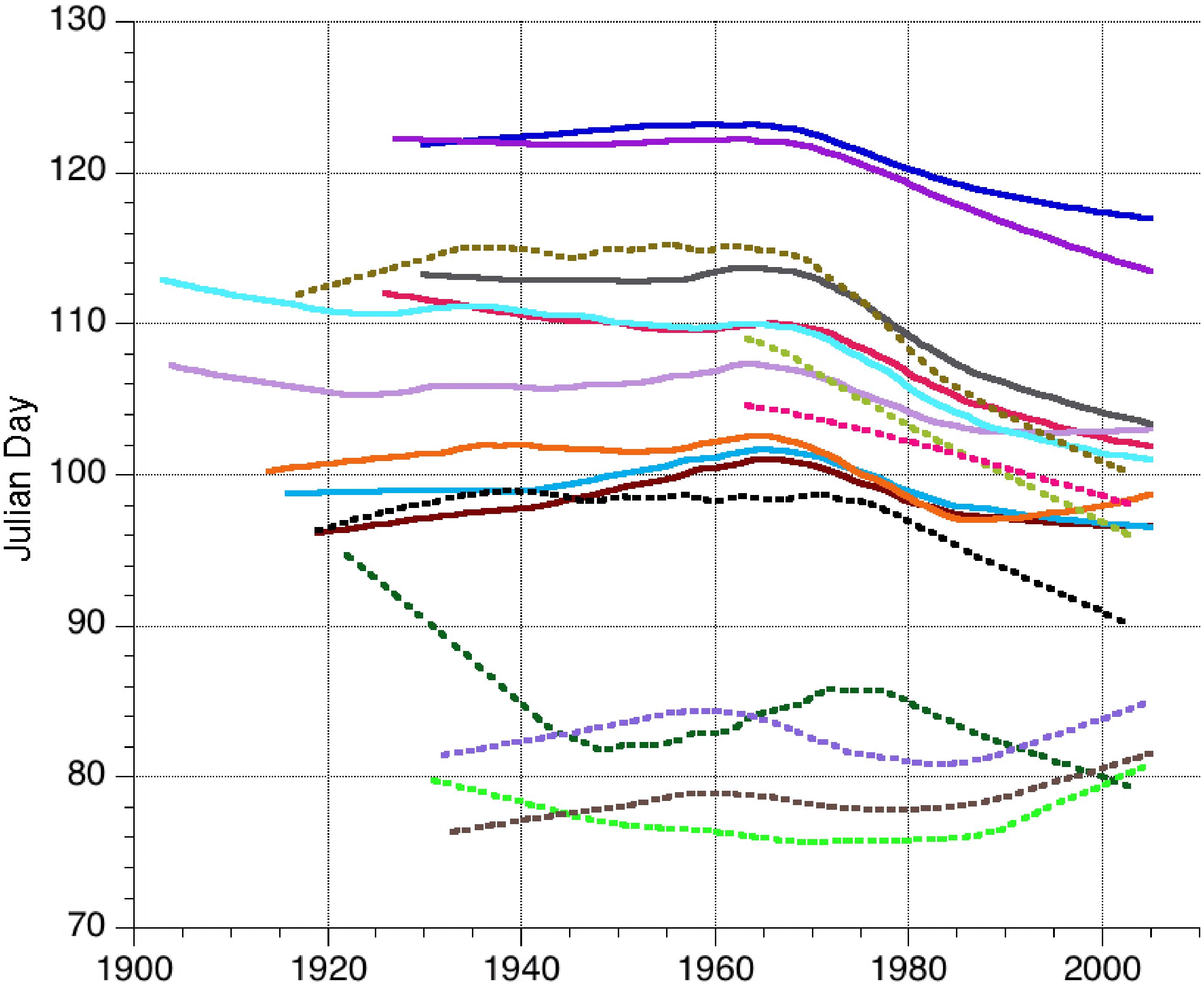
Average **Ice Out** Day Trend 1925-2005

(27 Lakes)



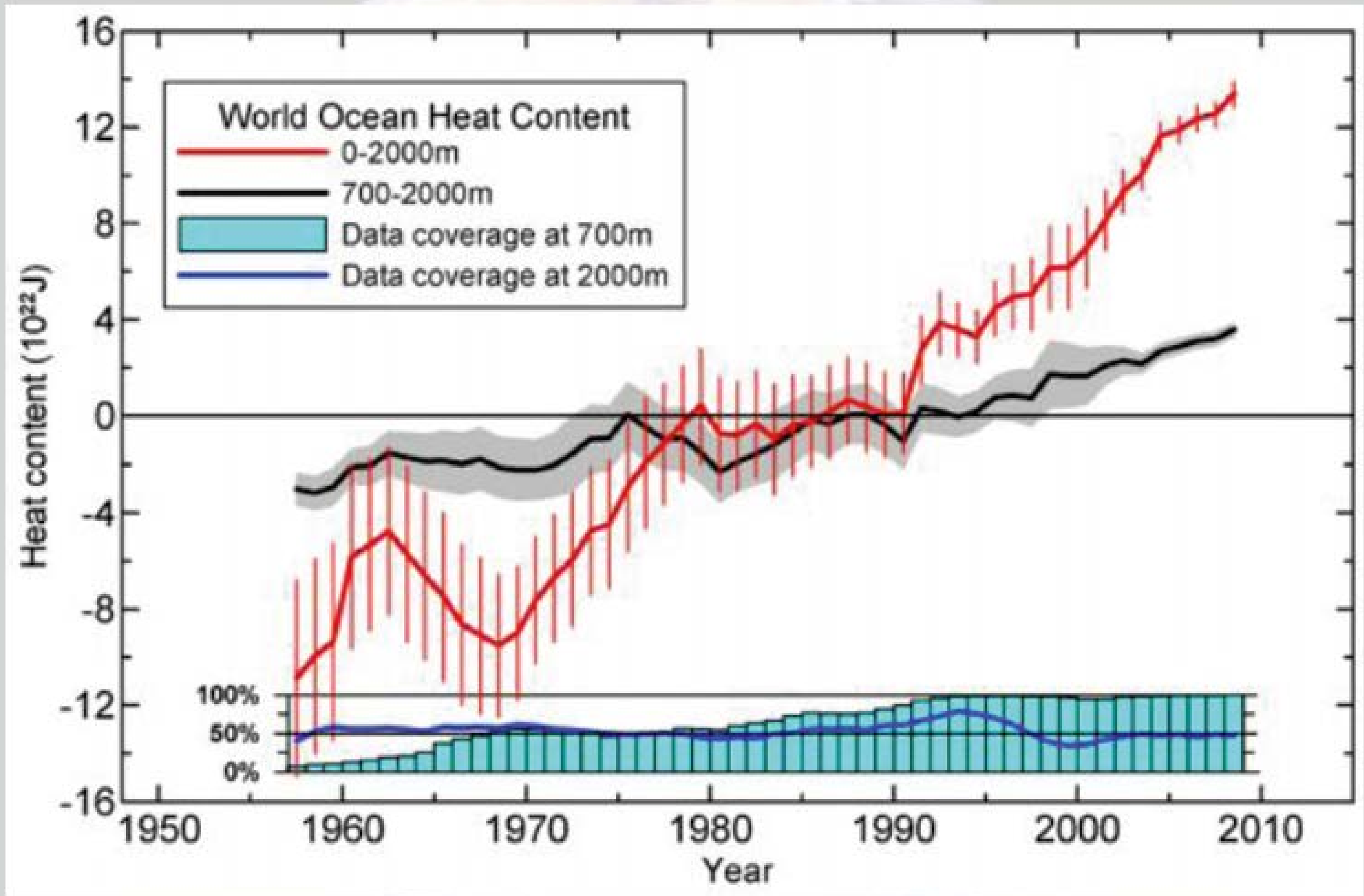
Ice Out data from Hodgkins et al., 2002 and at: http://me.water.usgs.gov/iceout.html

Winter/Spring (1 Jan - 31 May) Center-of-Volume Dates



All data from unregulated rivers; Hodgkins et al., 2003

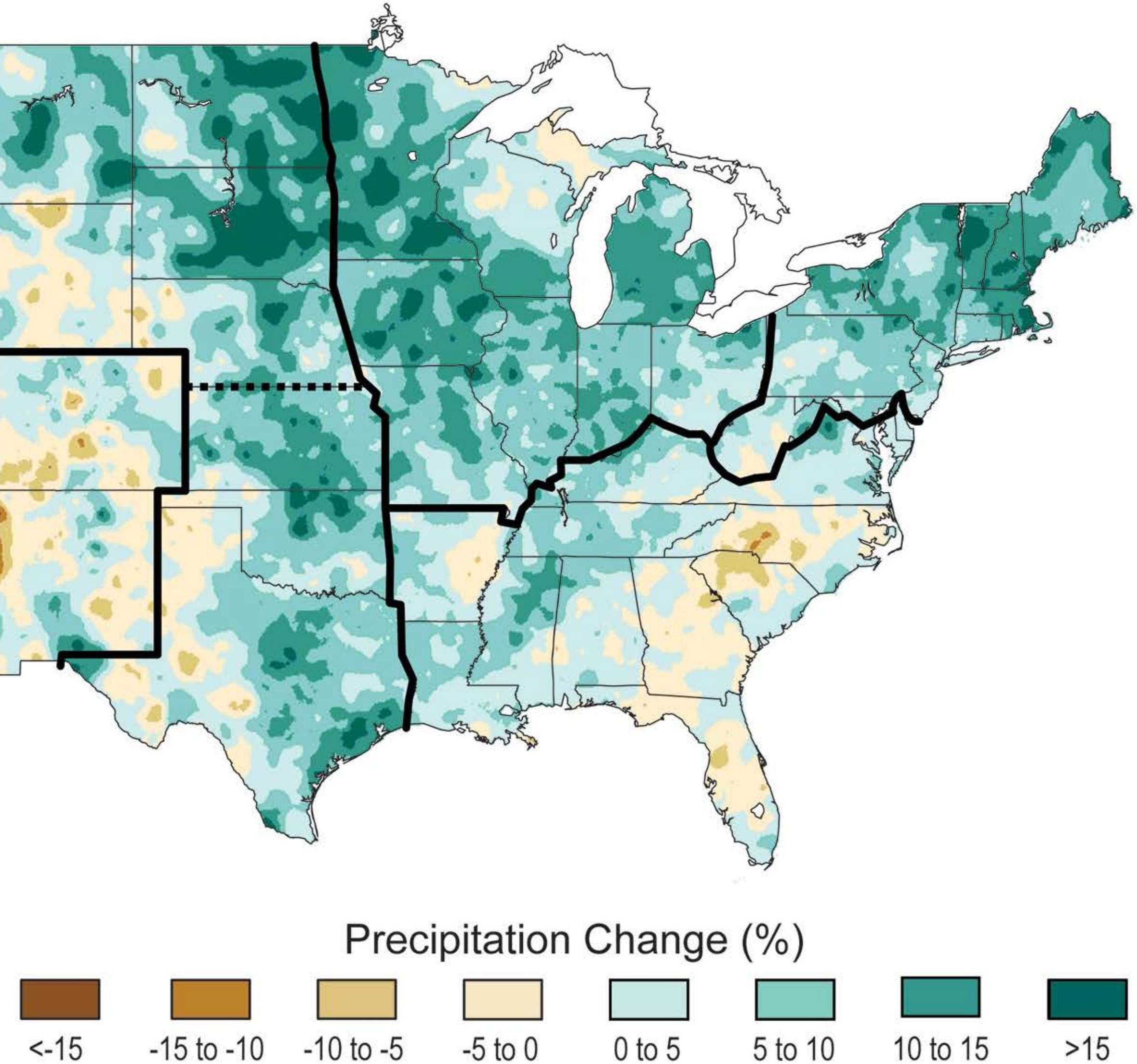
World Ocean Heat Content

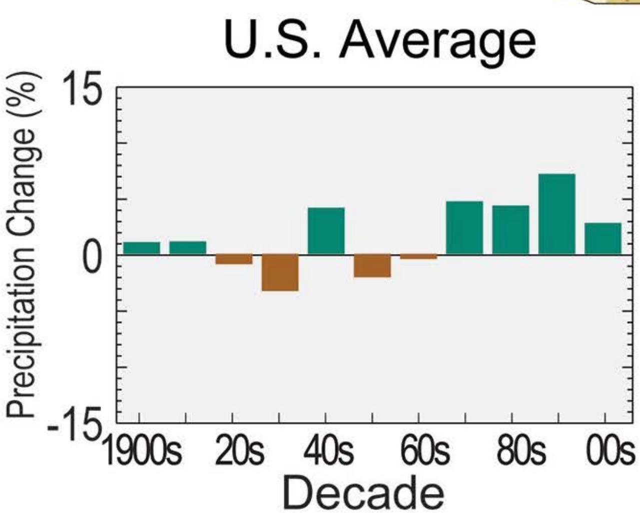


Levitus et al, 2012 GRL

Increase in Average Precipitation

1958 - 2012

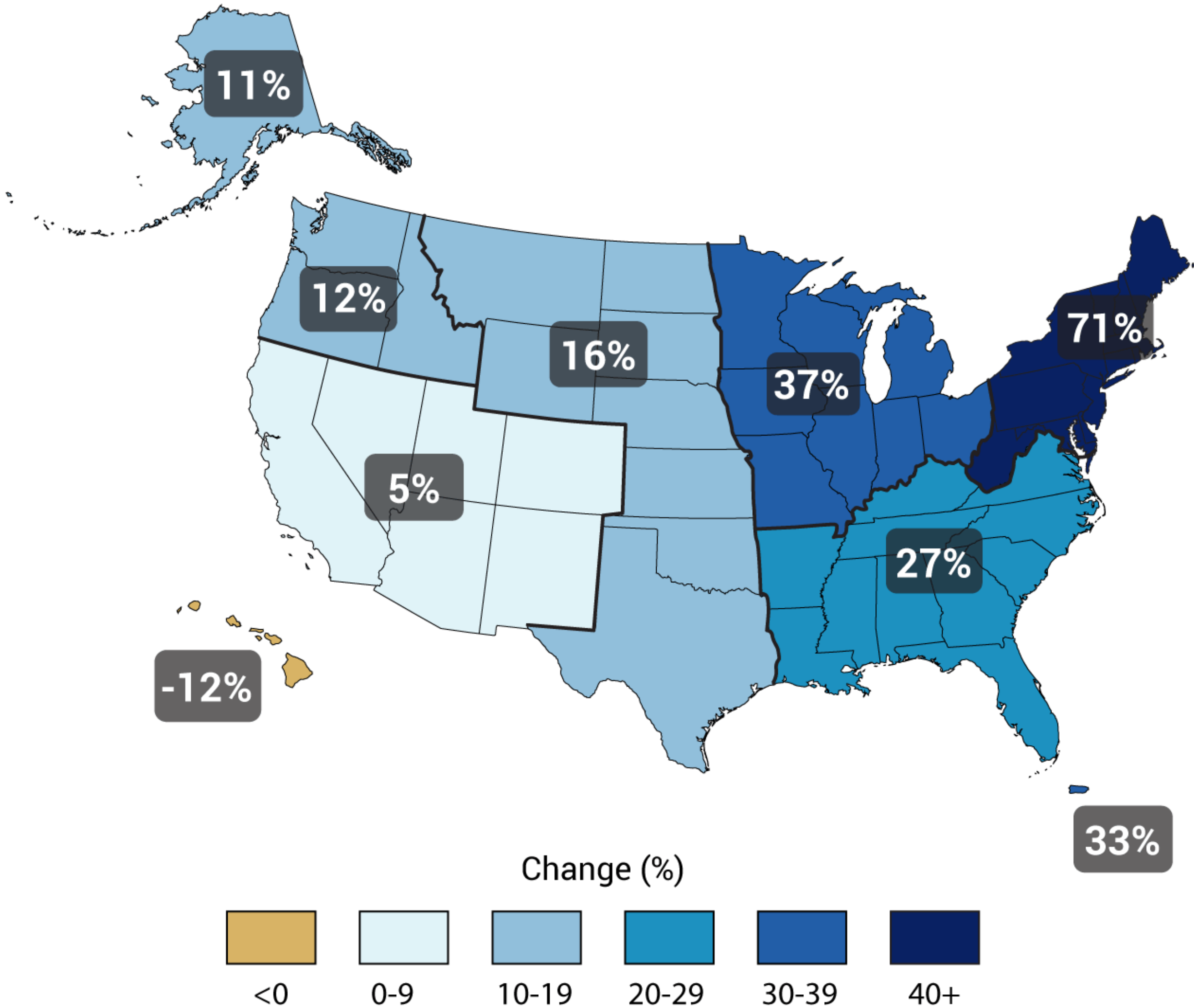




NCA 3 2014

Historic Increase in Heavy Precipitation

1958 - 2012



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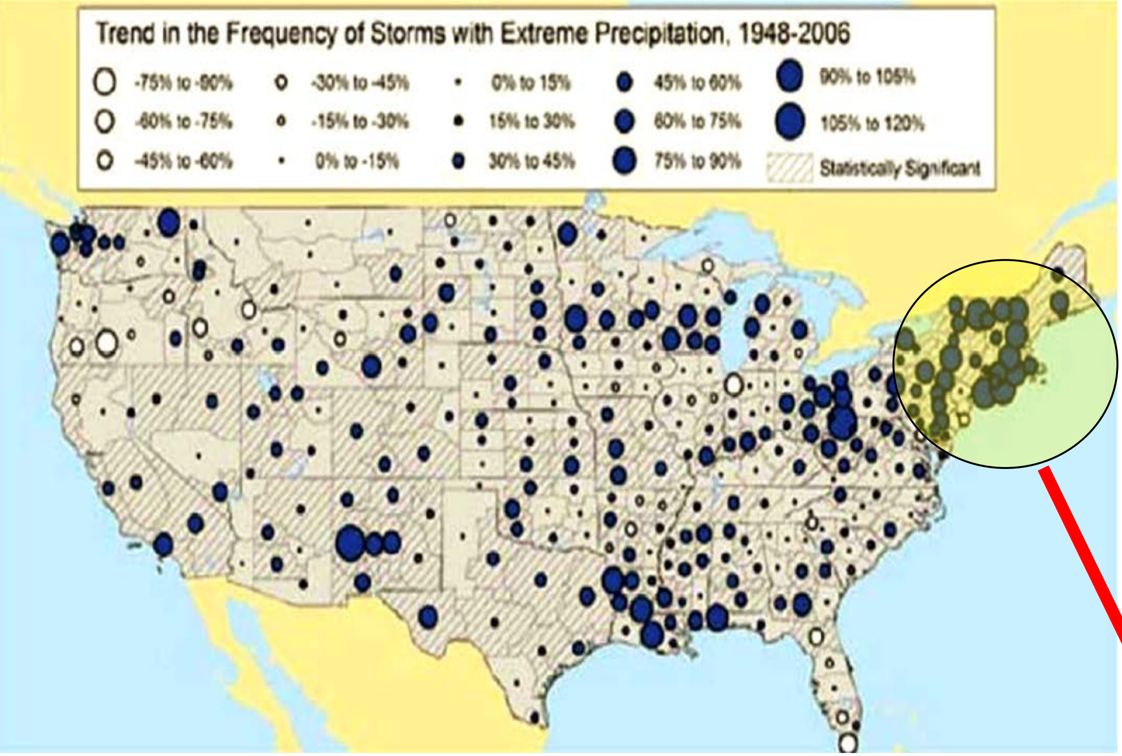
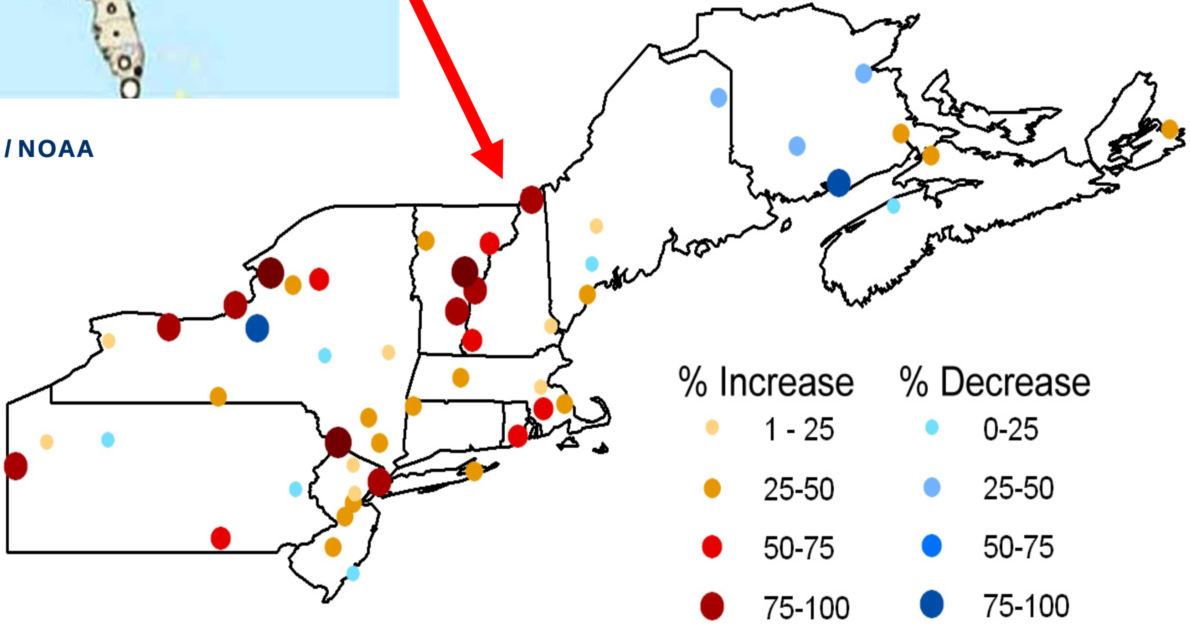


Source: National Climatic Data Center / NESDIS / NOAA



Wake, 2008

Highest Daily Discharge
Lamprey River near Newmarket since 1934

Rank	Date	Discharge (cfs)
1	16-May-2006	8400
2	15-May-2006	7600
3	18-Apr-2007	7590
4	17-Apr-2007	7410
5	7-Apr-1987	7360
6	22-Oct-1996	6310
7	17-May-2006	6240
8	23-Oct-1996	6150
9	8-Apr-1987	5920
10	6-Apr-1987	5460
11	20-Mar-1936	5270
12	19-Apr-2007	4830
13	15-Mar-2010	4810
14	21-Mar-1936	4690
15	27-Feb-2010	4640

Of 16 largest events since 1934:

- 13 have occurred in last 25 years
- 10 have occurred in last 15 years
- **8 have occurred in last 7 years**

