New Hampshire Water & Watershed Conference

March 18, 2016

Welcome!

Plymouth State University

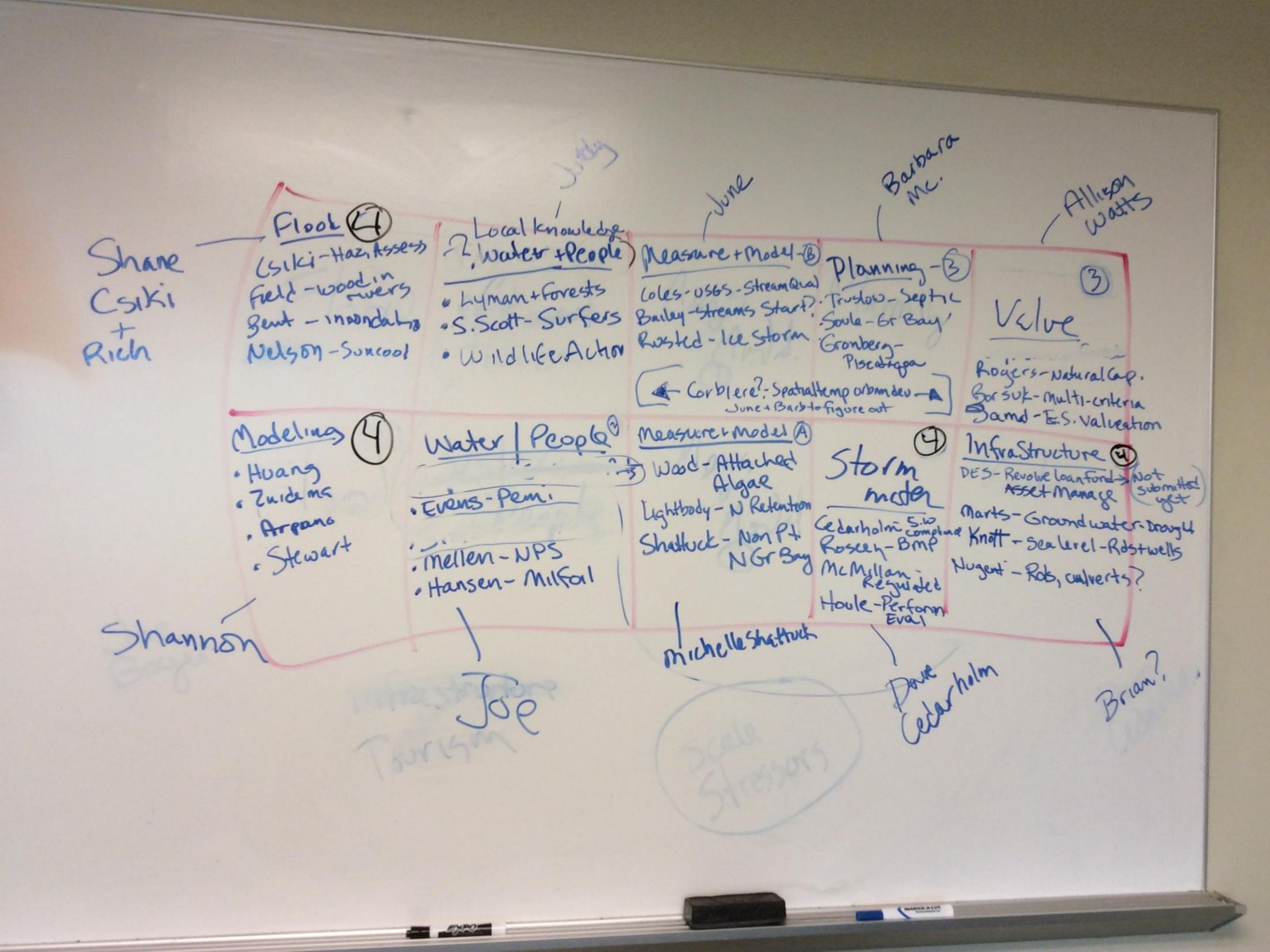
Center for the Environment



Managing New Hampshire's Water for a More Resilient Environment:

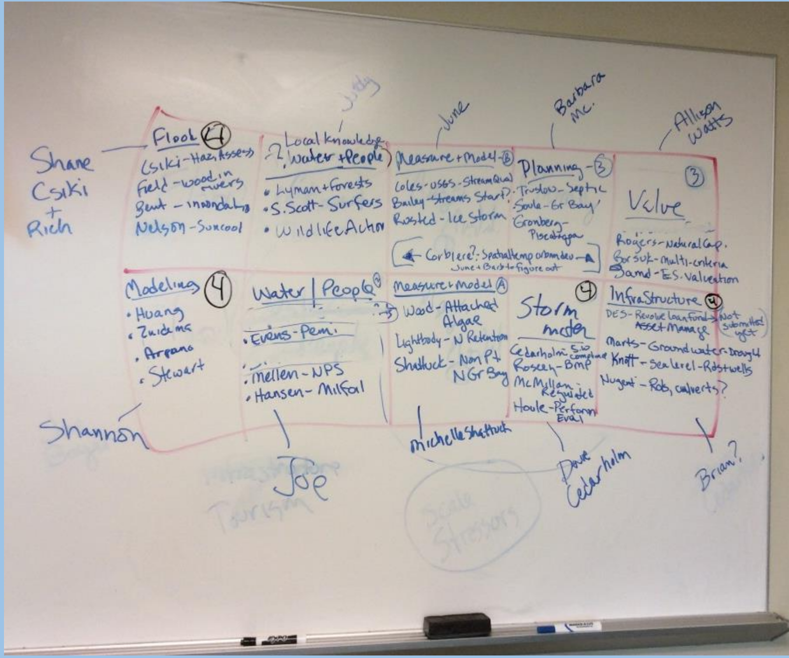
36 Talks & 12 Posters





Shane
Csiki
+
Rich
Flood 4
Csiki - Haz. Assess
Field - wood in rivers
Nelson - Suncook
Local knowledge
? Water + People
• Lyman + Forests
• S. Scott - Surfers
• Wildlife Action
June
Measure + Model - B
Coles - USGS - Stream Qual
Bailey - Streams Start?
Rusted - Ice Storm
Corbiere? - Spatial temp urban dev - A
June + Barb to figure out
Barbara Mc.
Planning - 3
Truslow - Septic
Soule - Gr Bay
Gronberg - Piscataqua
Allison Watts
3
Value
Rogers - Natural Cap.
Borsuk - multi-criteria
Samd - E.S. valuation
Modeling 4
• Huang
• Zuidema
• Arpano
• Stewart
Water | People
• Evens - Pemi
• Mellen - NPS
• Hansen - Milfoil
Measure + Model A
Wood - Attached Algae
Lightbody - N Retention
Shattuck - Non Pt N Gr Bay
4
Storm water
Cedarholm - S.W. compliance
Roseen - BMP
McMillan - Regulated
Houle - Perform Eval
InfraStructure 4
DES - Revolve loan fund → Asset Manage
Not submitted yet
Marts - Groundwater - Drought
Knott - Sea level - Rds + wells
Nugent - Rds, culverts?
Shannon
Joe
Michelle Shattuck
Dave Cedarholm
Brian?

Organizing Committee:



- David Cedarholm, Tighe & Bond
- Shane Csiki,, NH Geological Survey,
  NH Department of Environmental Services
- Brian Goetz, City of Portsmouth, NH
- Richard Kiah, US Geological Survey
- Barbara McMillan & Paul Susca, NH Department of Environmental Services
- Michelle Shattuck, NH Water Resources Research Center, University of New Hampshire
- Judy Tumosa, NH Fish and Game
- Alison Watts, University of New Hampshire
- June Hammond Rowan, Carolyn Greenough, Joe Boyer, Shannon Rogers, Center for the Environment, Plymouth State University

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silt PRISON by stormwater buffer zone

FB environmental

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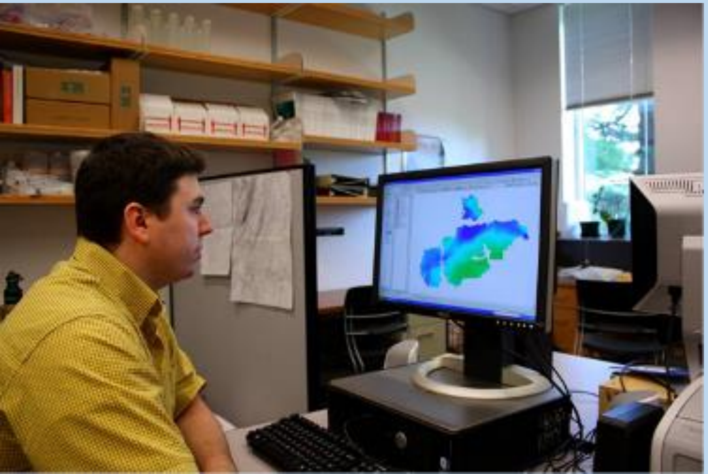
Environmental scholarship informed by the world, with a regional focus and local engagement.