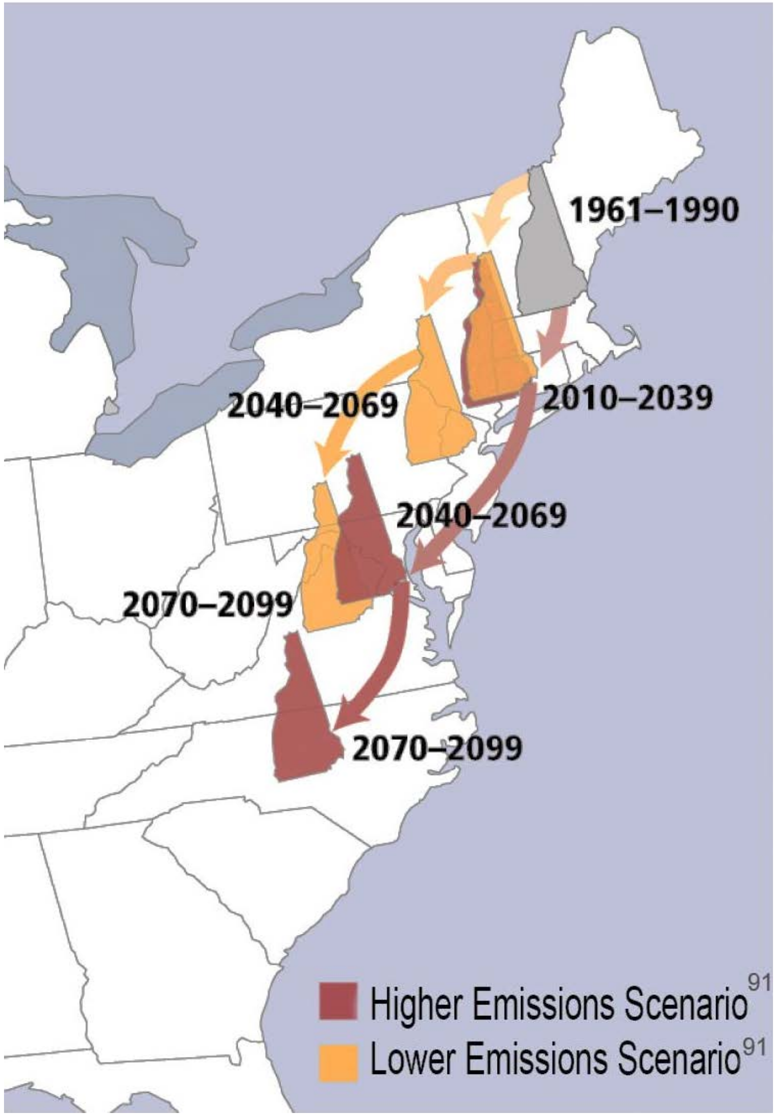
Roseen 2012

Indicators of Climate Change in the Northeast US over the last 30-40 yrs

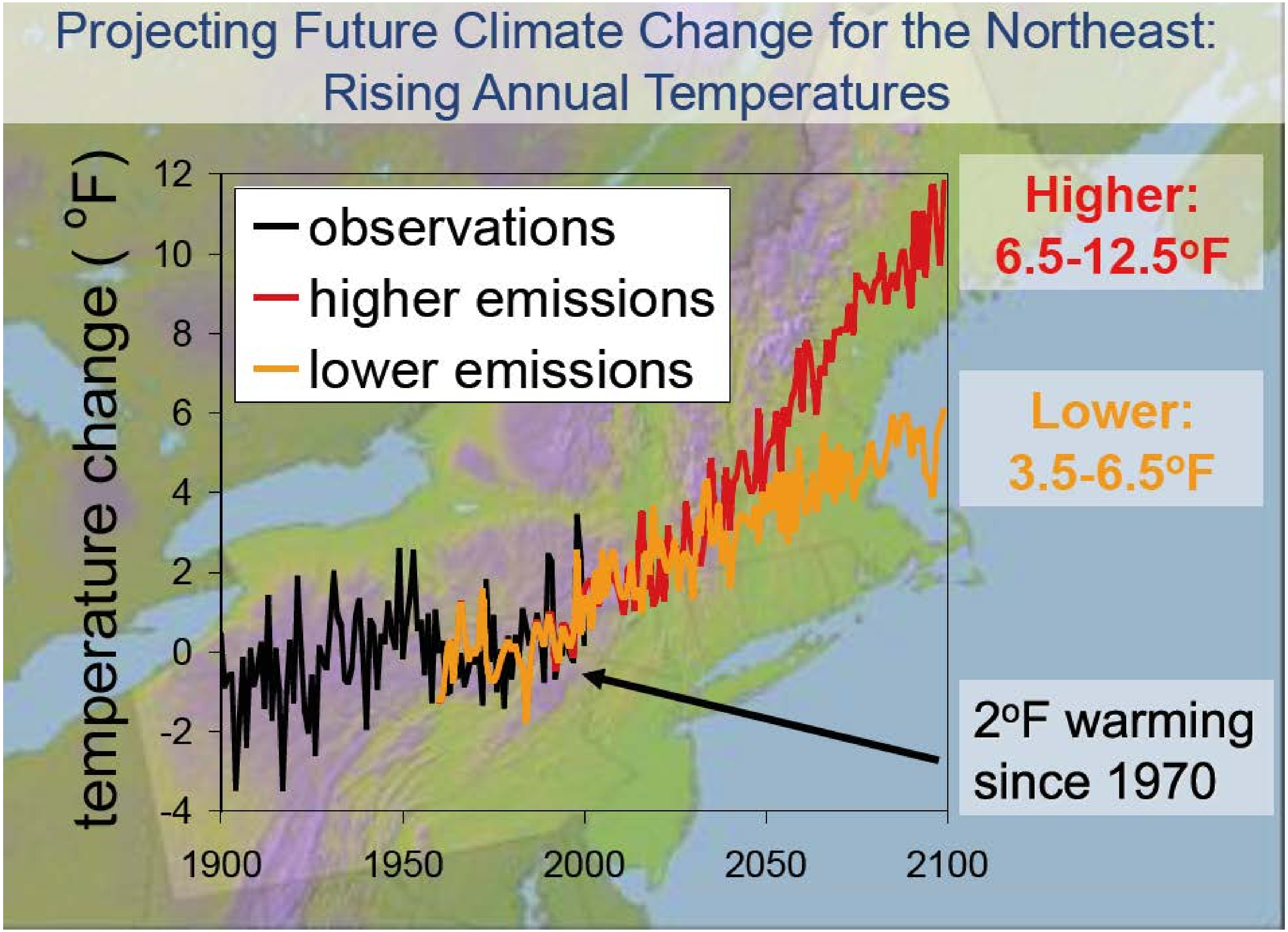
- Winter warming
- Decreased snowfall
- Fewer days with snow on ground
- Lake ice out dates earlier
- Earlier spring runoff
- More frequent extreme precipitation

Hodgkins et al., 2002; 2003; Wolfe et al., 2005;
Wake and Markham, 2005; Wake et al., 2006; Burakowski & Wake 2008

What is "Likely"



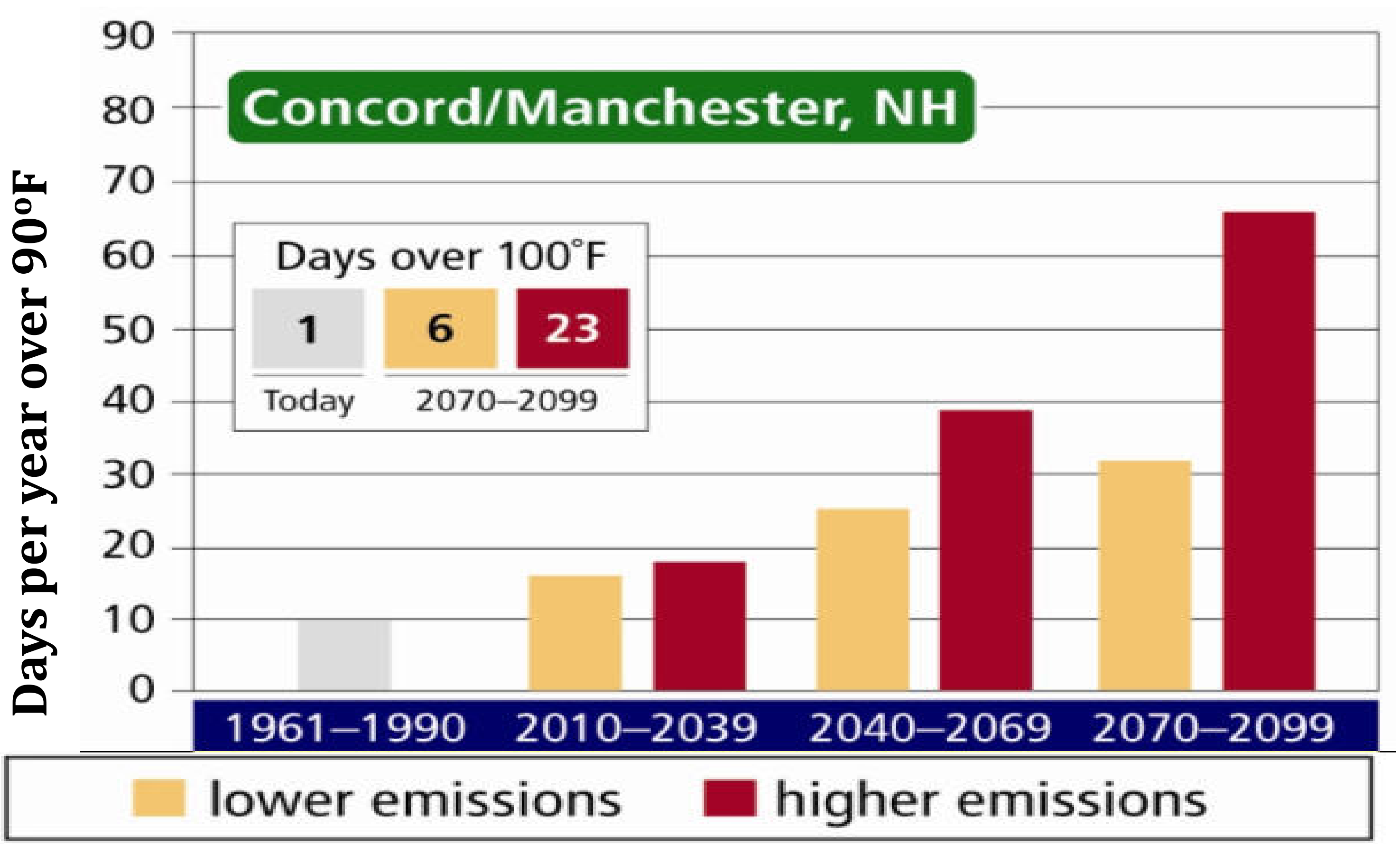
Hayhoe et al 2006



Projecting Future Climate Change for the Northeast:
Rising Annual Temperatures
temperature change (°F)
12
10
8
6
4
2
0
-2
-4
1900
1950
2000
2050
2100
observations
higher emissions
lower emissions
Higher:
6.5-12.5°F
Lower:
3.5-6.5°F
2°F warming
since 1970

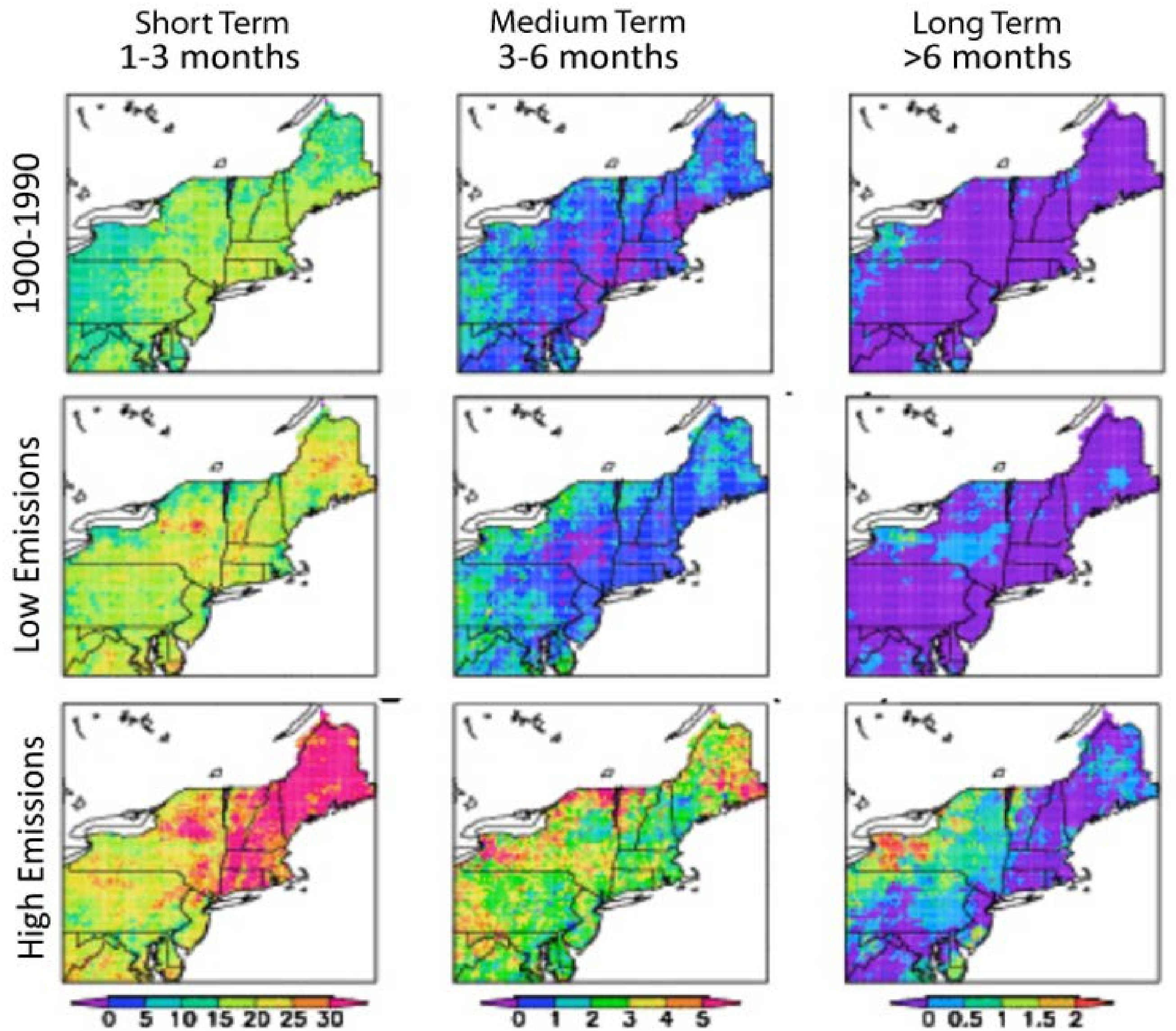
Wake, 2010

Projections of Climate Change in New Hampshire



Hayhoe et al. 2009

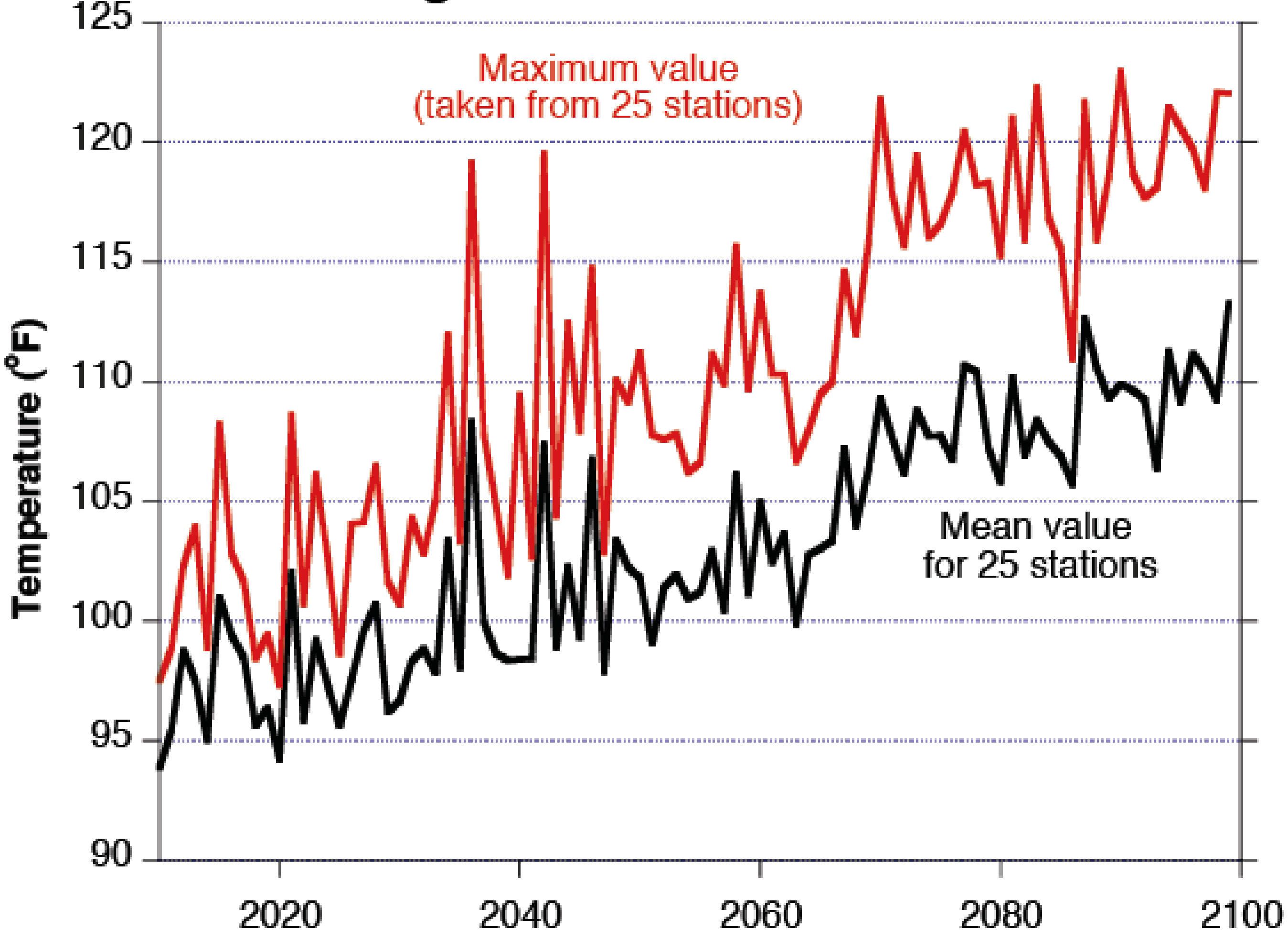
Frequency of Annual Droughts of Varying Length



Number of droughts

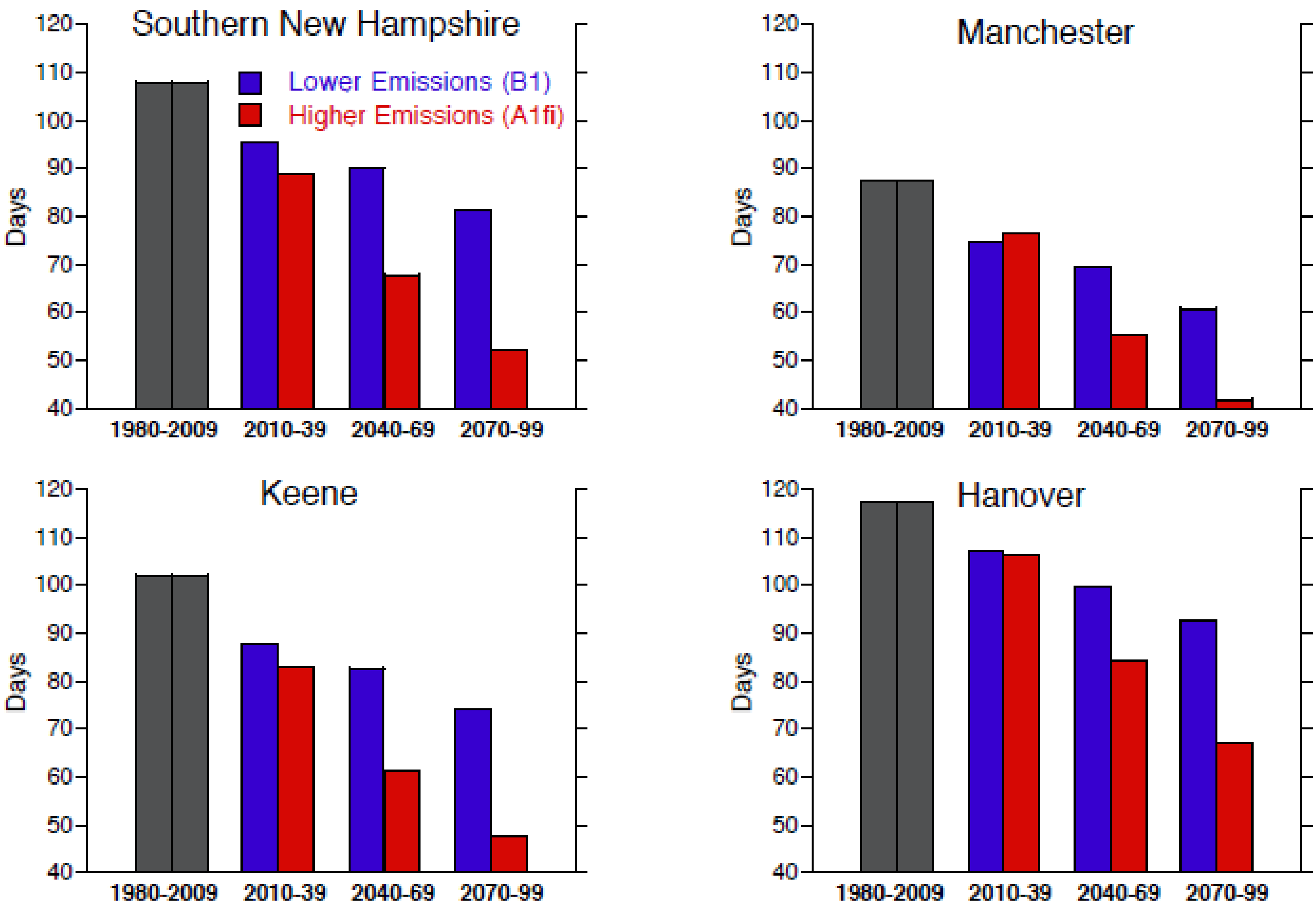
Hayhoe et al 2006

Projected Hottest Day of the Year in S. New Hampshire
High Emissions Scenario



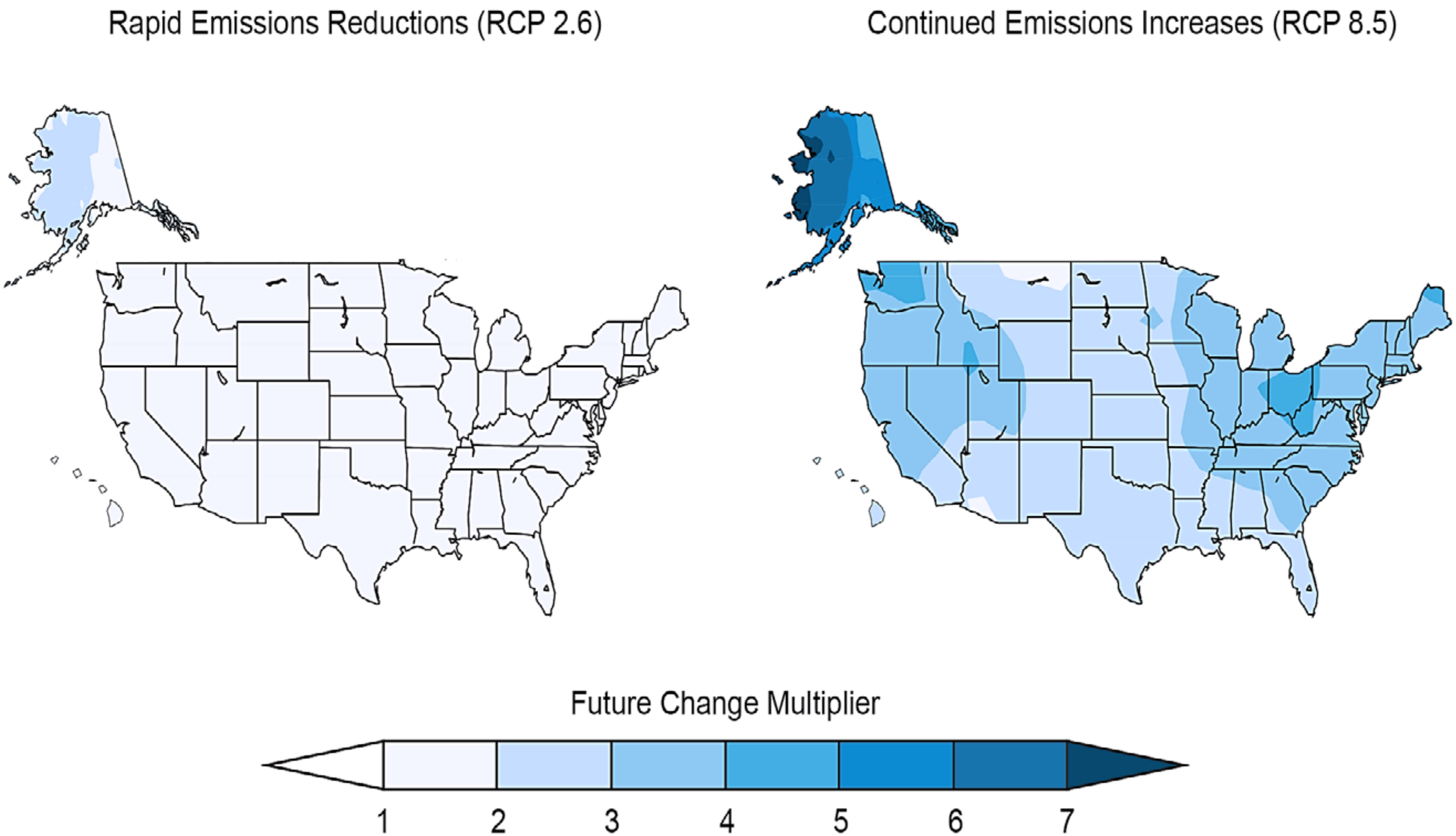
Wake 2013

Snow Covered Days (30 yr averages)



Wake 2013

Projected Increase Probability of Extreme Rainfall Events



NCA 3 2014

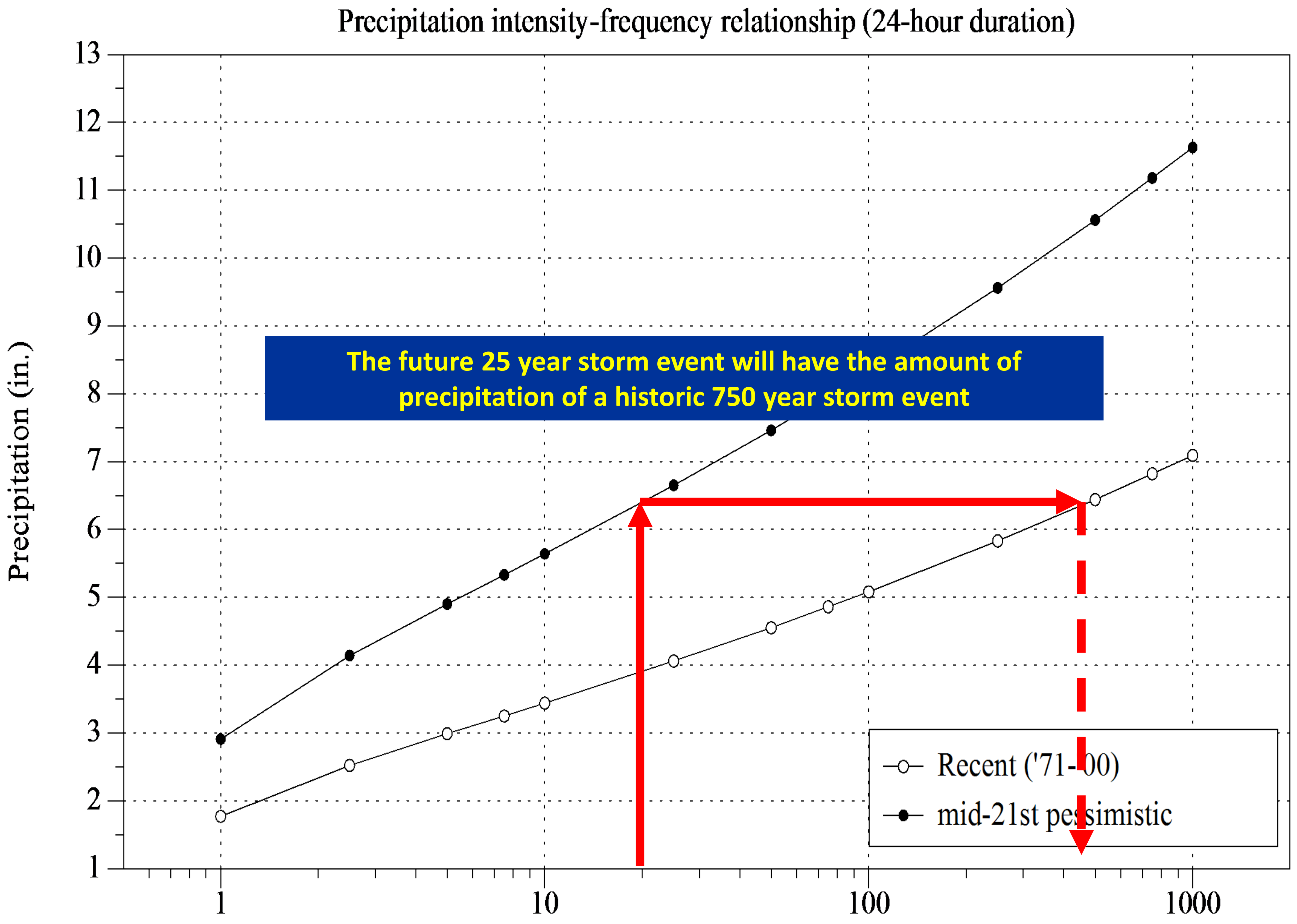
Return Period and Probability

Design Rainfall Amounts (inches)	Percentage Chance of Annual Rainfall	Return Period (year storm)
2.50	100%	1
2.80	40%	2.5
3.60	20%	5
3.80	13.33%	7.5
4.10	10%	10
4.80	4%	25
5.40	2%	50
5.70	1.33 %	75
6.00	1%	100

Oyster River Basin Study

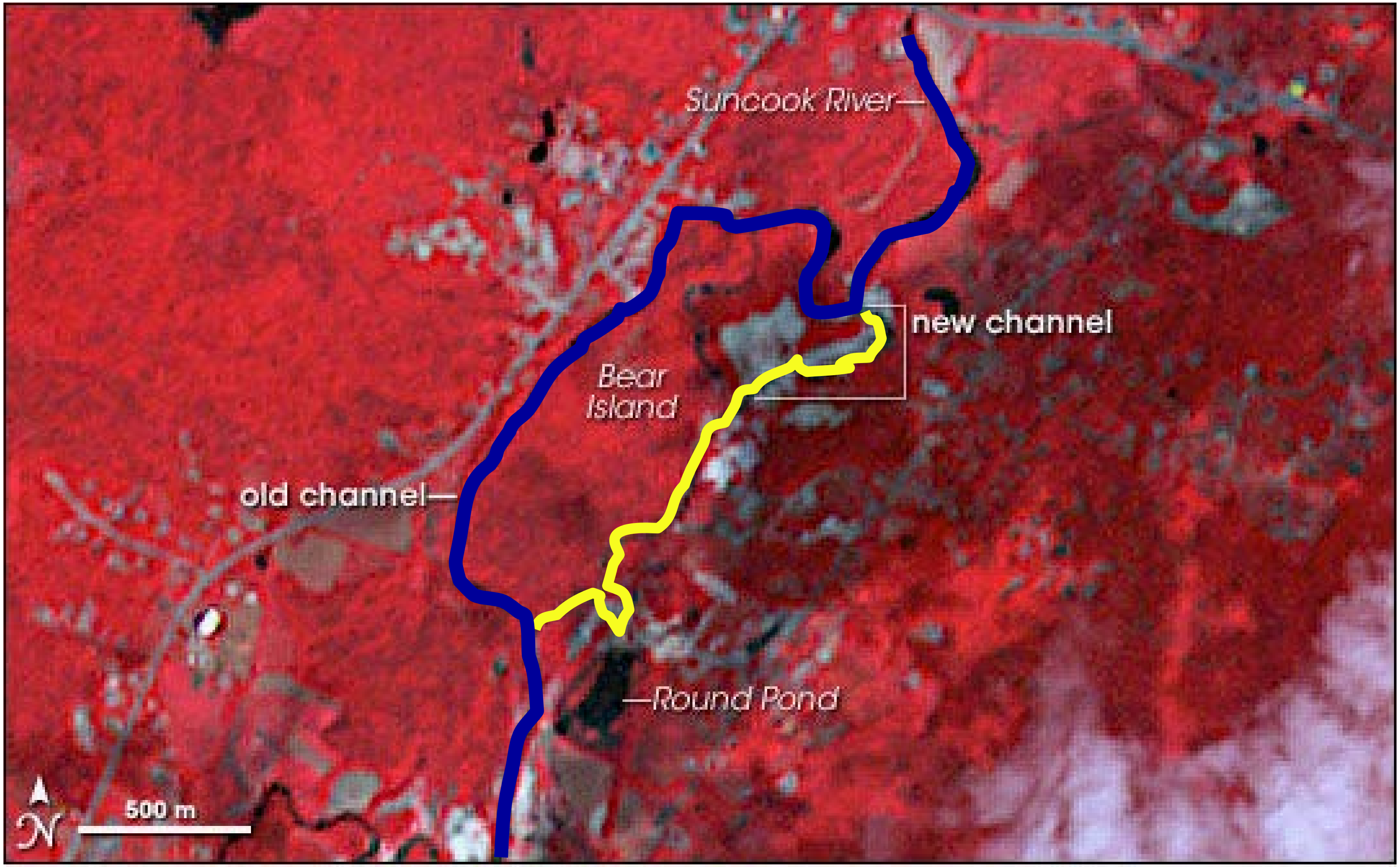
Return Period : Current and Future

Return period (years)	Recent climate	mid-21st cent. Optimistic	mid-21st cent. Moderate	mid-21st cent. Pessimistic
2.5	2.5	2.84	3.3	6.86
5	3.17	3.47	4.11	8.4
7.5	3.57	3.88	4.66	9.39
10	3.86	4.19	5.1	10.13
25	4.84	5.28 9%	6.74 32%	12.75 163%
50	5.67	6.22	8.31	15.03
75	6.2	6.82	9.39	16.5
100	6.59	7.27	10.23	17.59

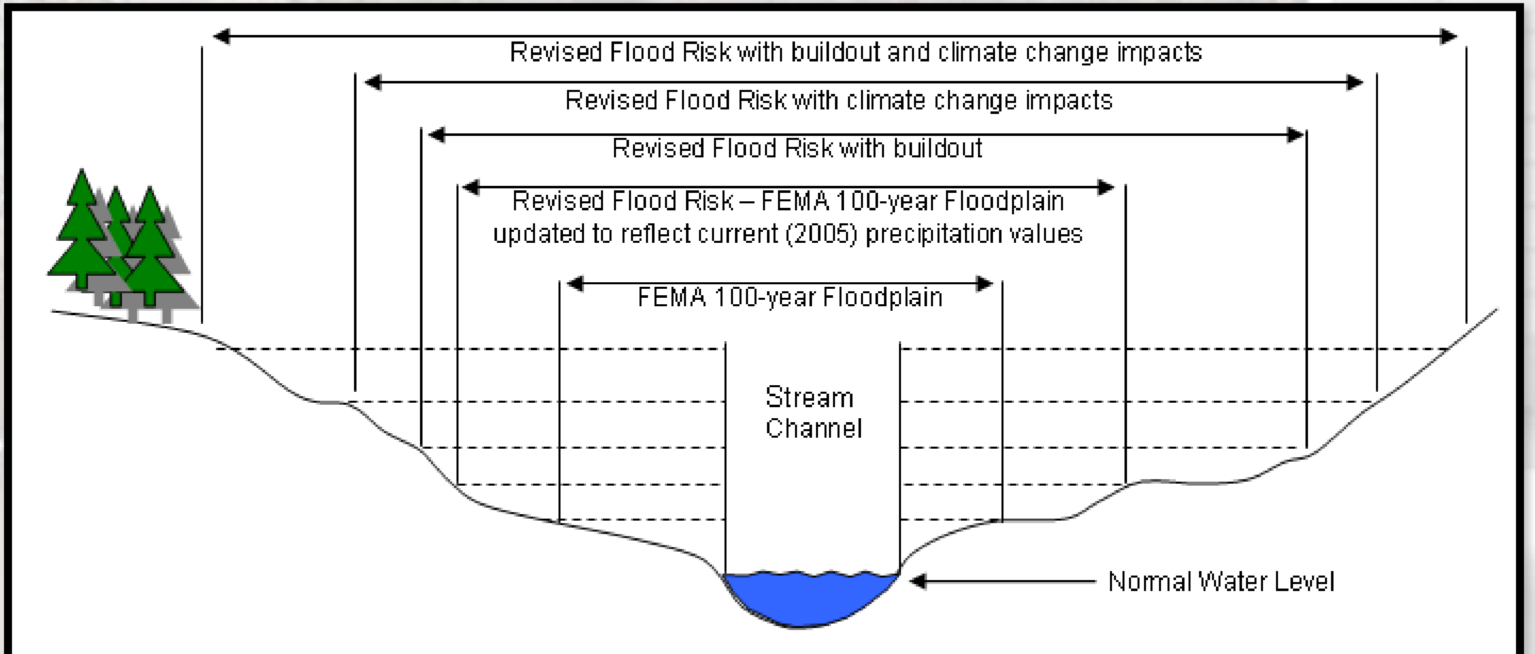


Simpson & Stack 2011

Increased Frequency of Flooding

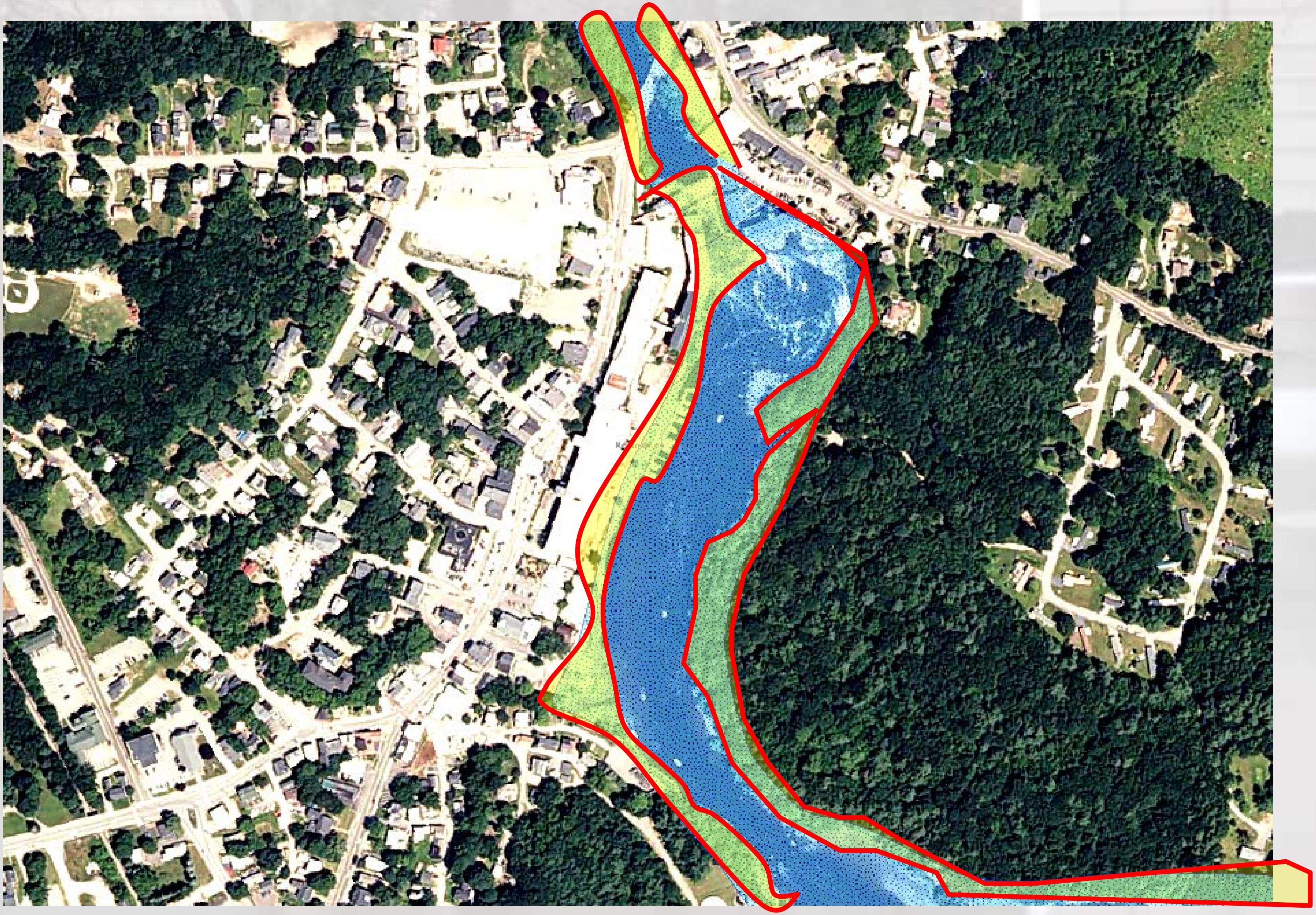

Suncook River
new channel
Bear Island
old channel
Round Pond
500 m
N

Lamprey River 100 Year Flood Risk Project

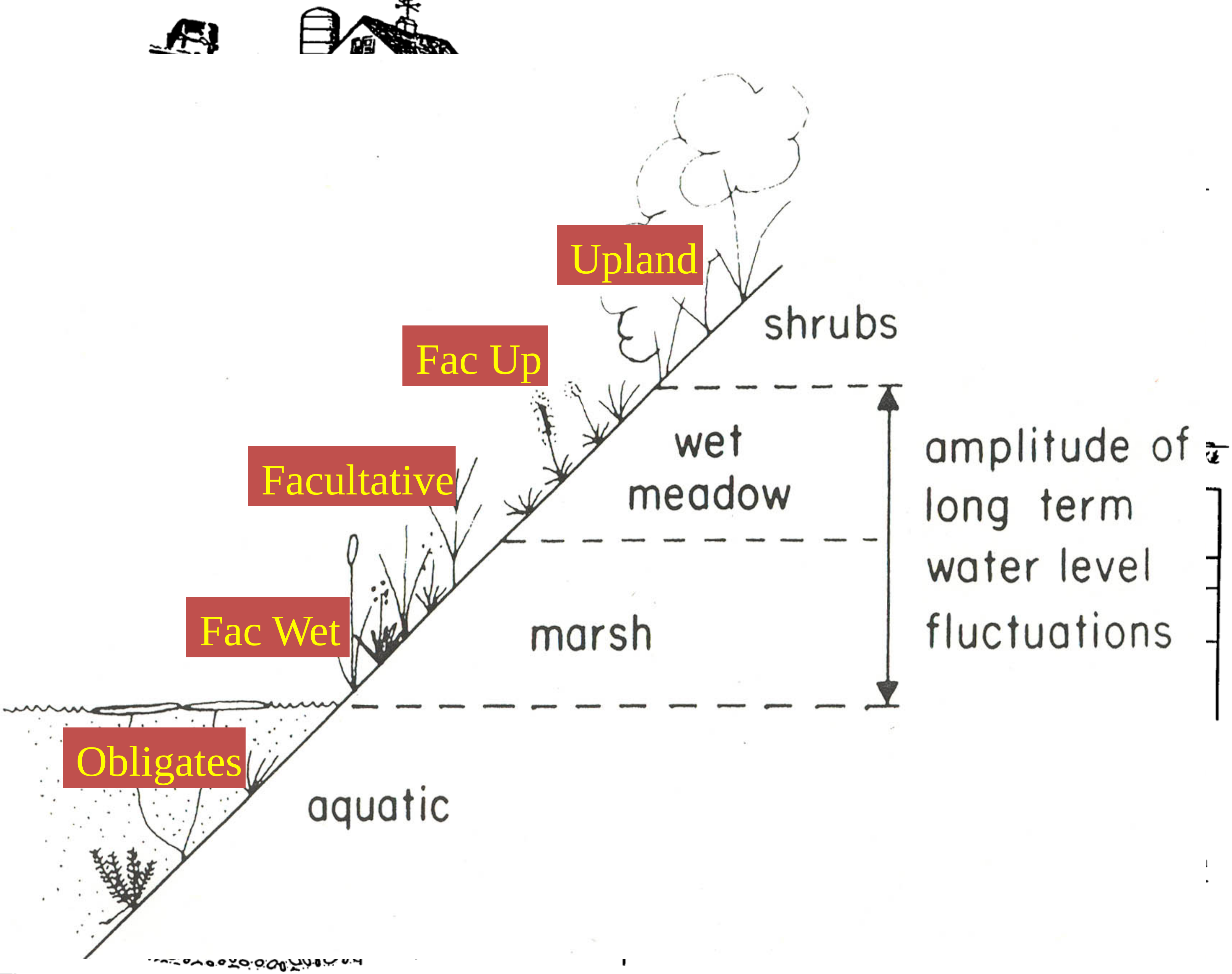


Land Use Condition	Climate Period and GCM Scenario					
	FIS Conditions 1981	1988-2007	2041-2070		2071-2100	
			A1F1 (HI)	B1 (LO)	A1F1 (HI)	B1 (LO)
FIS Conditions 1981	X	X				
Current Conditions(2005)		X	X	X	X	X
Build-out conditions		X	X	X	X	X
LID/build-out		X	X	X	X	X

Current Newmarket 100 Year Floodplain

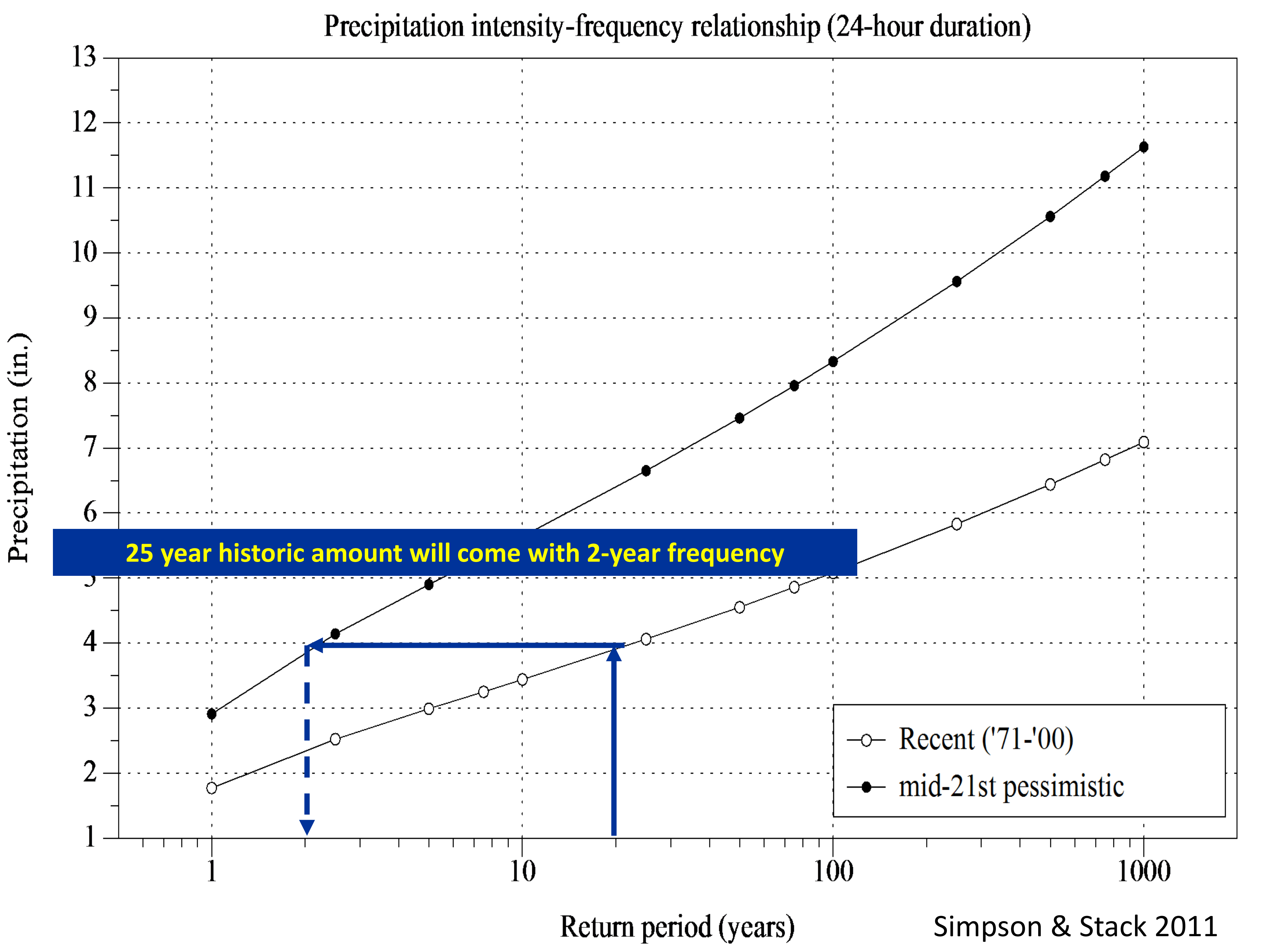


Wake, Rosseen & Simpson 2012

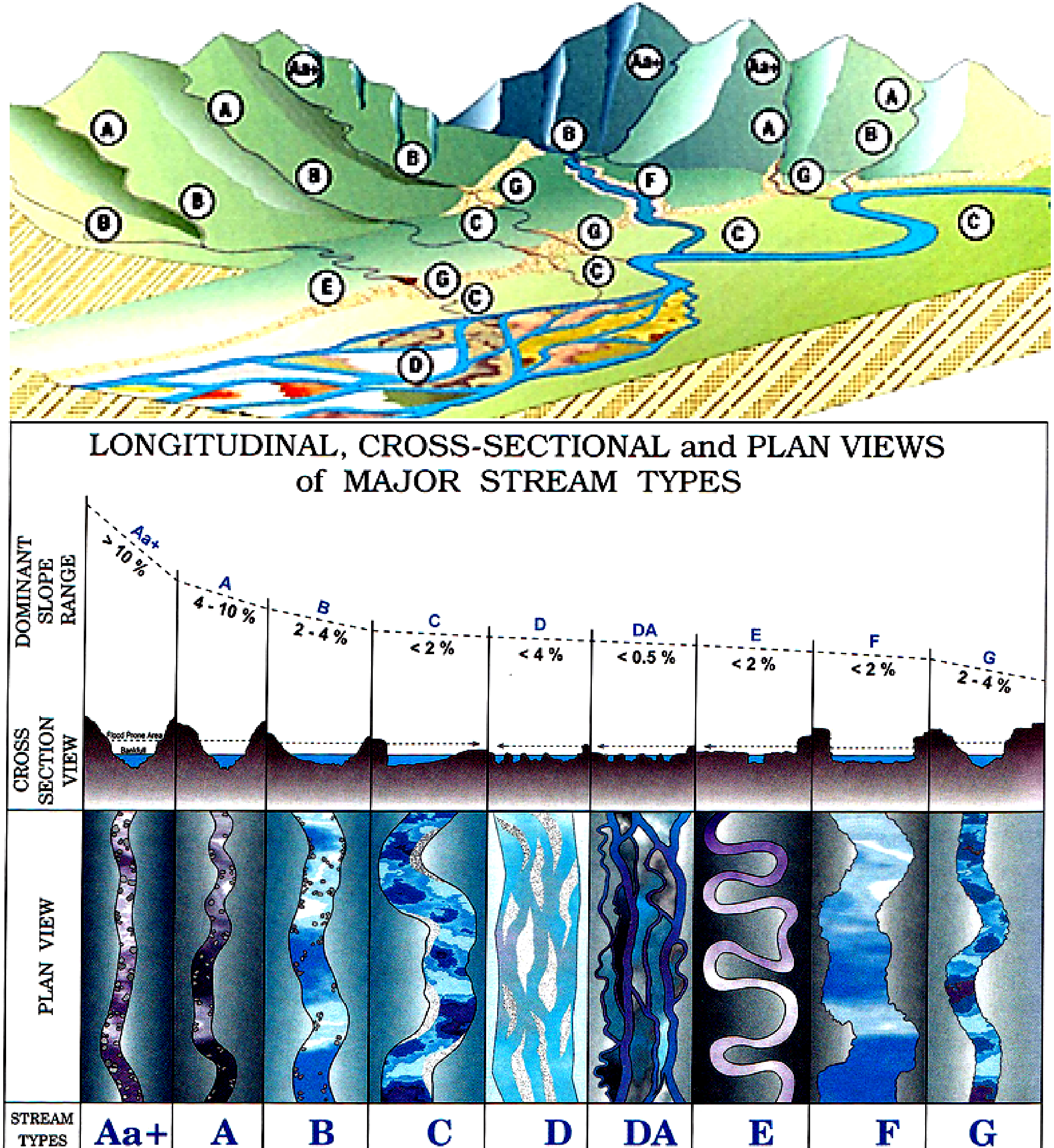


Upland
Fac Up
Facultative
Fac Wet
Obligates
shrubs
wet
meadow
marsh
aquatic
amplitude of
long term
water level
fluctuations