Donald Birx, President
Plymouth State University

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FOCUS ON THE VISION

Plymouth State University is a visionary institution at the hub of an ever-growing creative community where students, faculty, staff, and alumni are actively transforming themselves and the region. We develop ideas and solutions for a connected world and produce society's global leaders within interdisciplinary strategic clusters, open labs, partnerships and through entrepreneurial, innovative, and experiential learning.

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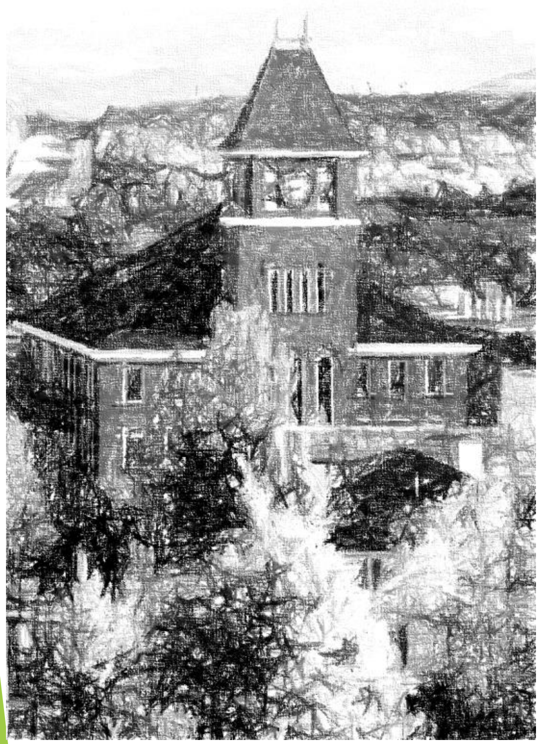
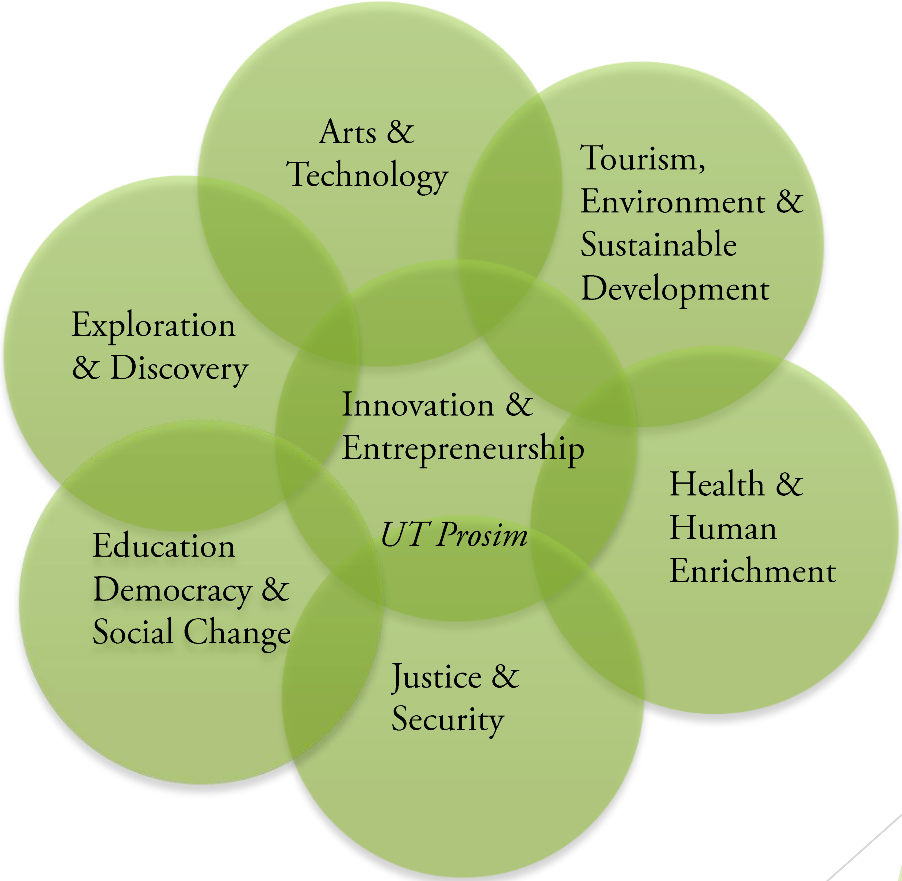
Strategic Clusters