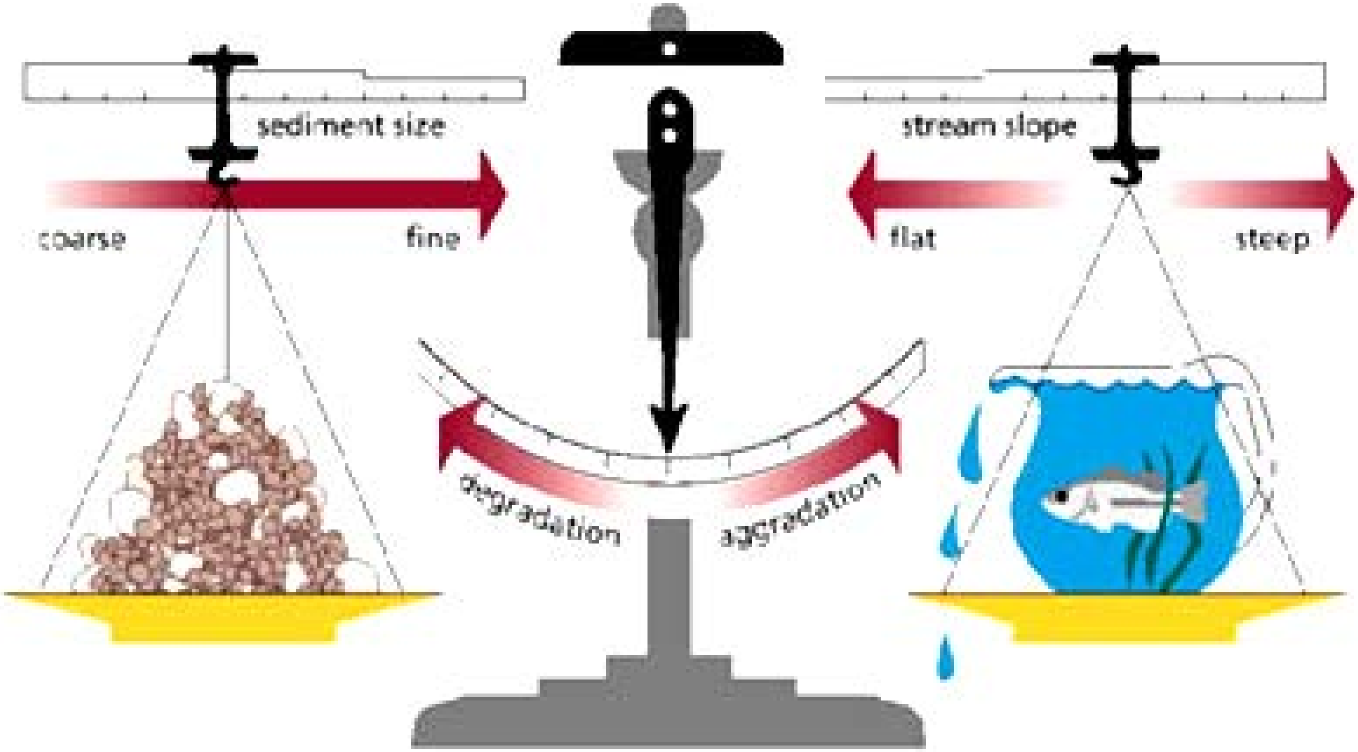



Simpson & Stack 2011



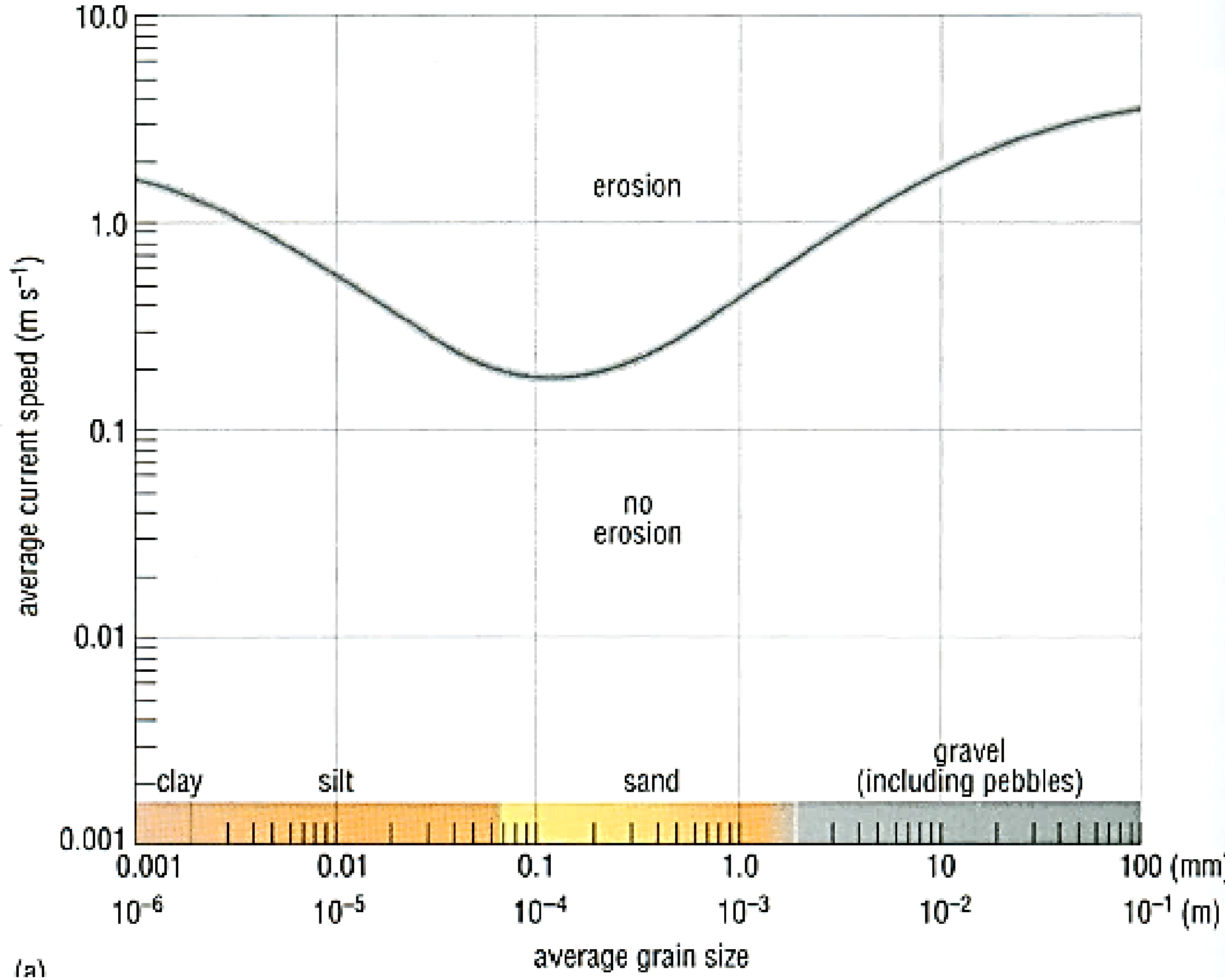
Aa+
A
B
C
D
E
F
G
LONGITUDINAL, CROSS-SECTIONAL and PLAN VIEWS
of MAJOR STREAM TYPES
DOMINANT SLOPE RANGE
Aa+
> 10 %
A
4 - 10 %
B
2 - 4 %
C
< 2 %
D
< 4 %
DA
< 0.5 %
E
< 2 %
F
< 2 %
G
2 - 4 %
CROSS SECTION VIEW
Flood Prone Area
Bankfull
PLAN VIEW
STREAM TYPES
Aa+
A
B
C
D
DA
E
F
G

Rosgen 1993

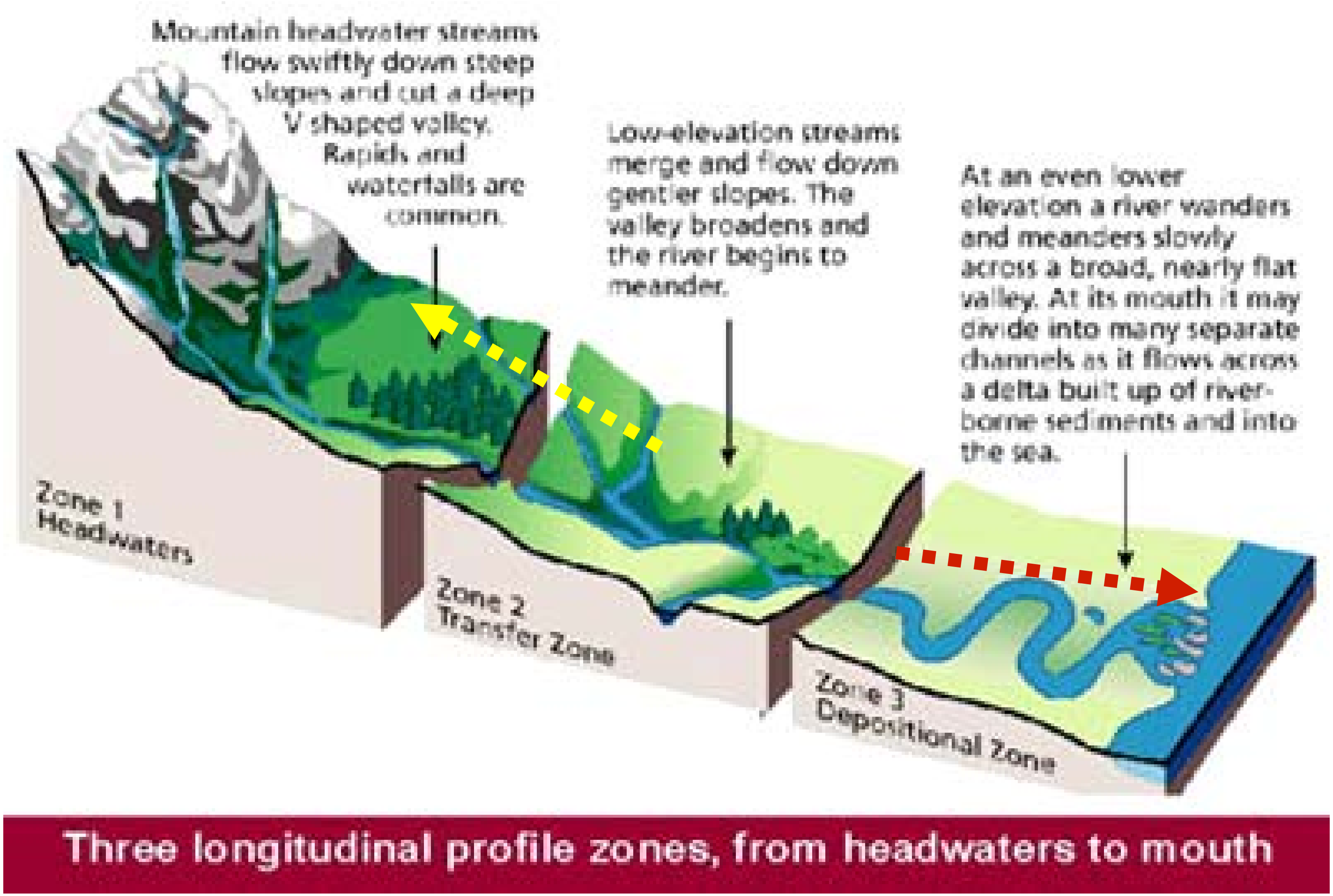


$$Q_s \cdot D_{50} \propto Q_w \cdot S$$

Factors affecting channel equilibrium. At equilibrium, slope and flow balance the size and quantity of sediment particles the stream moves.

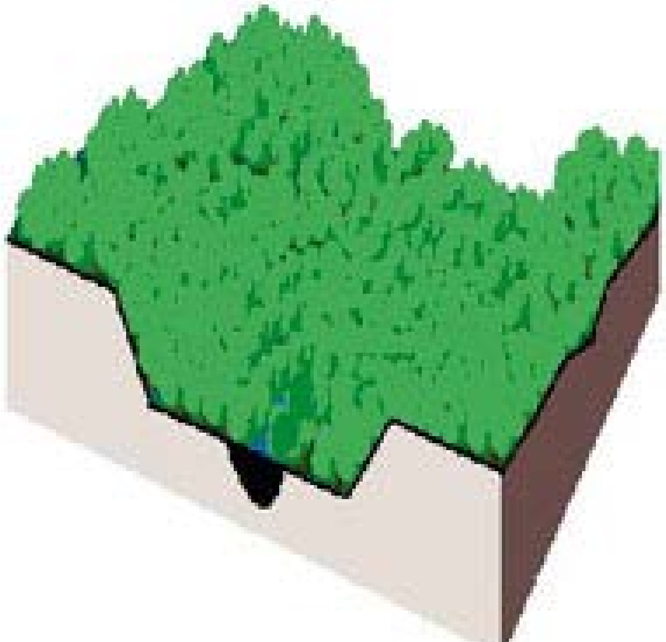


average current speed (m s^{-1})
10.0
1.0
0.1
0.01
0.001
erosion
no
erosion
clay
silt
sand
gravel
(including pebbles)
0.001
0.01
0.1
1.0
10
100 (mm)
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1} (m)
average grain size
(a)

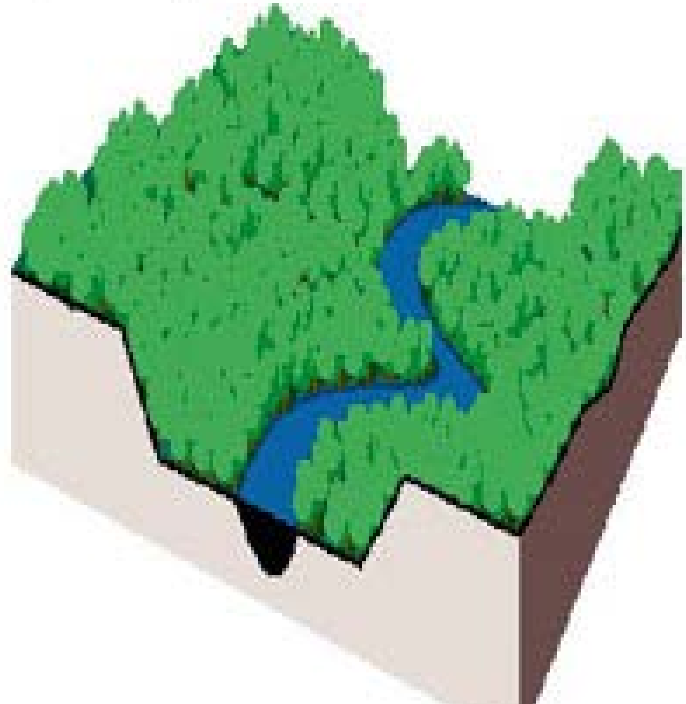

Mountain headwater streams flow swiftly down steep slopes and cut a deep V shaped valley. Rapids and waterfalls are common.
Low-elevation streams merge and flow down gentler slopes. The valley broadens and the river begins to meander.
At an even lower elevation a river wanders and meanders slowly across a broad, nearly flat valley. At its mouth it may divide into many separate channels as it flows across a delta built up of river-borne sediments and into the sea.
Zone 1 Headwaters
Zone 2 Transfer Zone
Zone 3 Depositional Zone
Three longitudinal profile zones, from headwaters to mouth

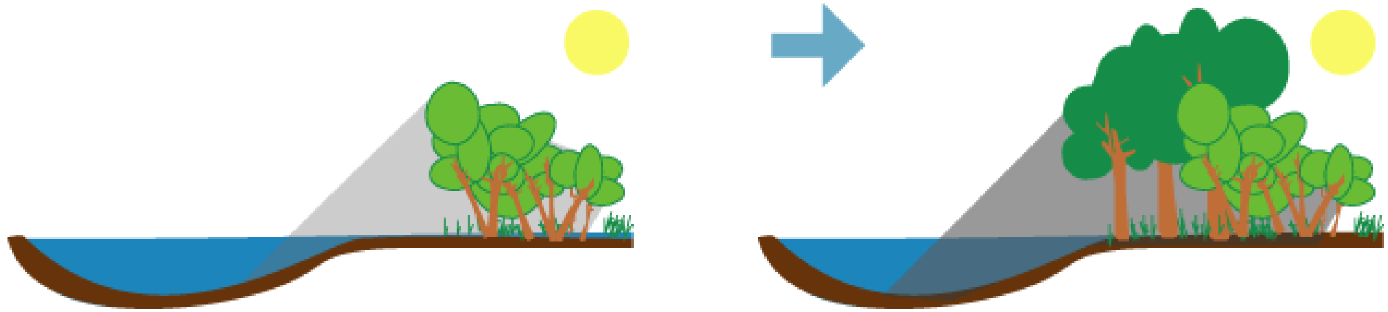
US EPA

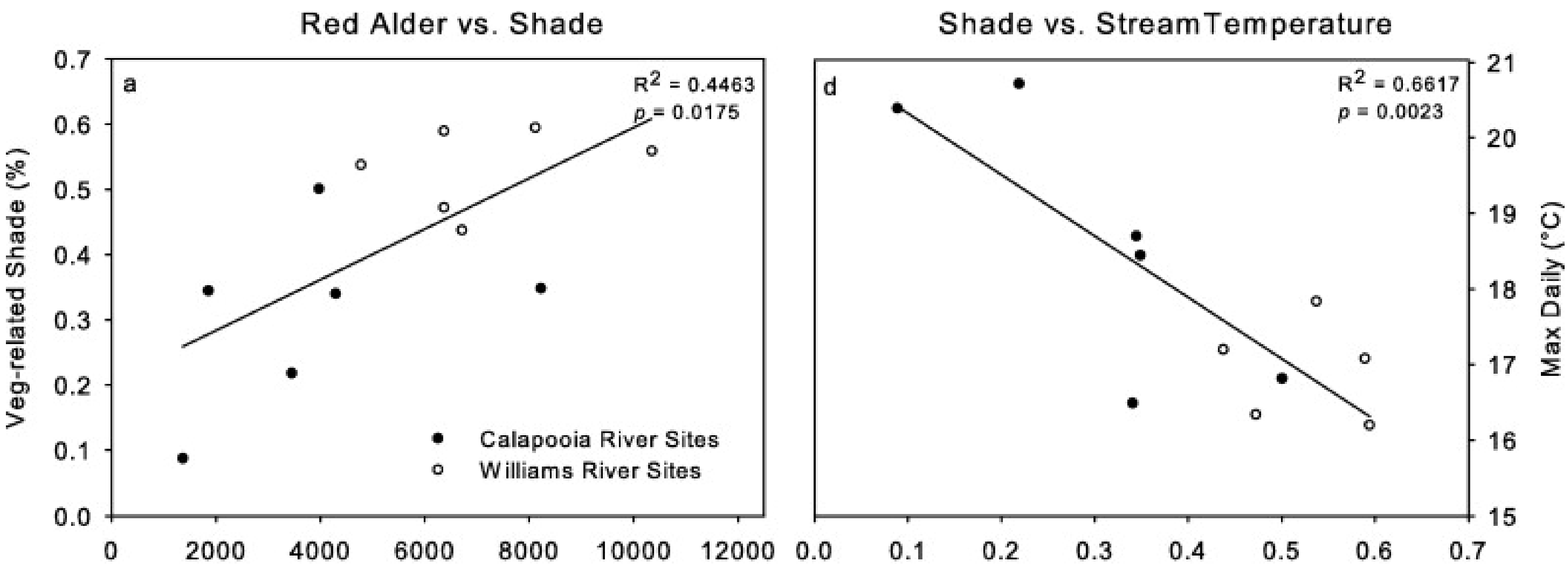
Closed Canopy Over Channel, Floodplain, and Transitional Upland Fringe



Open Canopy Over Channel





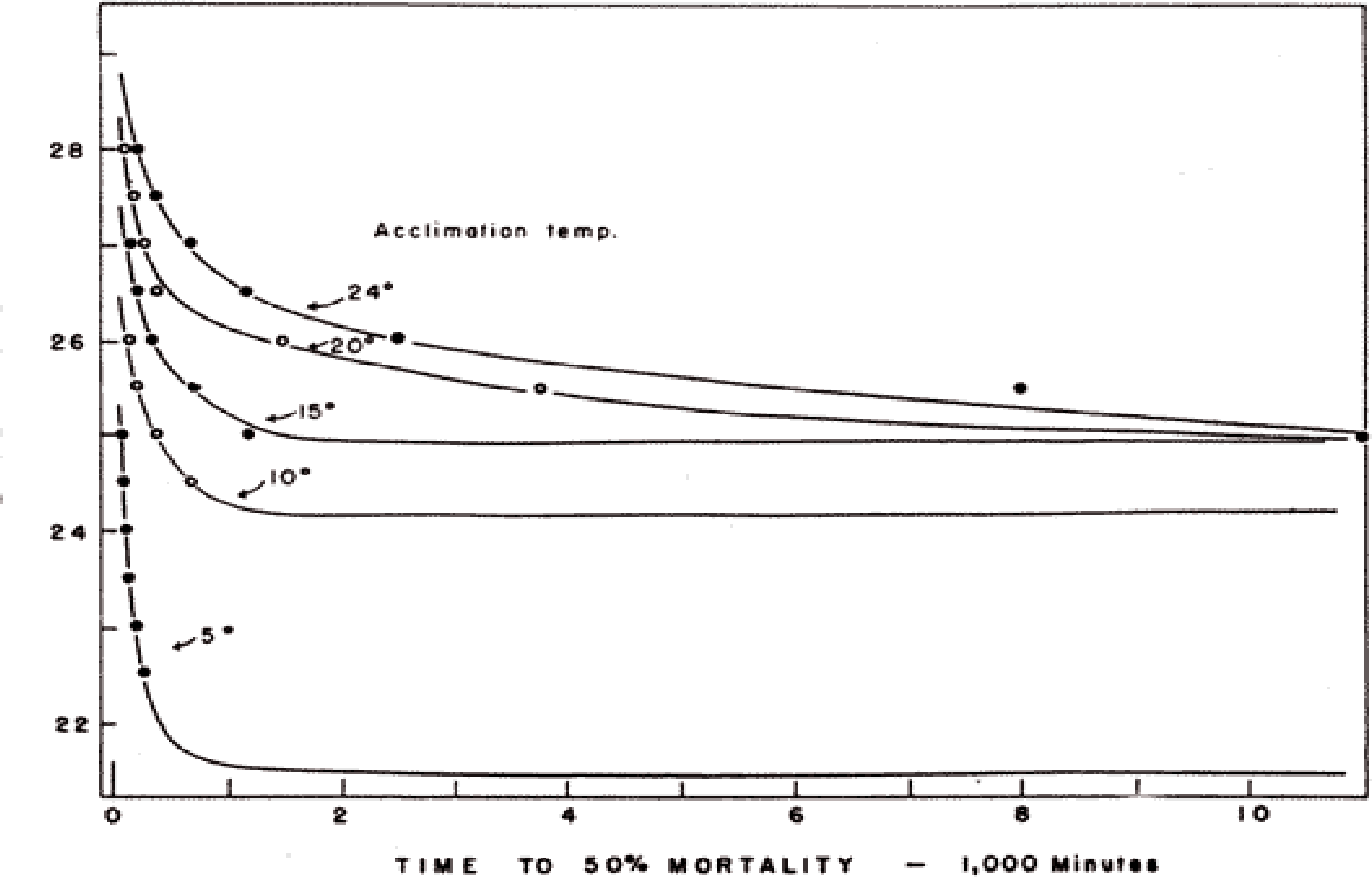


Cristea & Janisch, 2007

Blacknose Dace

Tesselated Darter

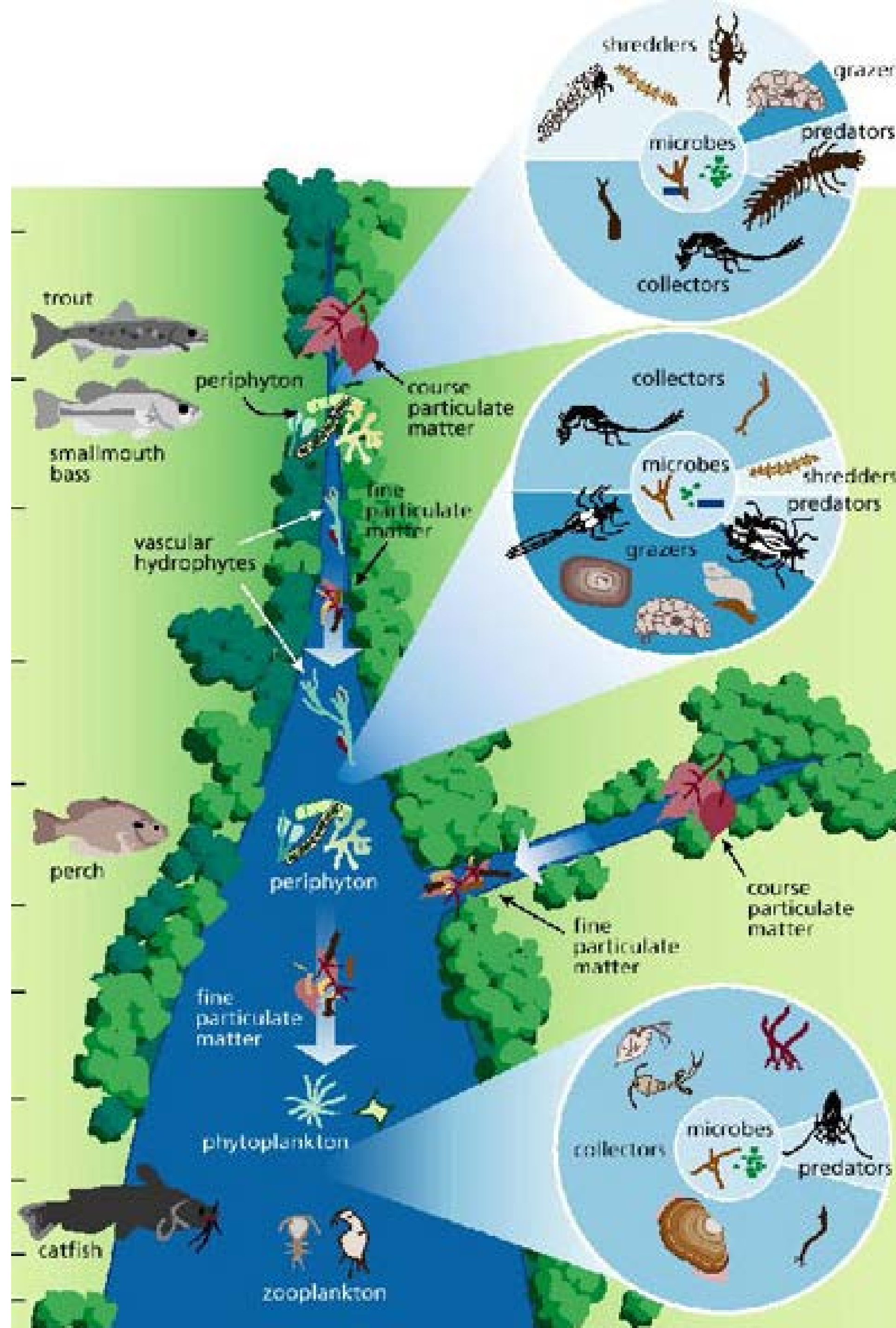
Brook Trout

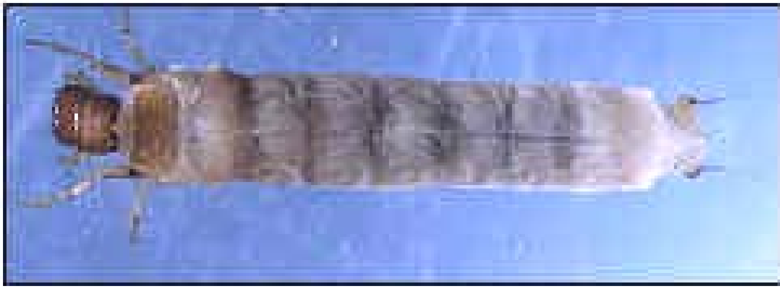


IGURE 4a. Median resistance times to high temperatures among young spring salmon acclimated to temperatures indicated. Plotted on arithmetic axes.

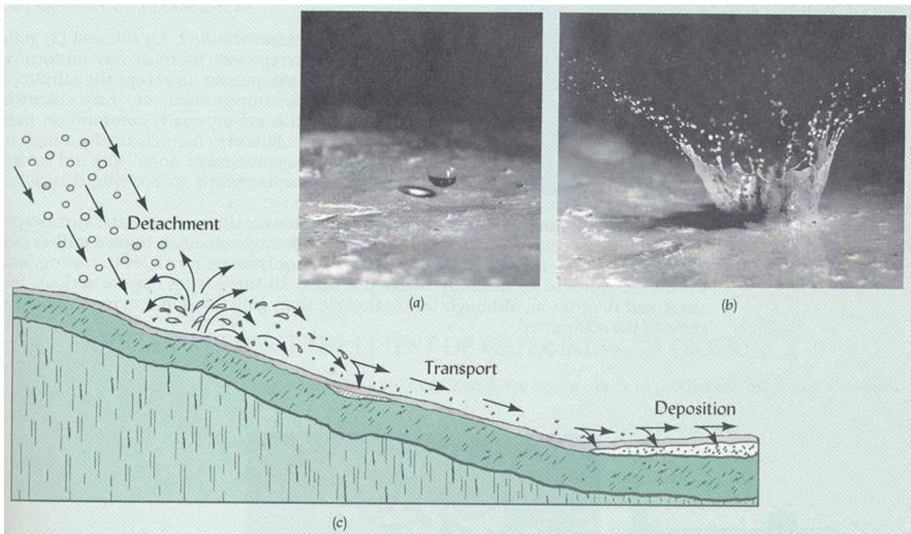
Steinhausen et al 2008


© thomasfitzgeraldphotography


shredders
grazers
microbes
predators
collectors
trout
periphyton
course
particulate
matter
smallmouth
bass
collectors
microbes
shredders
predators
fine
particulate
matter
vascular
hydrophytes
grazers
perch
periphyton
course
particulate
matter
fine
particulate
matter
fine
particulate
matter
microbes
collectors
predators
phytoplankton
catfish
zooplankton




Increase in **intensity** and **frequency** of greater rainfall amounts will translate to:



- Smaller proportion of total rainfall depth will be used to wet soils
- Resulting in an exponential decrease in soil infiltration during such events
- Soil surface roughness will decreased
- Soil ponding volume will decrease
- Resulting in a disproportional rate of run-off

The ratio of erosion increase to increase in precipitation is on the order of

1.7 times

Nearing et al 2004

SCS Soil Loss Procedure (rUSLE)

$$A = (R)(K)(LS)(C)(P)$$

A = Soil Loss (Tons/Year)

R = rainfall erosivity index

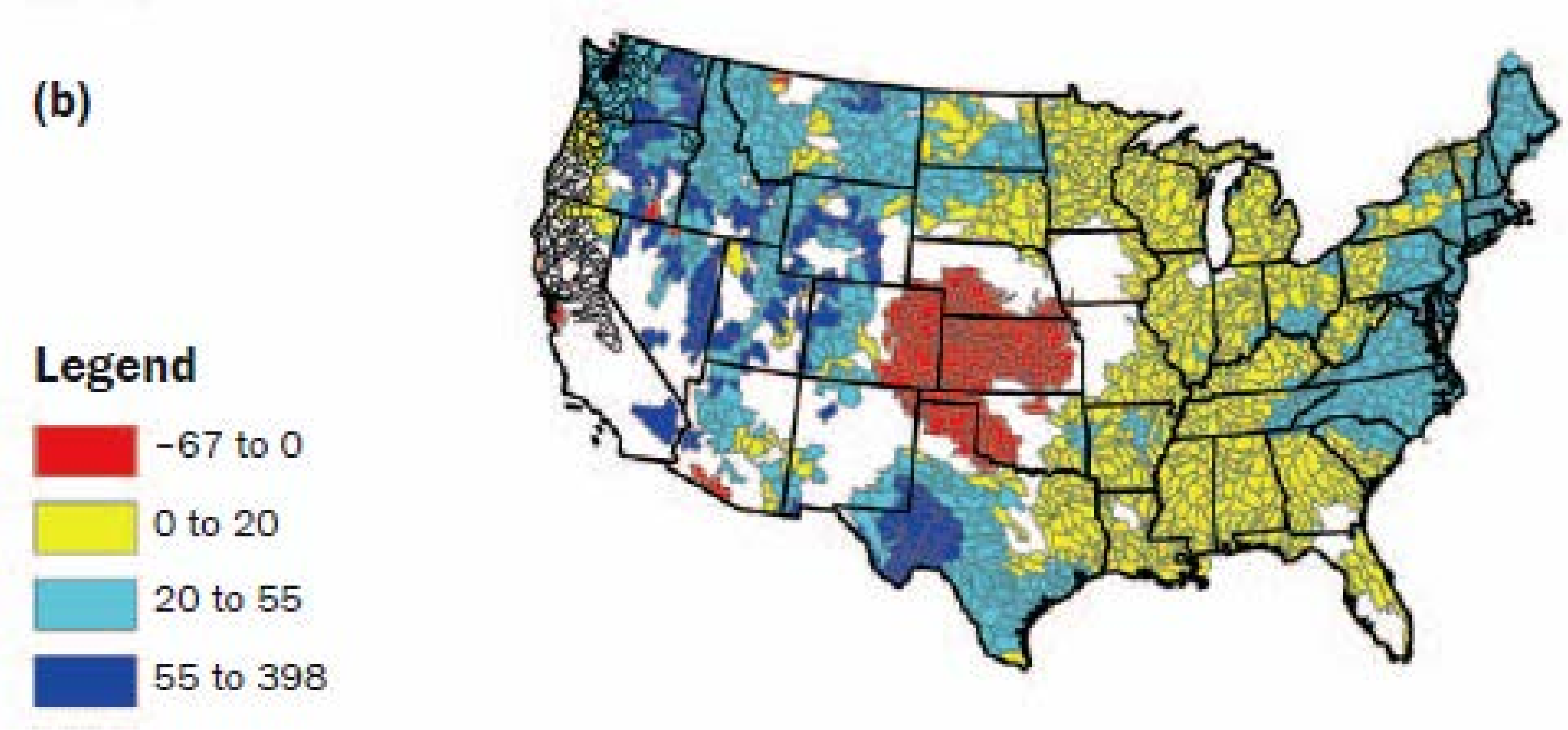
K = soil erodability

LS = length/slope index

C = cropping-management factor

P = erosion-control practice factor

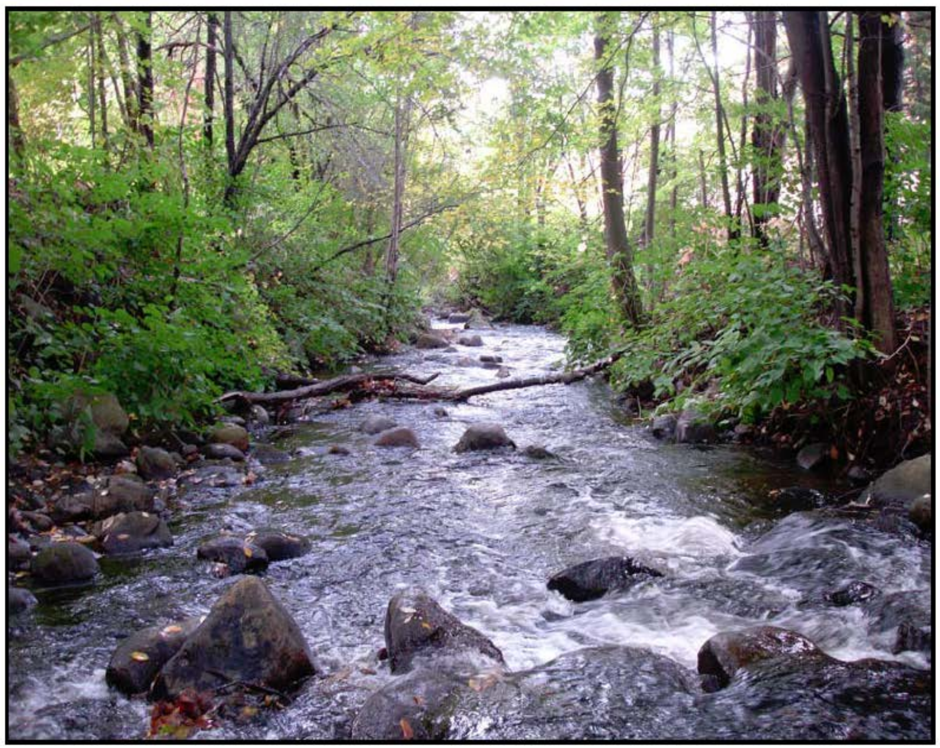
Percentage increase in mean erosivity (K factor) between 1970 to 2010 and 2050 to 2090,

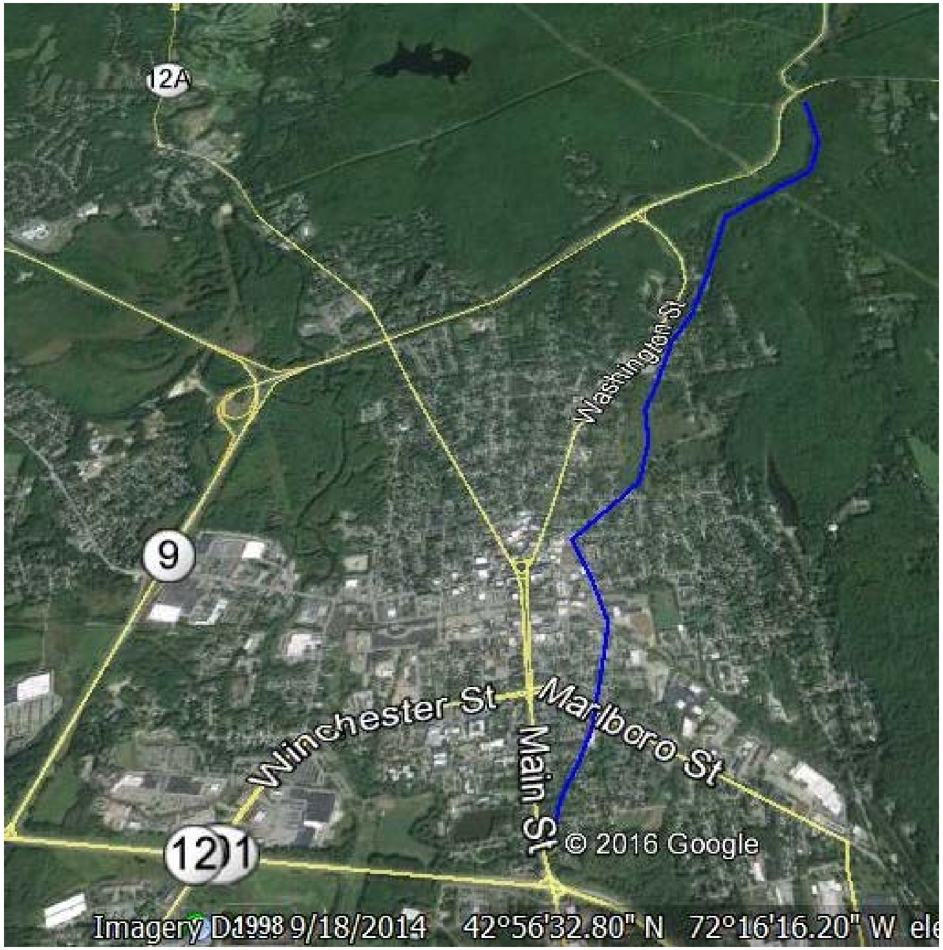


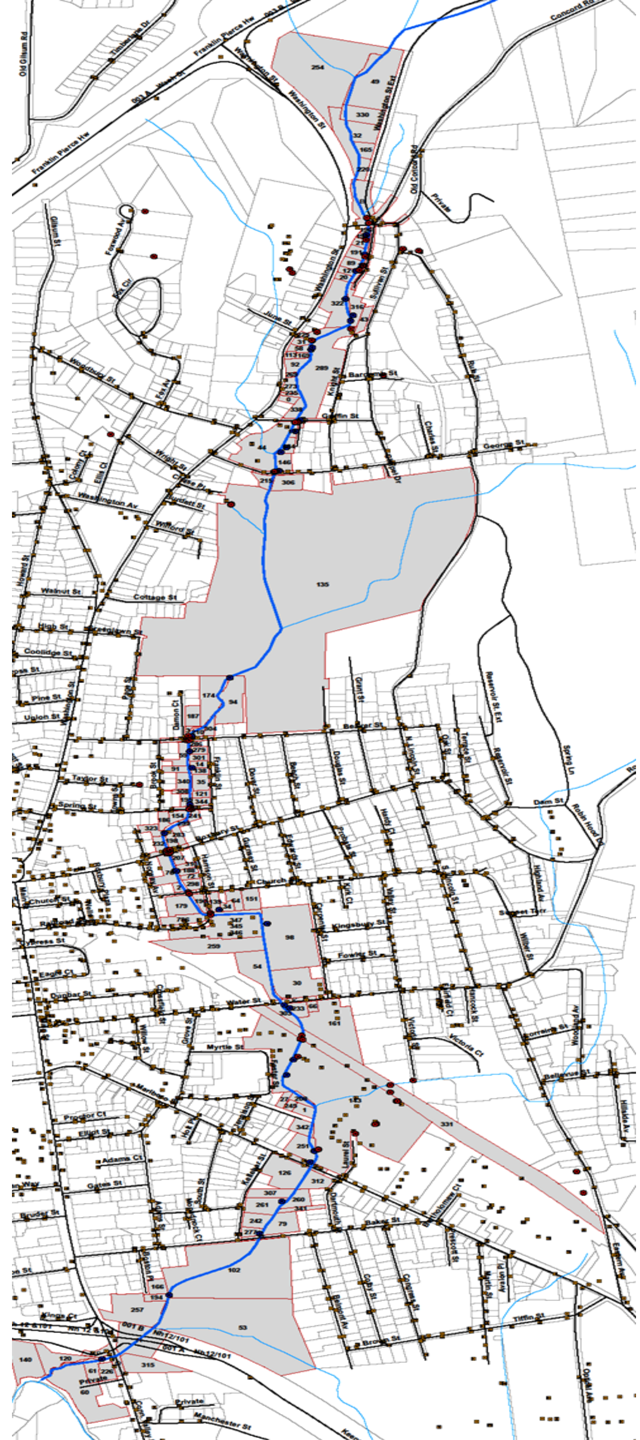
Segura et al 2014

BEAVER BROOK RESTORATION PLAN

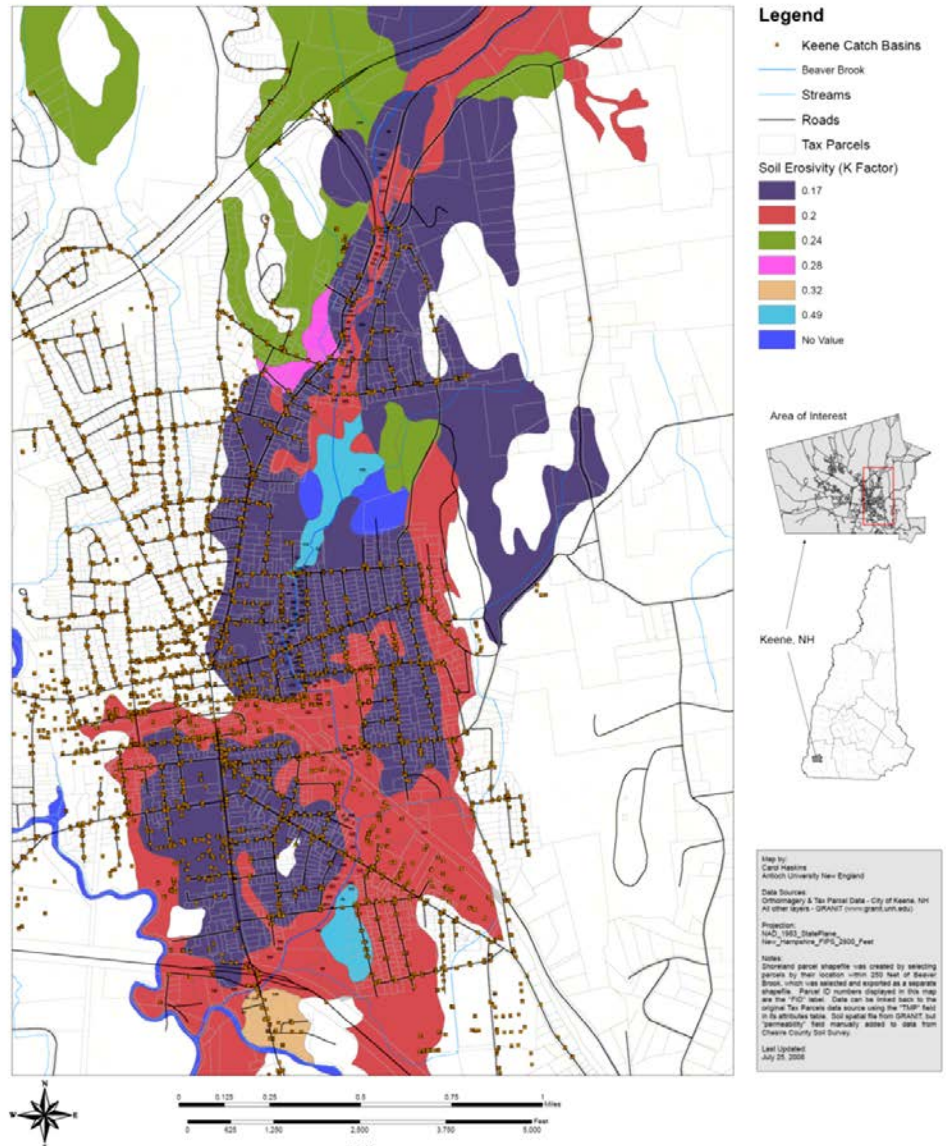
STREAM MORPHOLOGY, WILDLIFE HABITAT, AND LAND USE ASSESSMENT

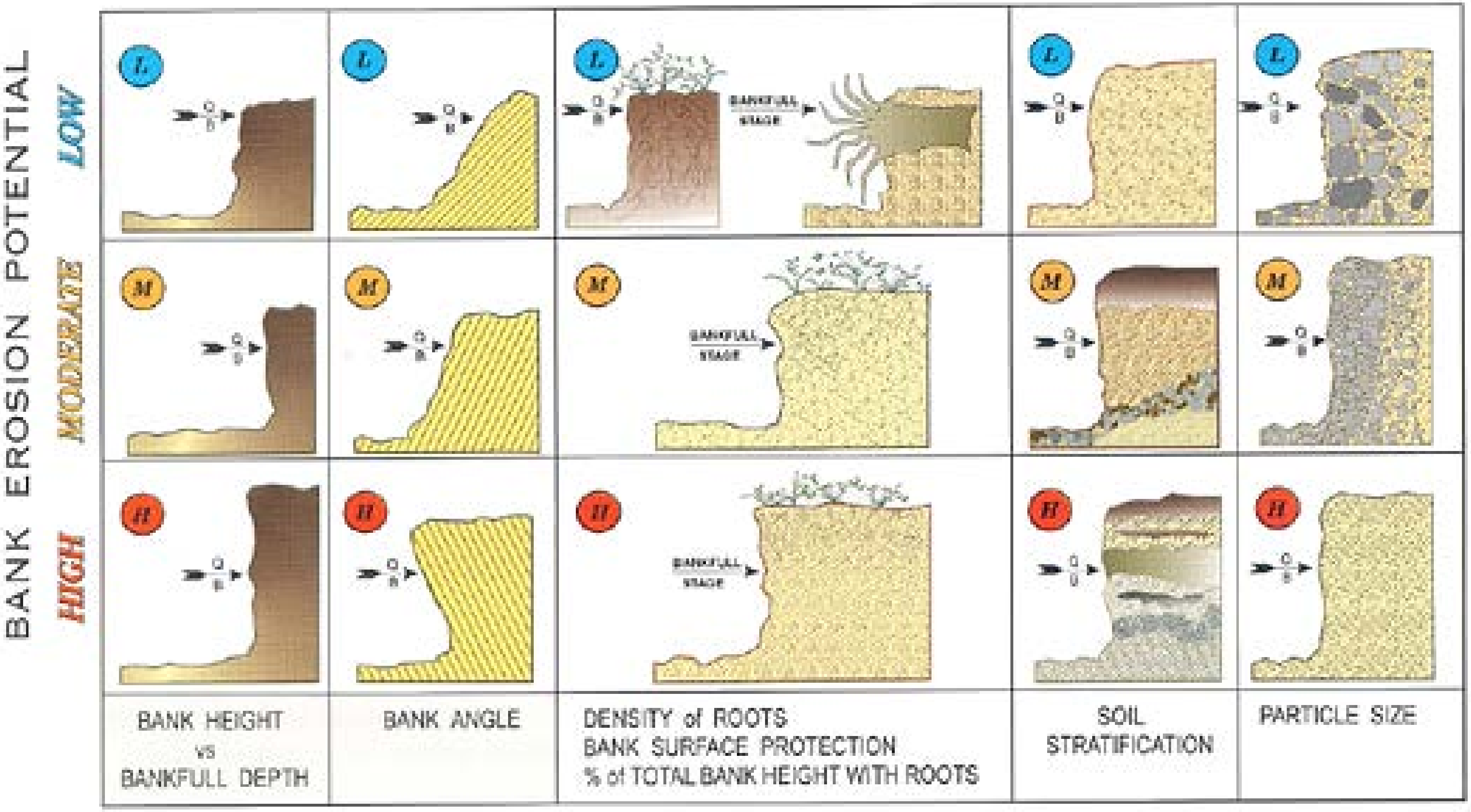



12A
9
Washington St
Winchester St
Marlboro St
Main St
12
© 2016 Google
Imagery Date: 9/18/2014 42°56'32.80" N 72°16'16.20" W