Resilience of New Hampshire’s Hydrology to Forest Harvesting

Mark Green

Center for the Environment - Plymouth State Univ., U.S.A.

Northern Research Station - U.S. Forest Service

Plymouth State UNIVERSITY

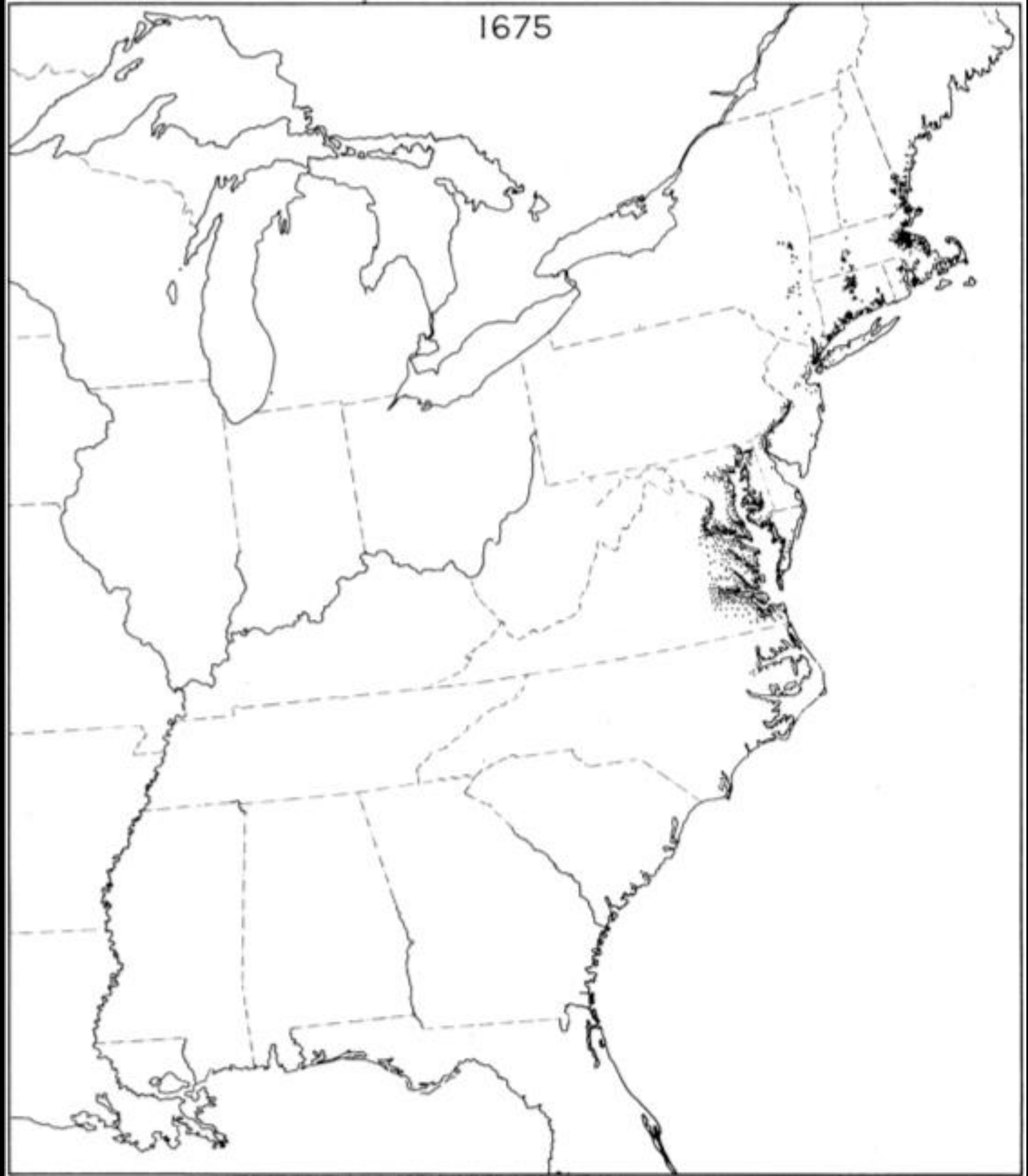
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Charlie Vörösmarty et al.'s 500-year challenge