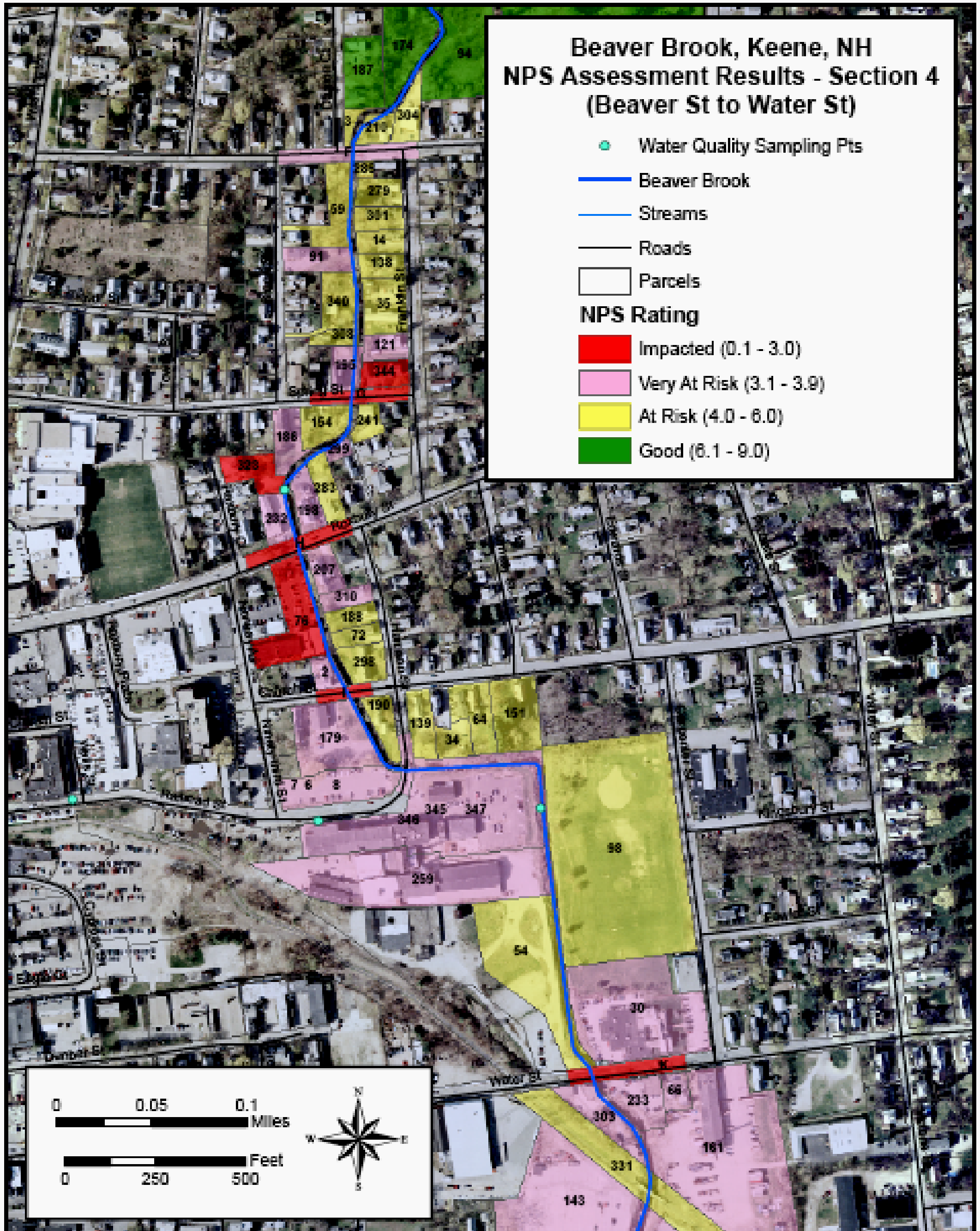


Beaver Brook, Keene, NH
Soil Erosivity (K-Factor)





Stream Bank Erodibility Factors
(Rosgen 1993d)

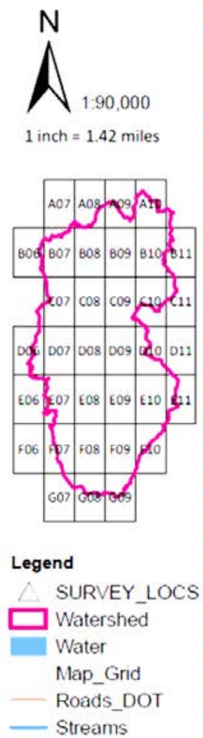

Beaver Brook, Keene, NH
NPS Assessment Results - Section 4
(Beaver St to Water St)
Water Quality Sampling Pts
Beaver Brook
Streams
Roads
Parcels
NPS Rating
Impacted (0.1 - 3.0)
Very At Risk (3.1 - 3.9)
At Risk (4.0 - 6.0)
Good (6.1 - 9.0)
0 0.05 0.1 Miles
0 250 500 Feet
Water St

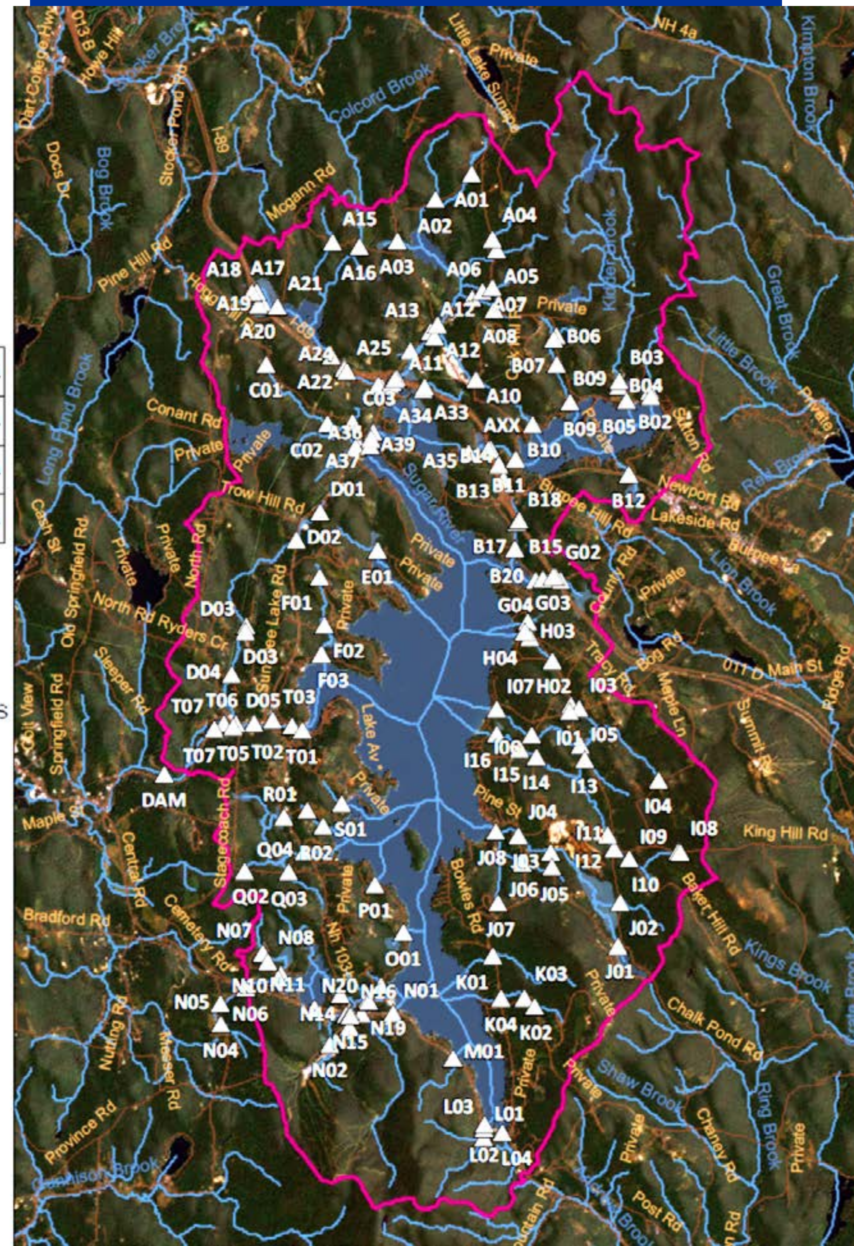
What Happens with Increased Flow at Road Crossings

Field Data Collection

210 road crossings

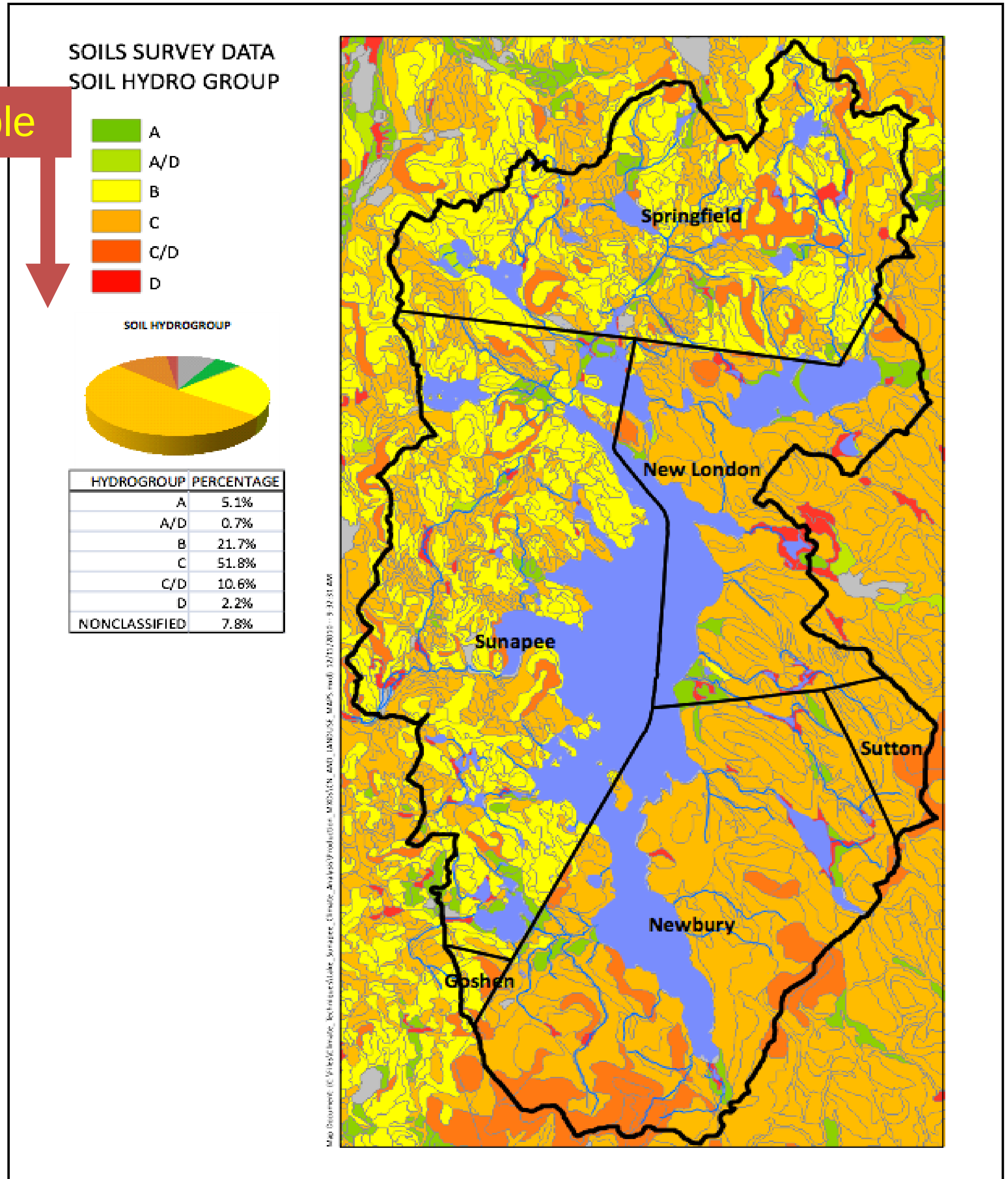
Field Atlas





Soil Type

Less permeable



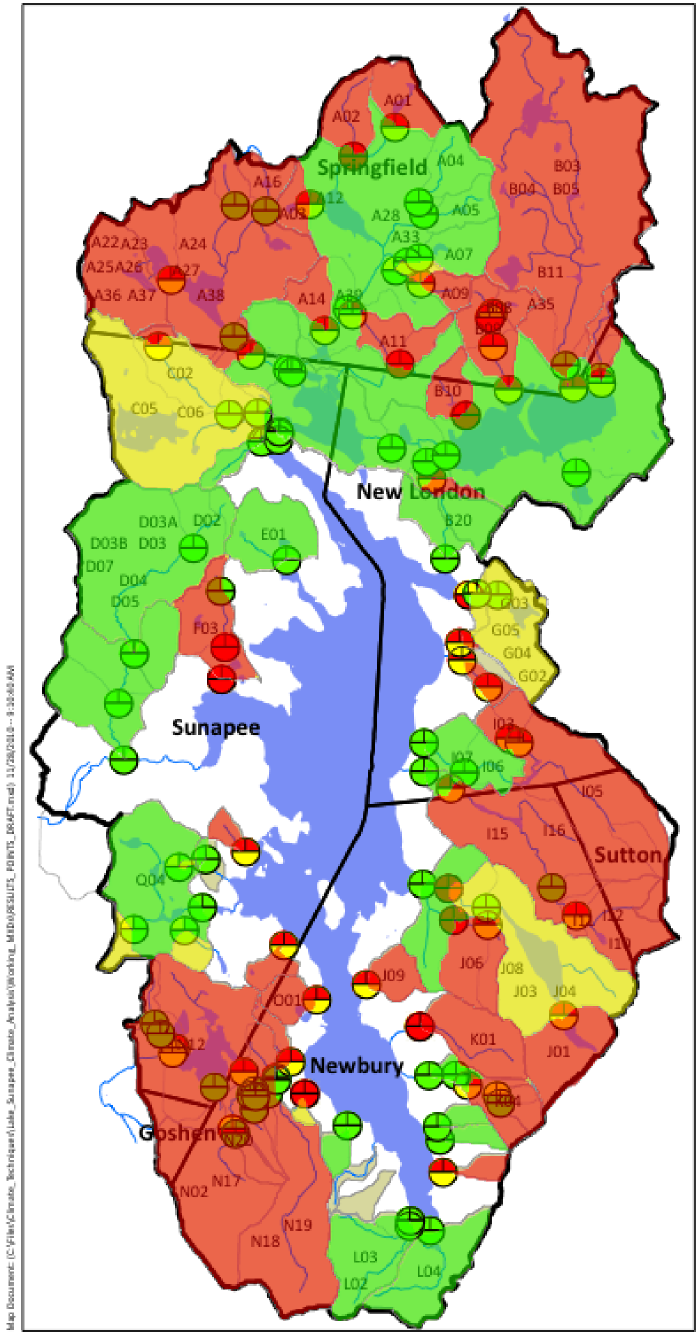
HYDROGROUP	PERCENTAGE
A	5.1%
A/D	0.7%
B	21.7%
C	51.8%
C/D	10.6%
D	2.2%
NONCLASSIFIED	7.8%

SYNTECTIC INTERNATIONAL

ANTIOCH UNIVERSITY NEW ENGLAND

Lake Sunapee watershed:

Spatial impact of undersized culverts



Mid-21st projected 25-yr storm:
35% of culverts undersized

REPLACE (YES, TRANS, or NO)

- YES
- TRANS
- NO

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SYNTECTIC INTERNATIONAL

“High water flows in spring over the last few years has impacted the timing and the amount of diadromous fish from moving beyond dams and fish ladders.”

Cheri Patterson, NH Fish and Game

Over time…

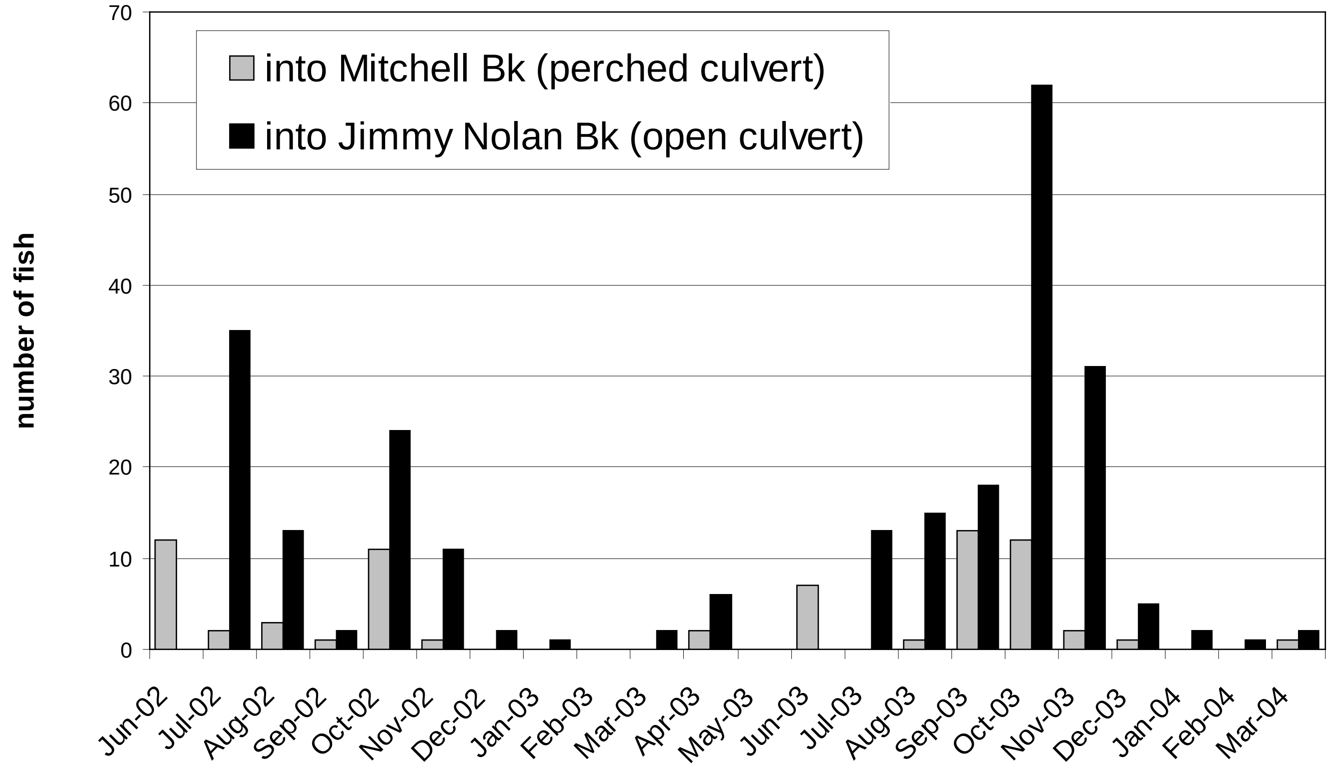
1979 – Siegel Creek

1998 – Siegel Creek

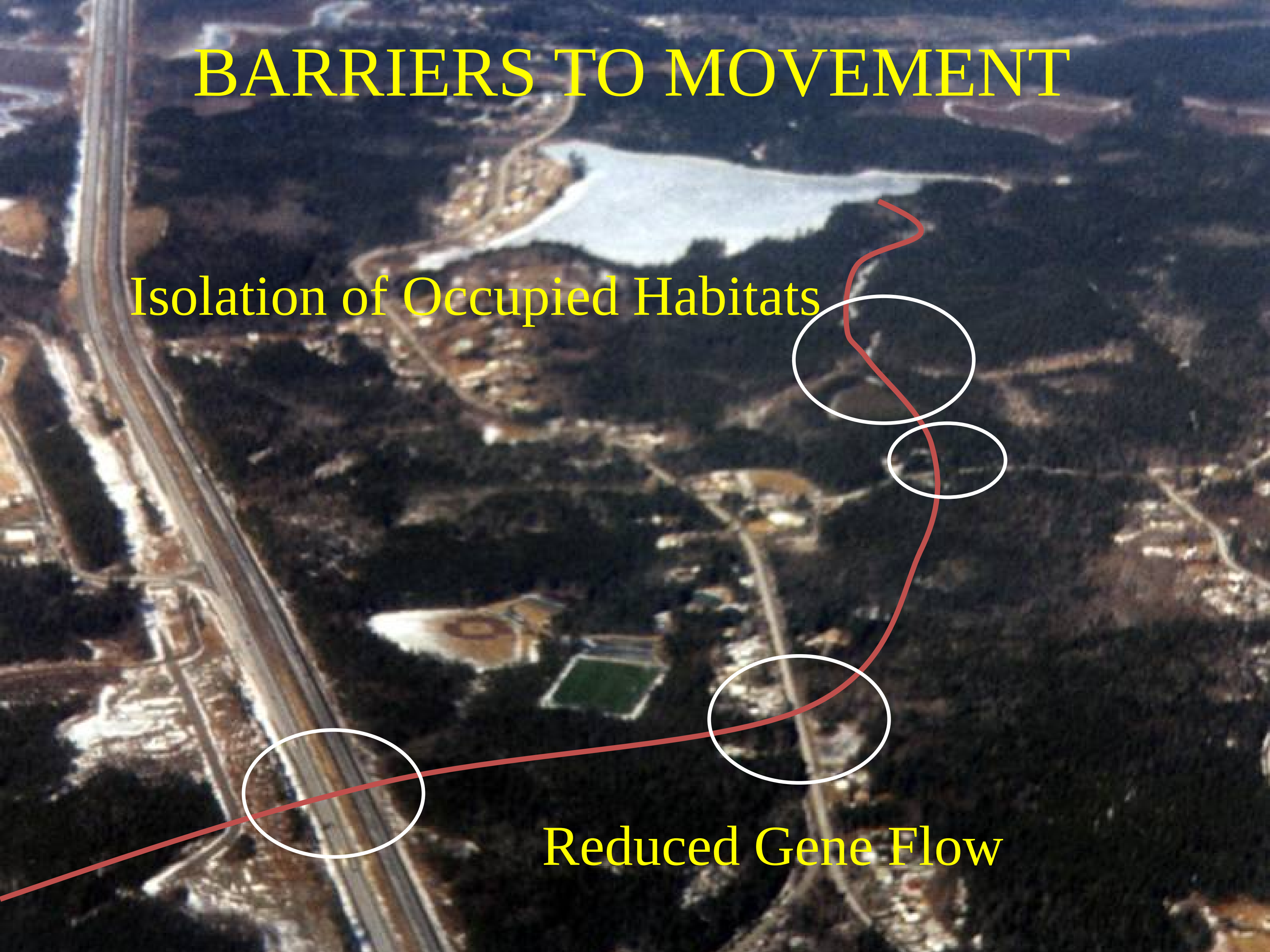
Blacknose Dace

Brook Trout

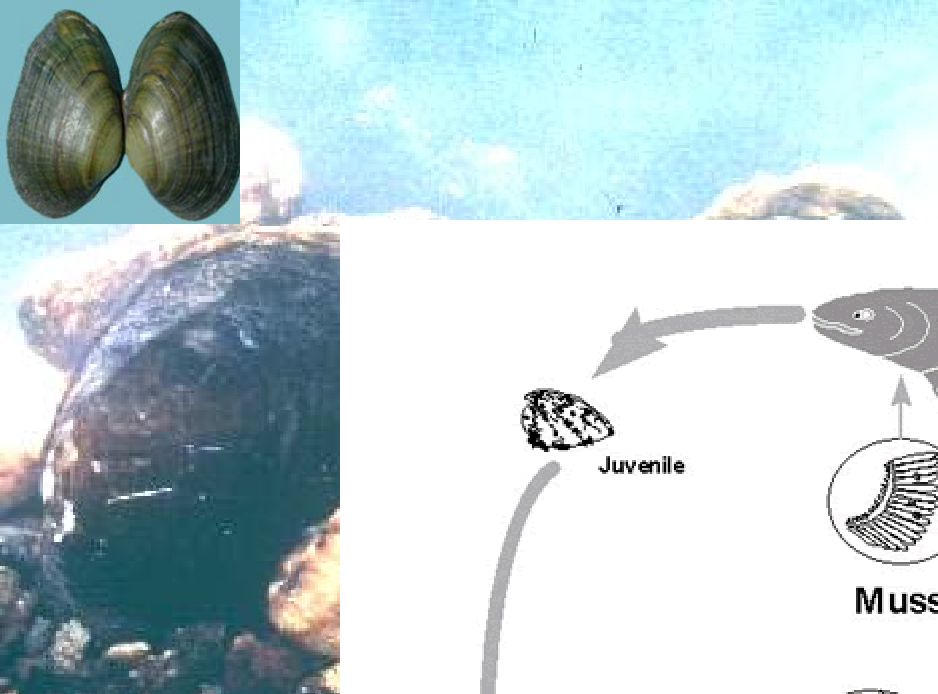
Upstream Movement into Tributaries
(total Atlantic salmon, brook trout, brown trout)

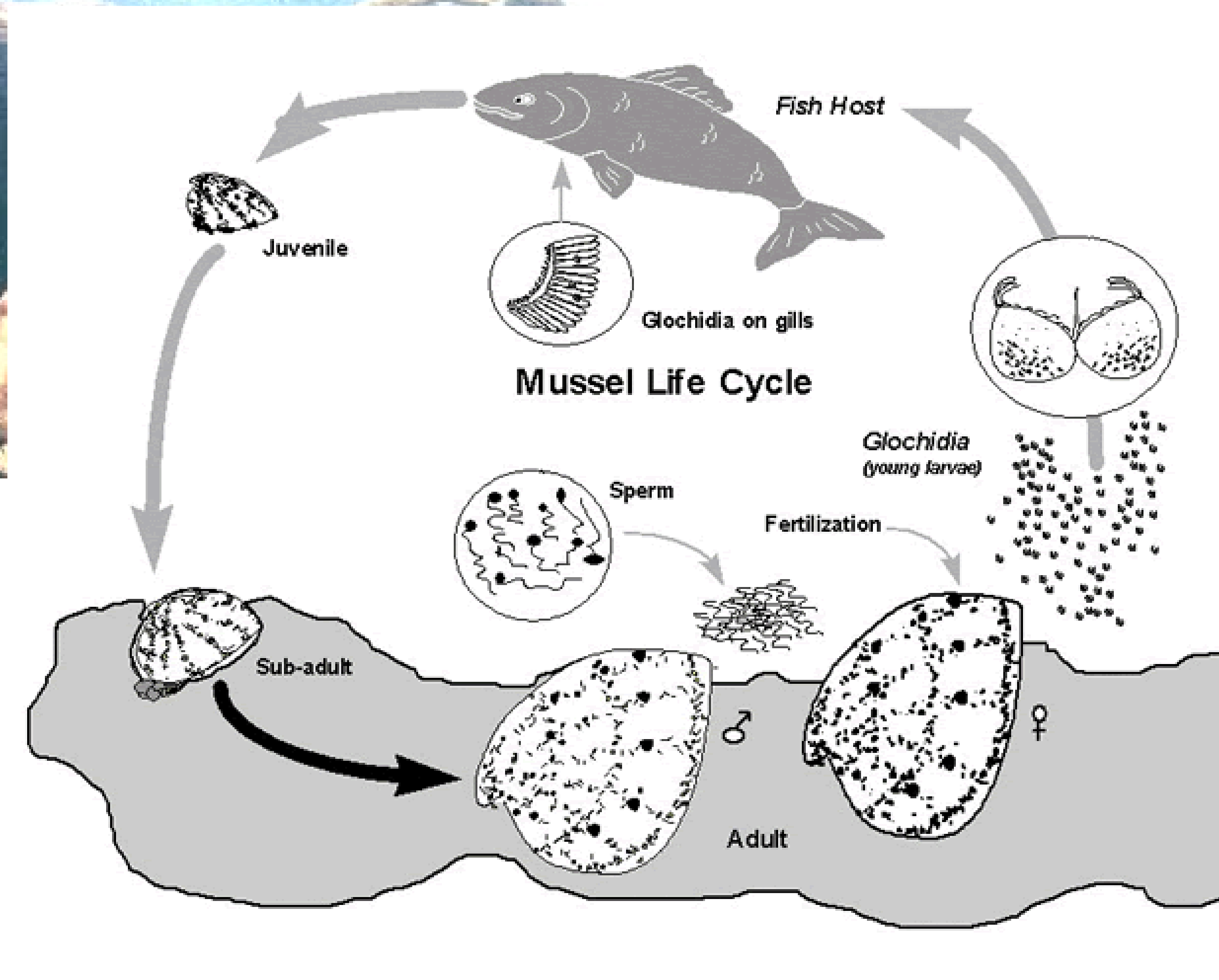


Data from Ben Letcher, Silvio O. Conte
Research Lab

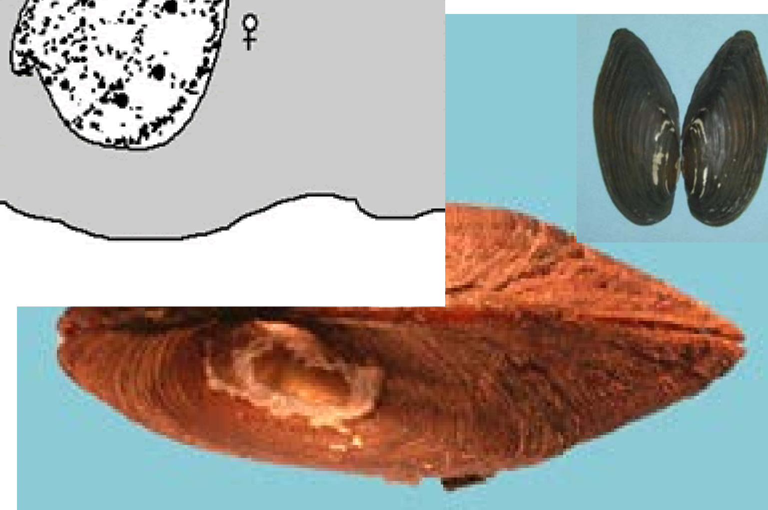

BARRIERS TO MOVEMENT
Isolation of Occupied Habitats
Reduced Gene Flow

Dwarf Wedge Mussel





oater Mussel



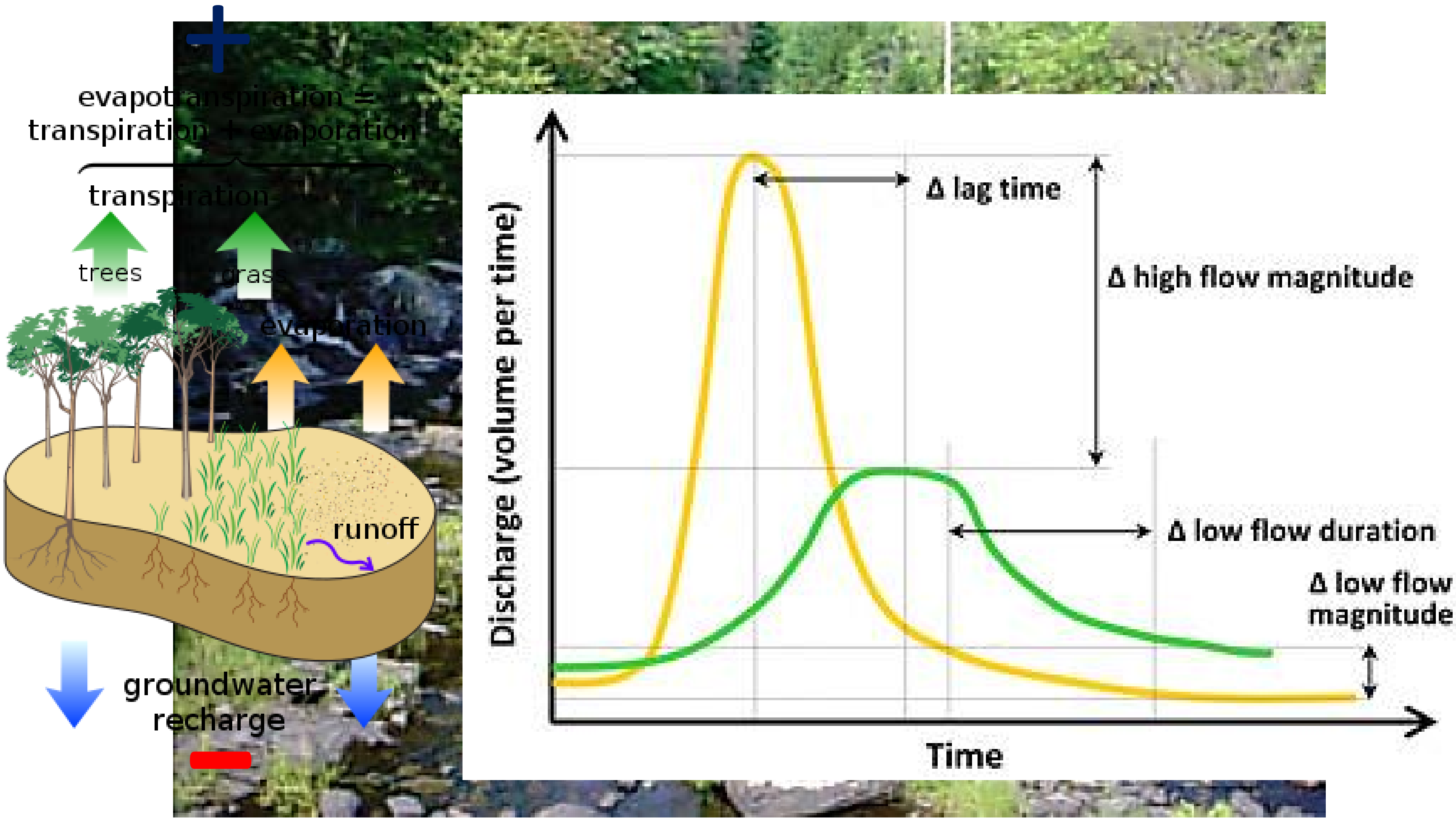
Eastern Pond Mussel

Mussels

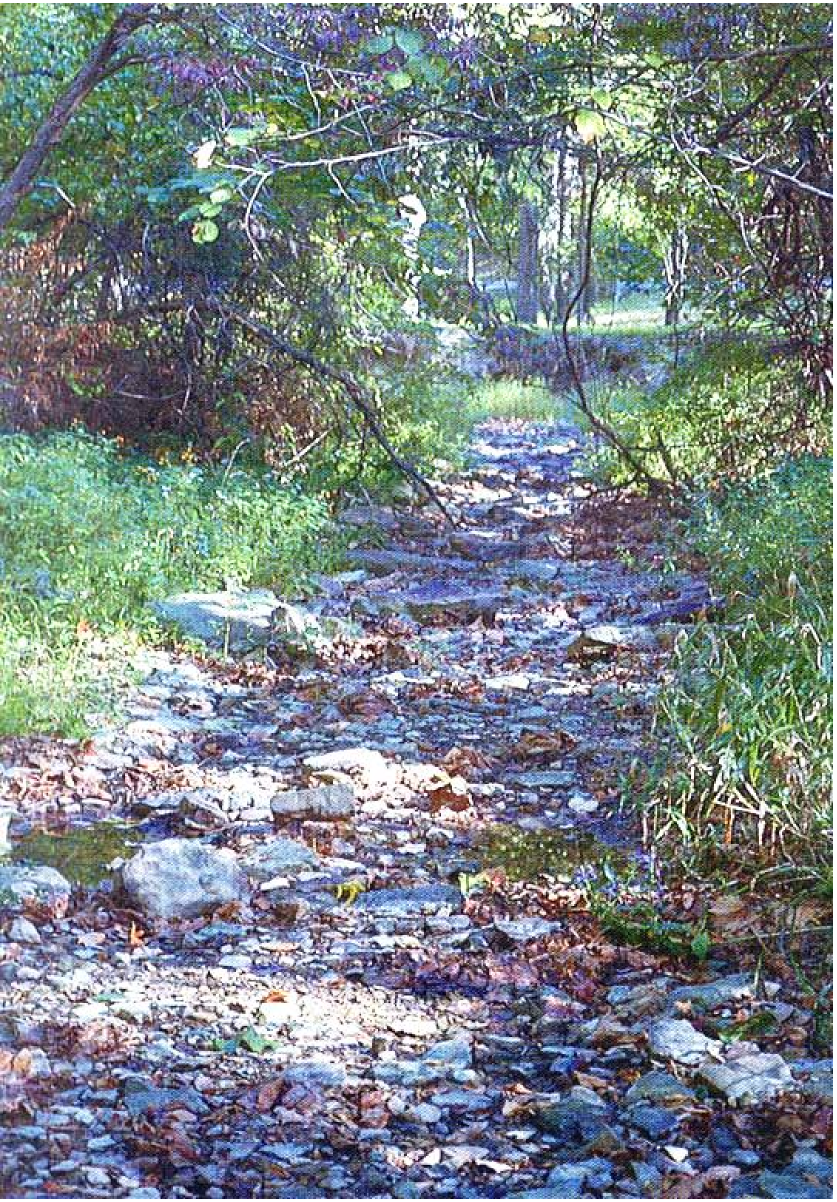
Biology- requires host fish for larval stage (glochidia)

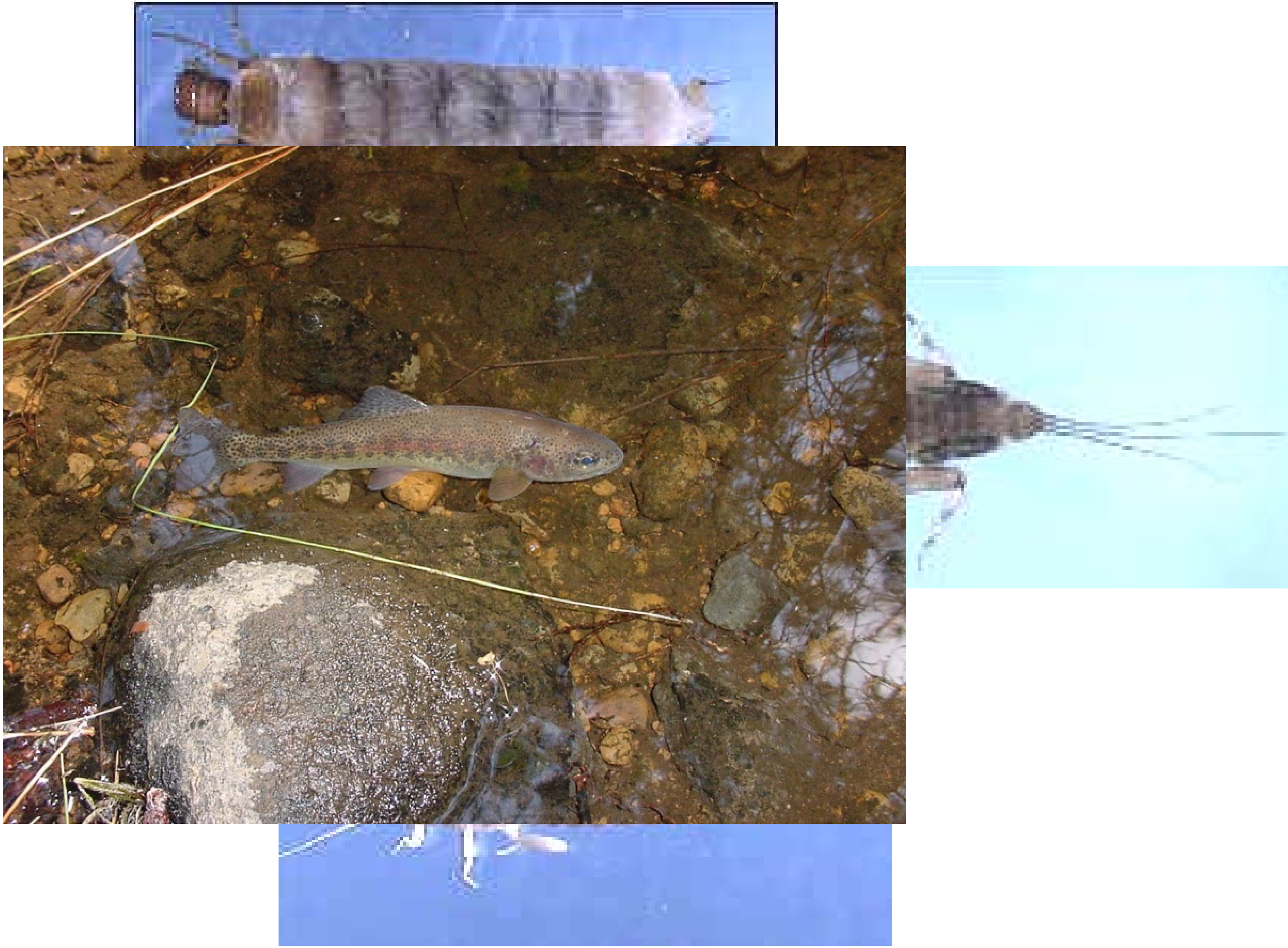
Species	Fish host	Status
Brook floater	Longnose dace, Golden shiner, Slimy sculpin	State endangered (NH)
Eastern pondmussel	unknown	Special concern- NH; regional concern- Northeast
Dwarf wedgemussel	Tessellated darter, Slimy sculpin, Atlantic salmon	Federal & state endangered

Reduced Base Flow



Warmer Winters





A Changing Landscape

Isolated Wetlands: Duration & Timing

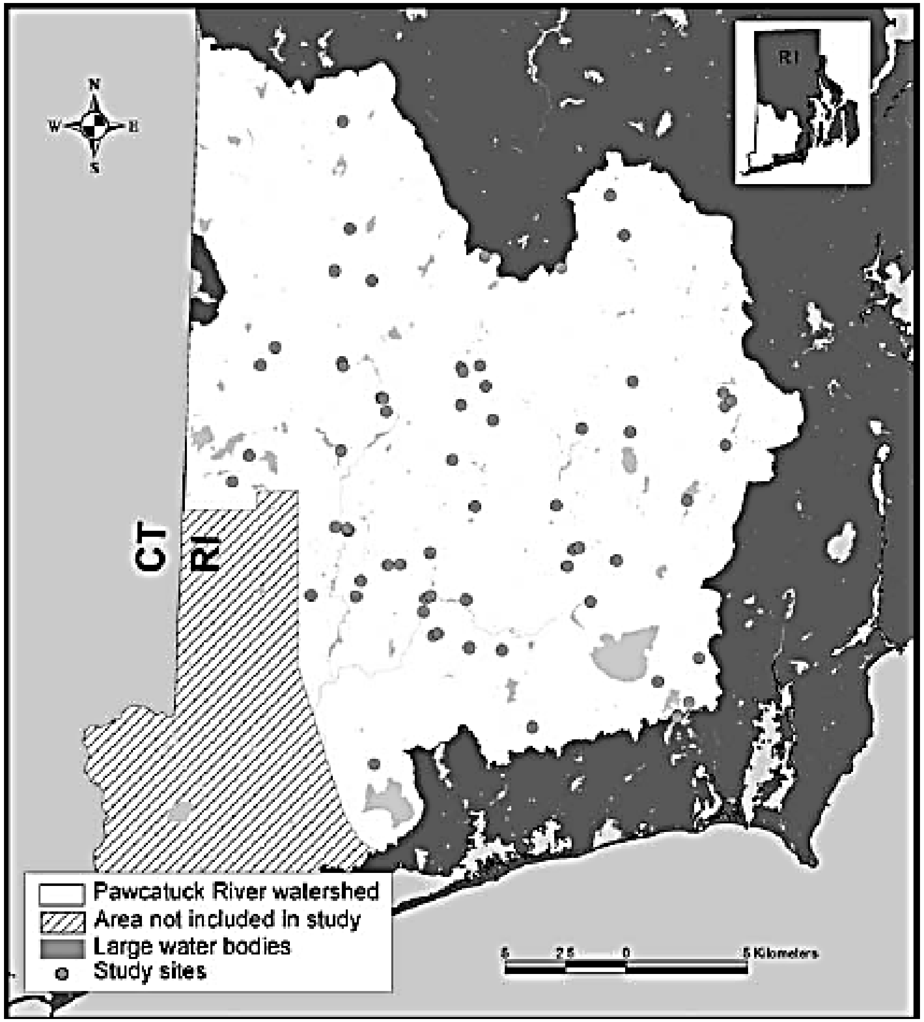
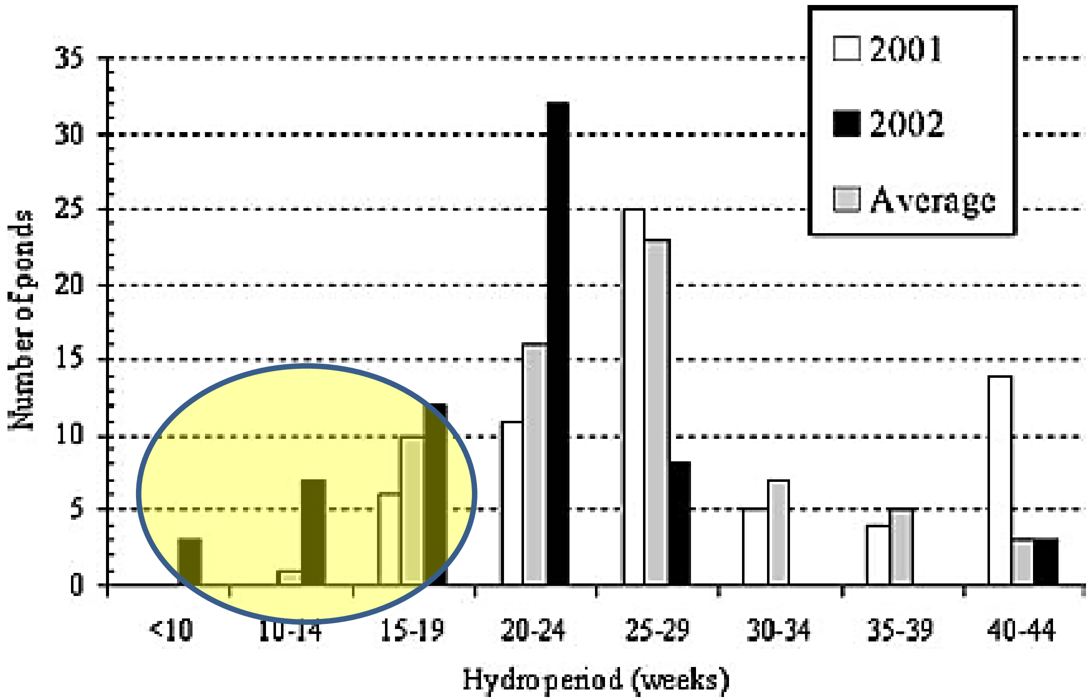
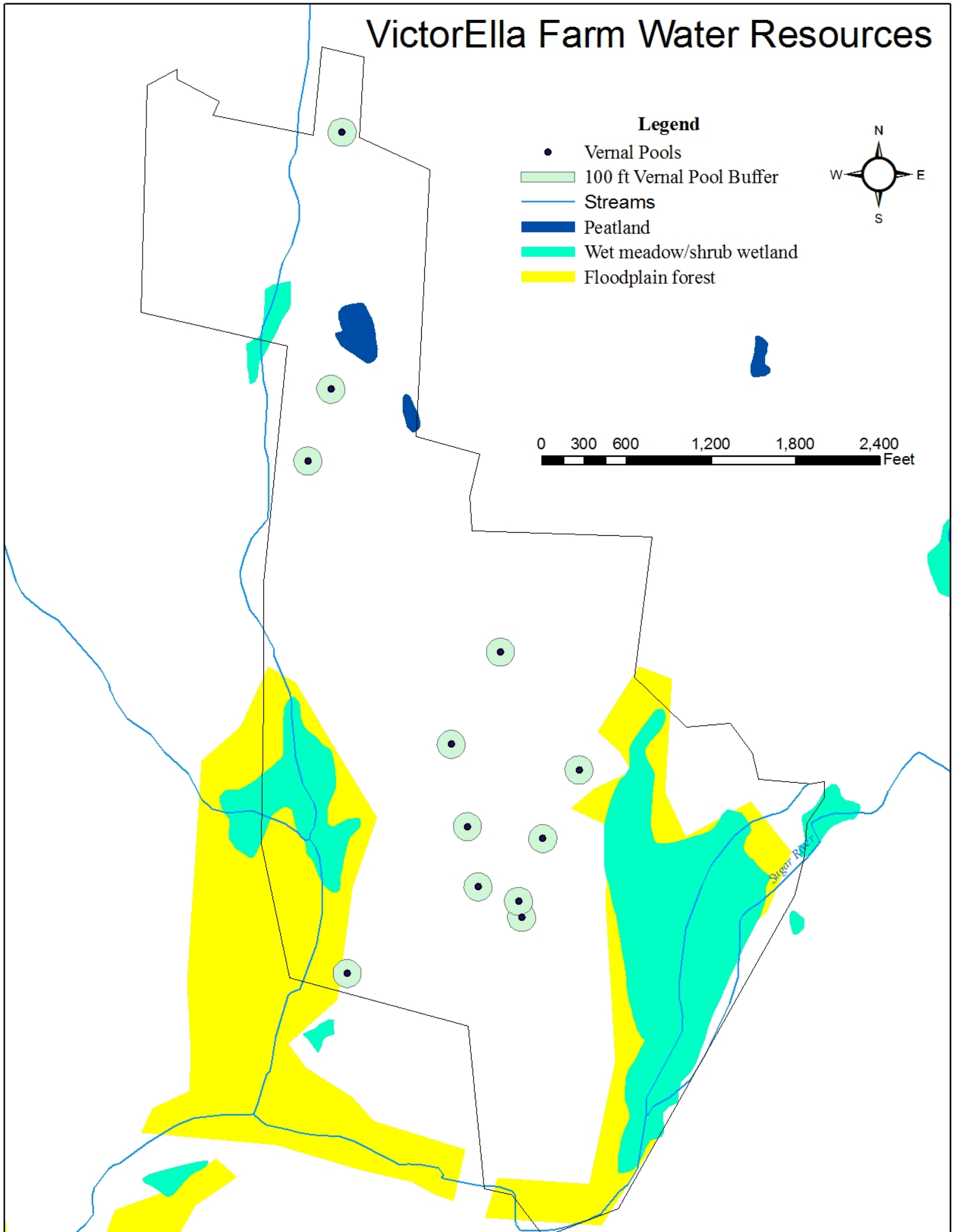


Figure 1. Distribution of seasonal pond study sites within the Pawcatuck River watershed of southern Rhode Island, USA. Pond inventory data were not available for the southwestern part of the watershed (diagonal lines).