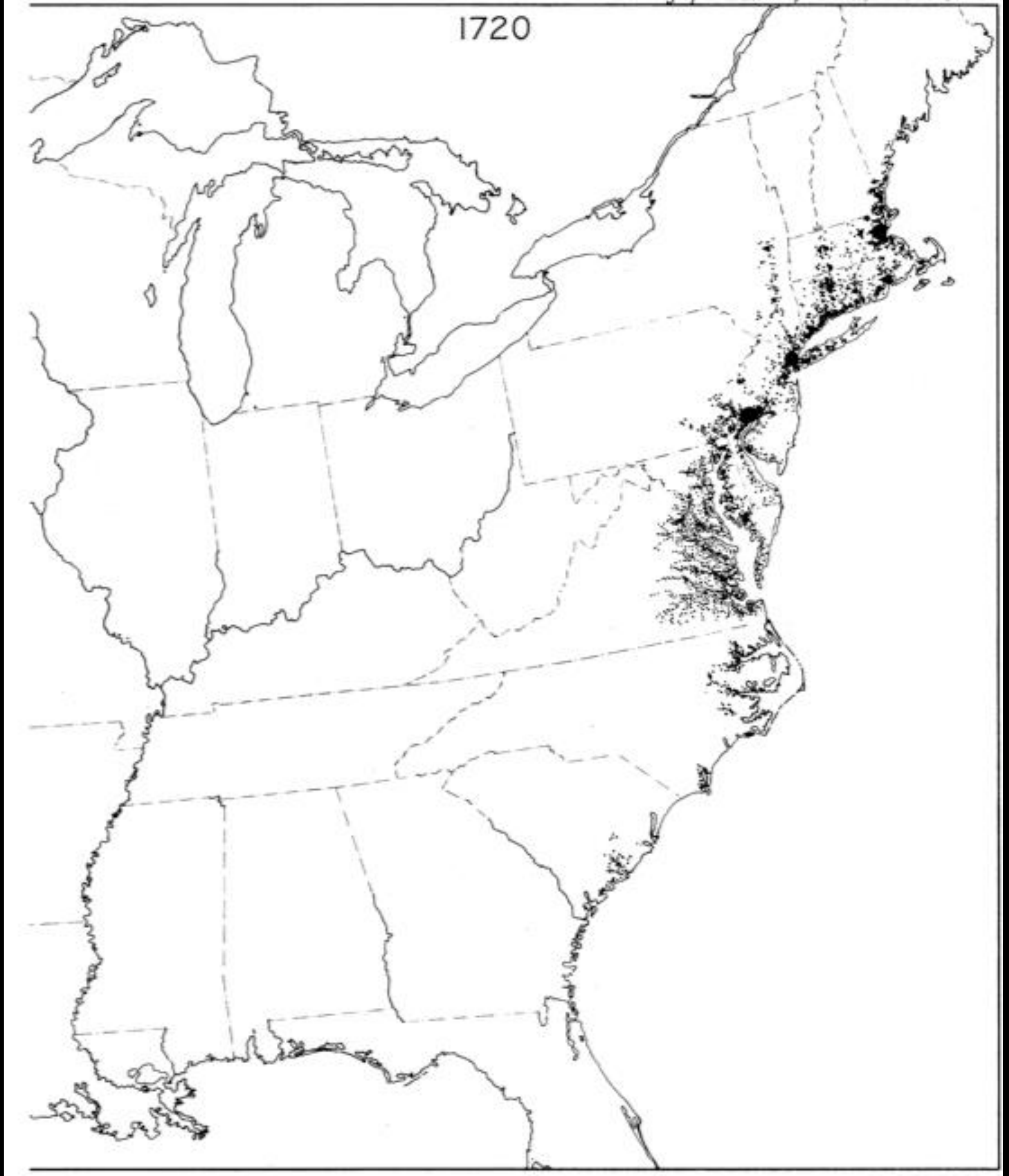
To *quantify* the widespread alteration of hydrologic systems over local-to-regional domains focusing on the Northeast corridor of the United States over a 500-yr period (1600 to 2100).