Skidds & Golet

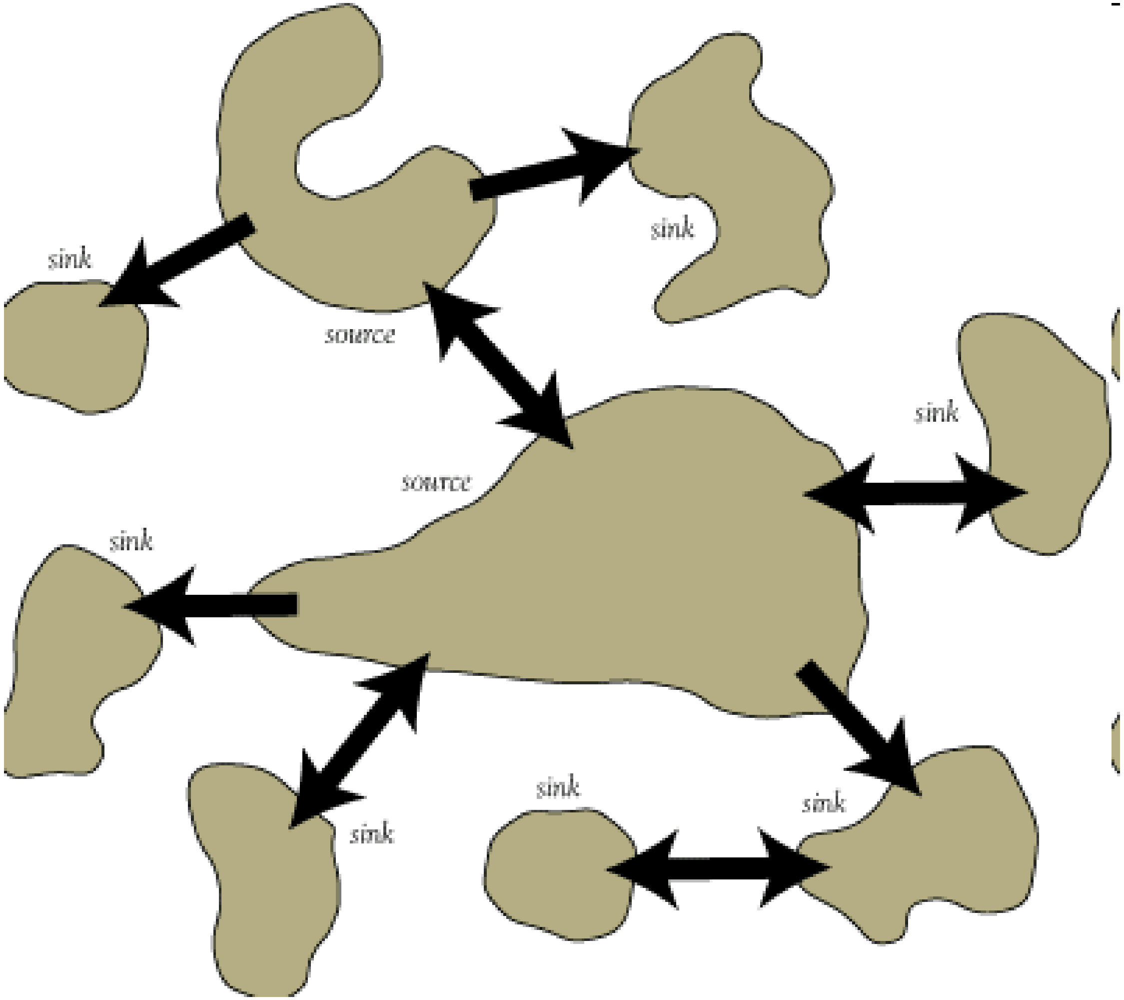


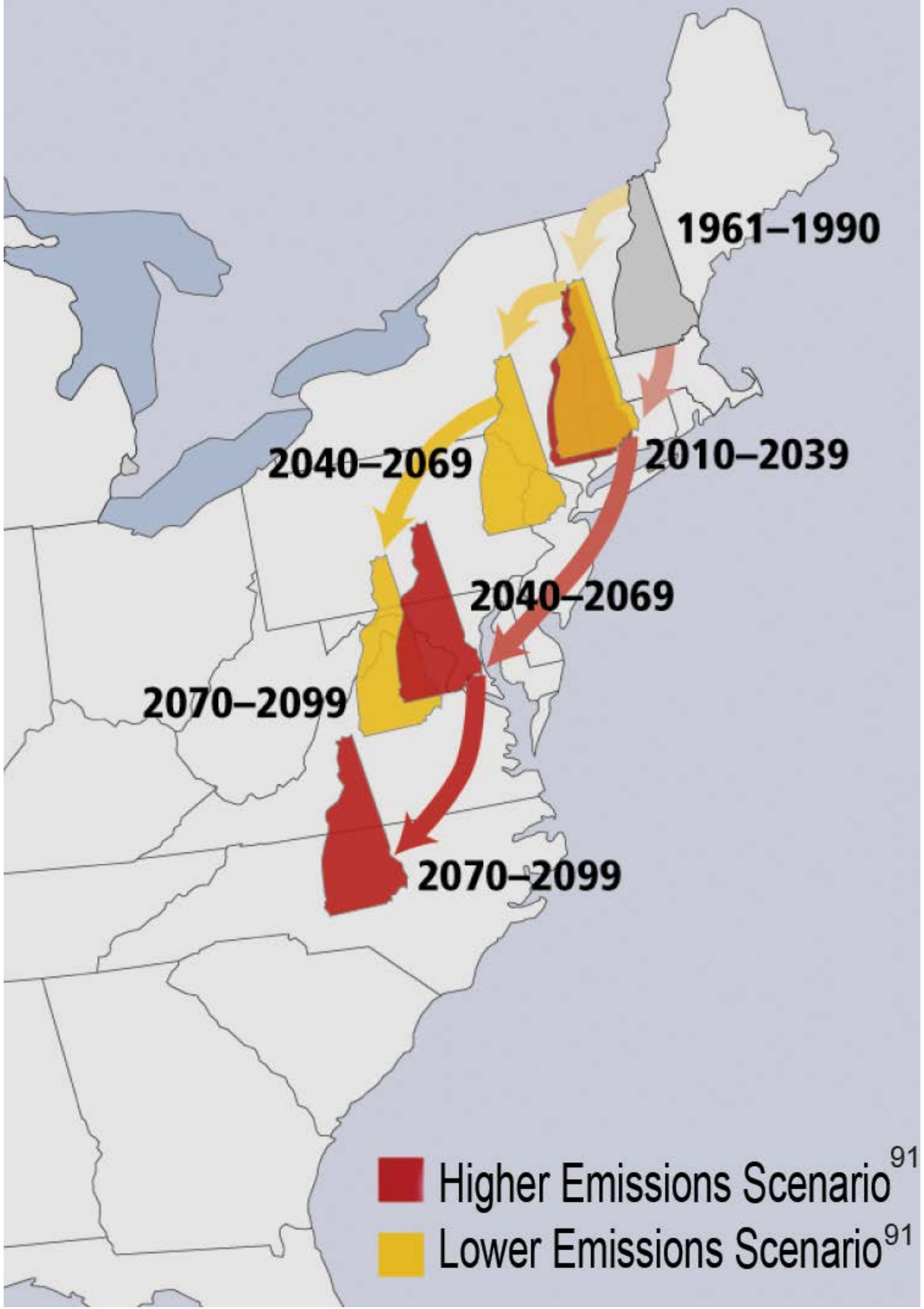
Skidds & Golet



Simpson 2002

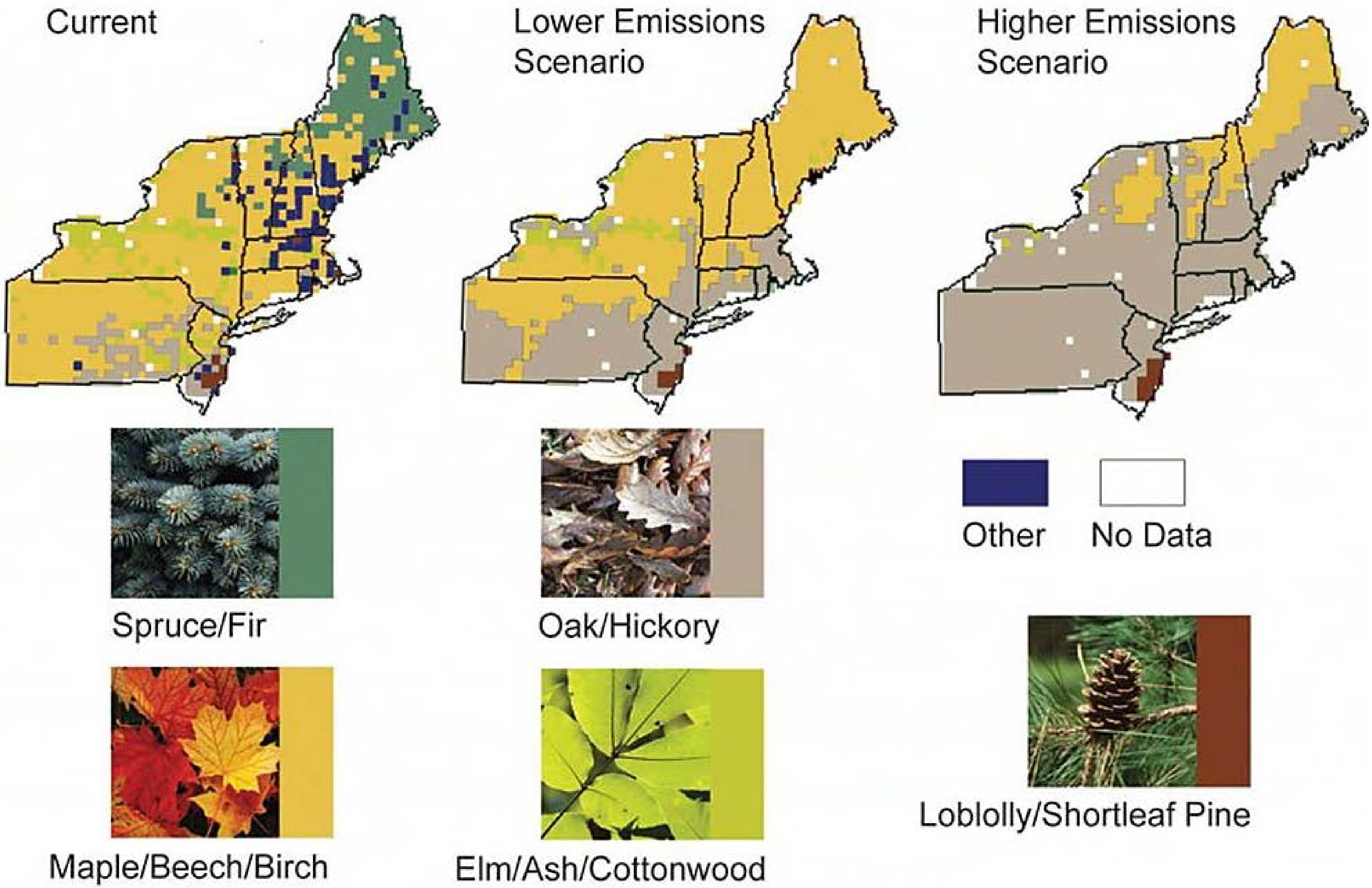
The Meta Population





Hayhoe et al 2009

Shifting Habitats



US EPA 2014

Southern-most Range

Carex lenticularis

(lakeshore sedge)

Rumex pallidus

(seaside dock)

Thuja Occidentalis

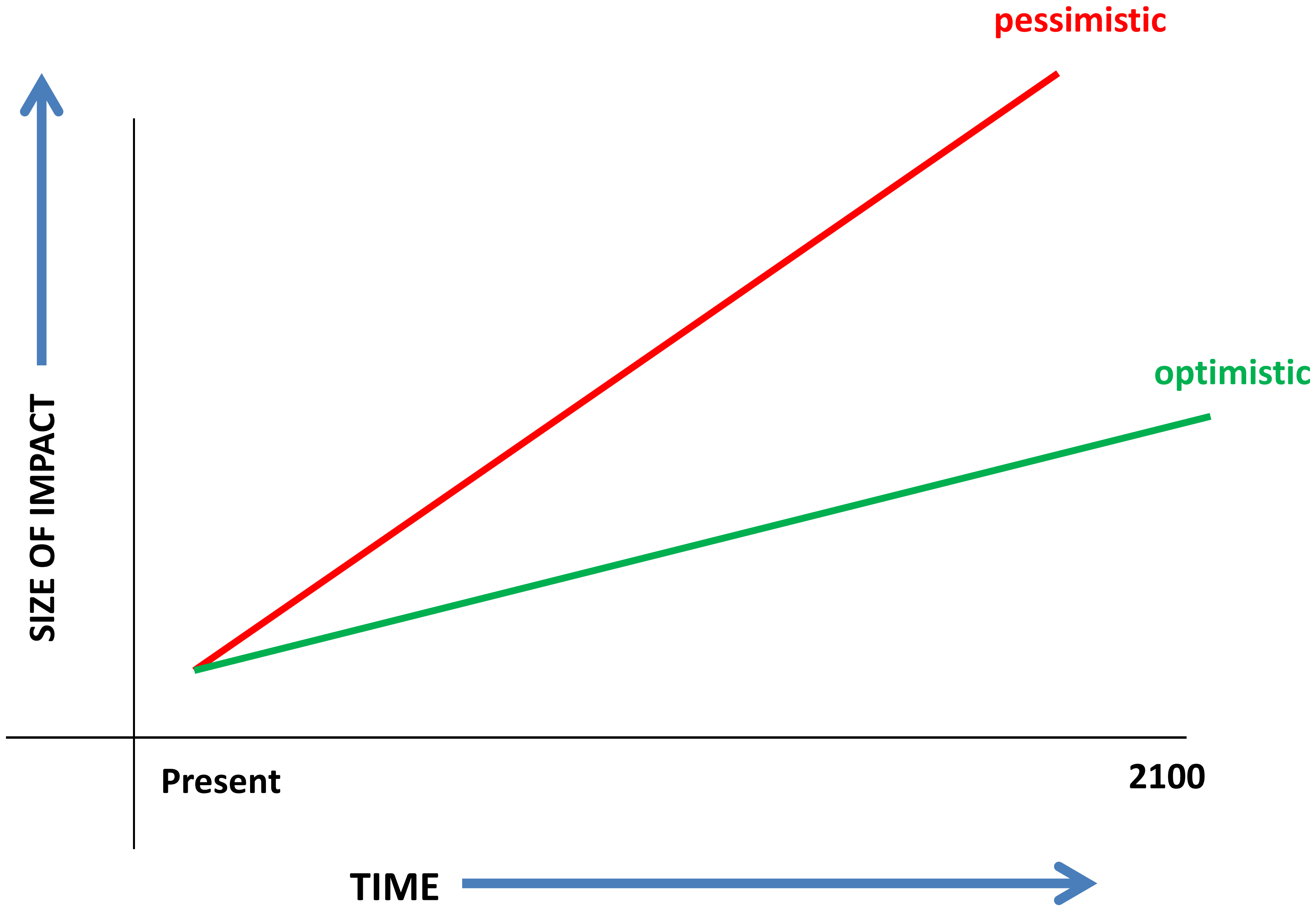
(northern white cedra)

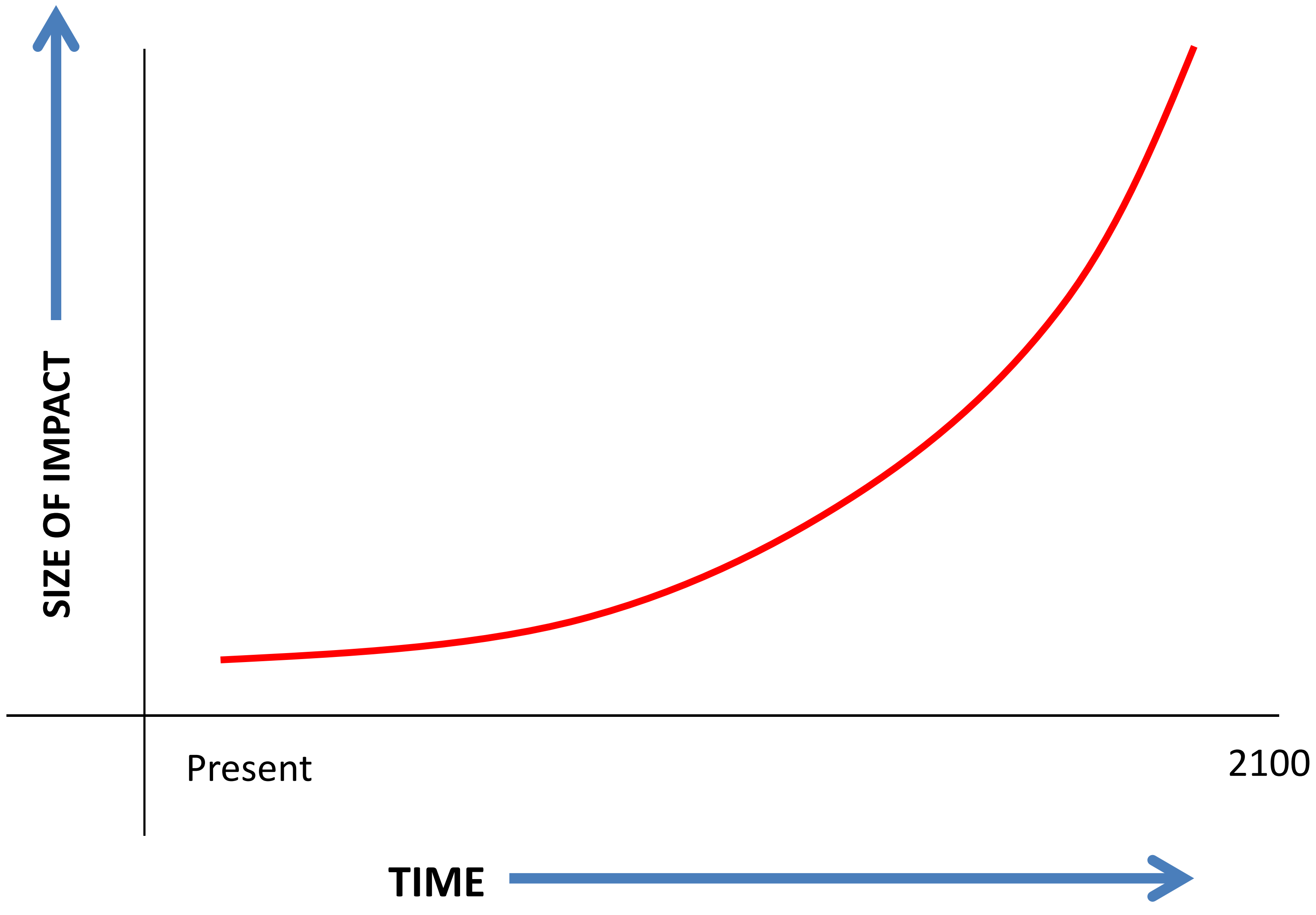
What may be coming your way…or is already here

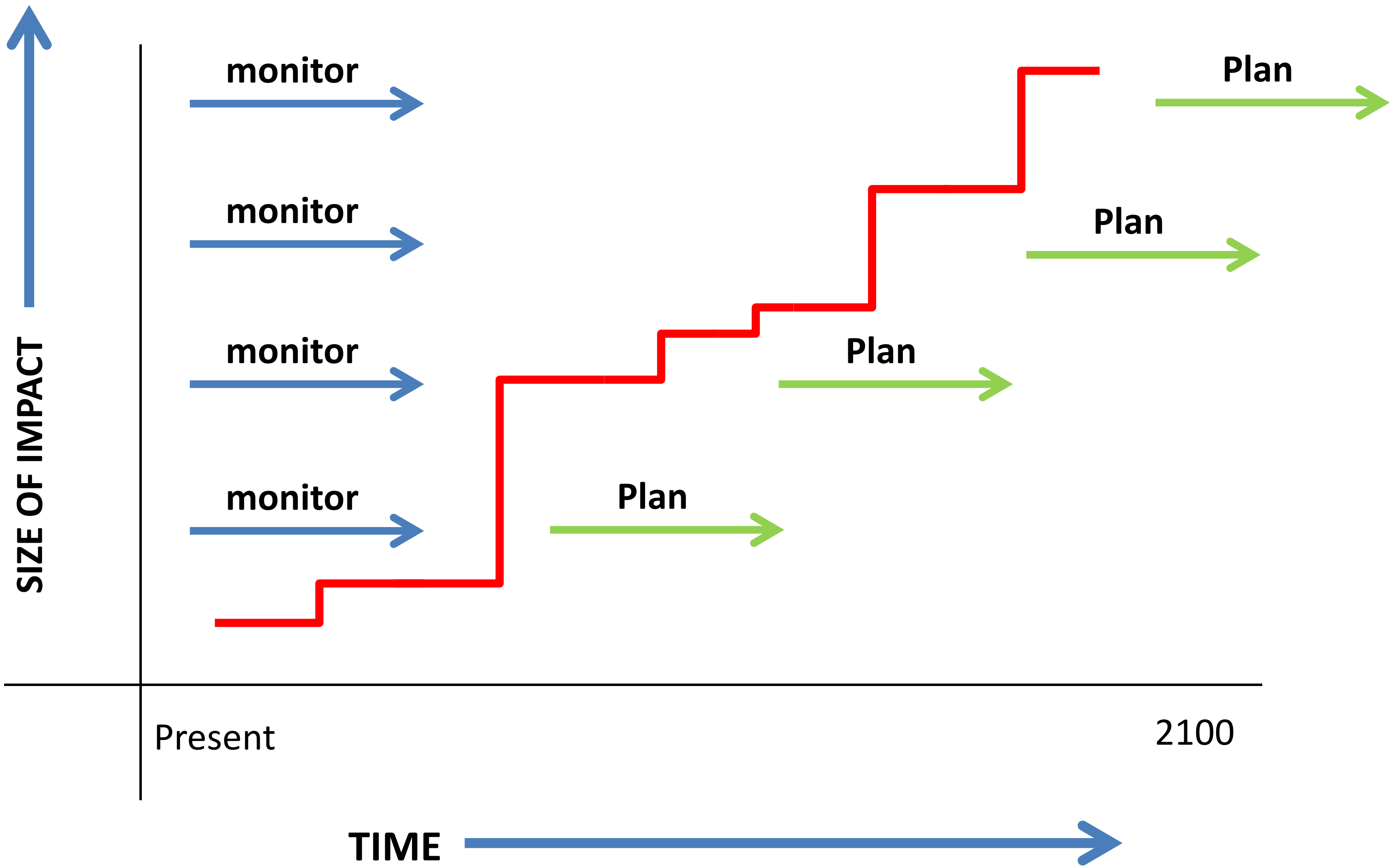
Myriophyllum aquaticum
(parrotfeather)

Microstegium vimineum
(stiltgrass)

Pueraria lobata
(Kudzu)


pessimistic
optimistic
SIZE OF IMPACT
Present
2100
TIME


SIZE OF IMPACT
Present
2100
TIME



SIZE OF IMPACT
monitor
monitor
monitor
monitor
Plan
Plan
Plan
Plan
Present
2100
TIME