The American Geographical Society of New York
1625
Each dot represents approximately 200 rural inhabitants
Each circle represents one or more families

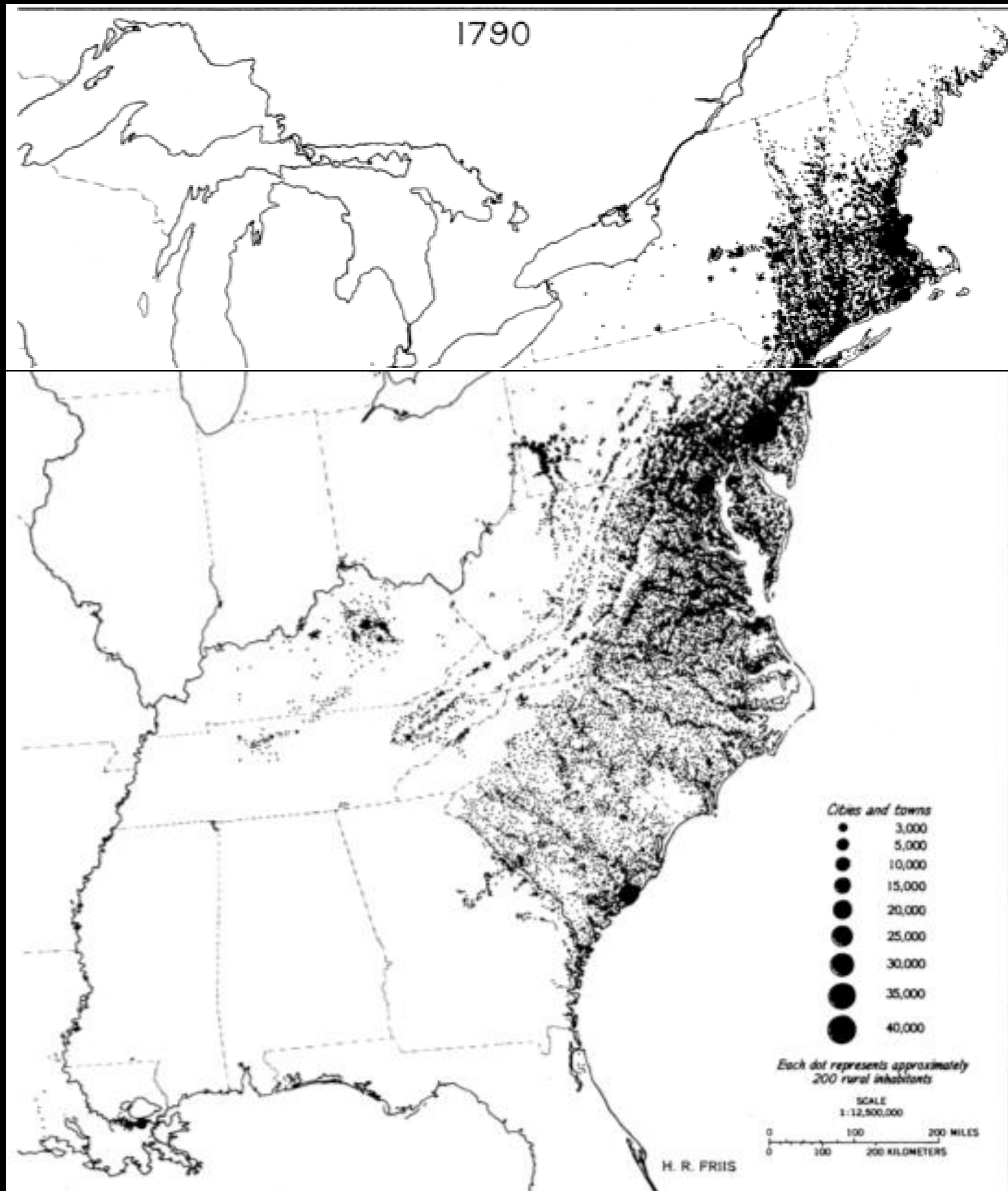
Friis 1940



Friis 1940

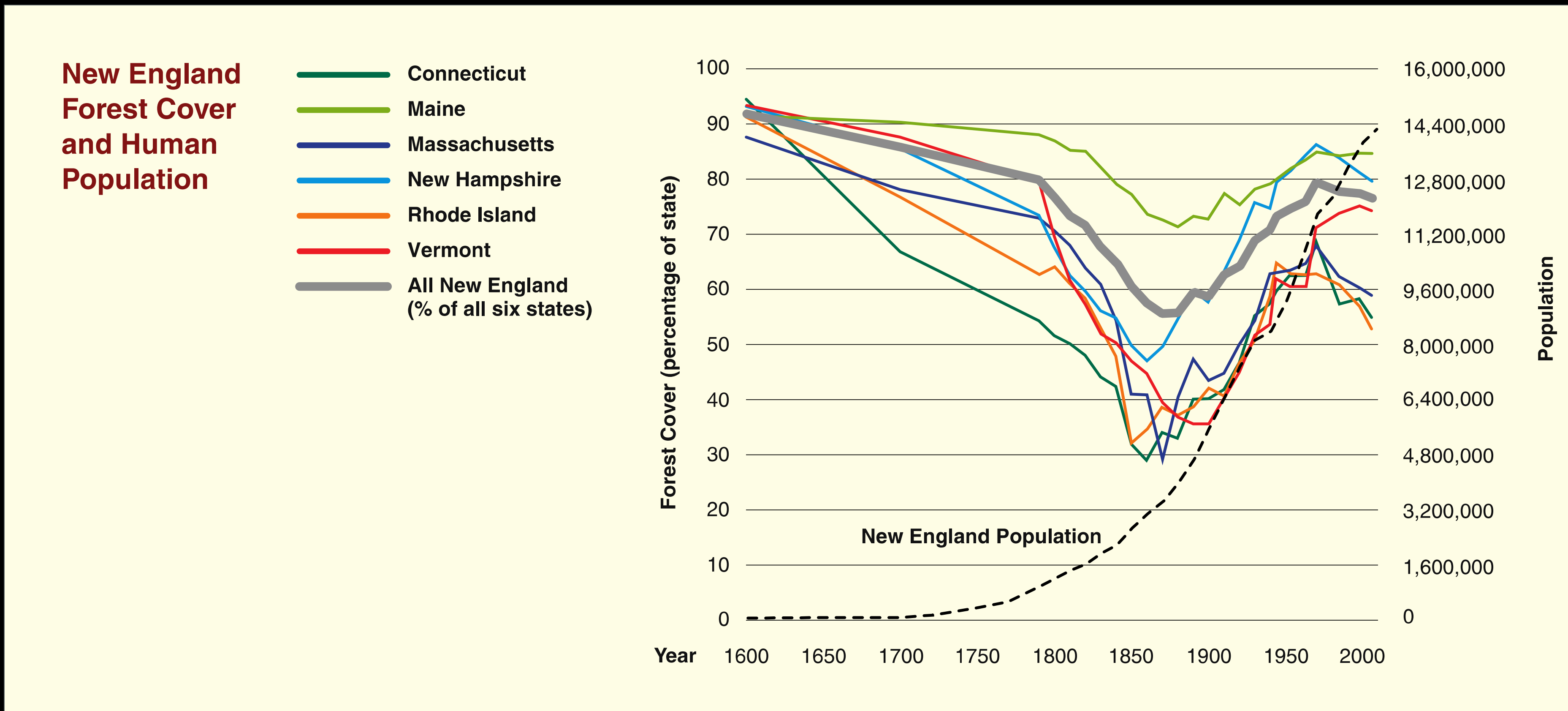


Friis 1940


1790
Cities and towns
3,000
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
Each dot represents approximately 200 rural inhabitants
SCALE 1:12,500,000
0 100 200 MILES
0 100 200 KILOMETERS
H. R. FRIIS

Friis 1940

Photograph from the New Hampshire Historical Society collection



Modified and updated from Foster, D. R., and J. Aber, editors. 2004. Forests in time: the environmental consequences of 1,000 years of change in New England. Yale University Press, New Haven, Connecticut

The Resilience Hypothesis

The Resilience Hypothesis

The major impacts of forest harvesting during and after European settlement had short-lived impacts and the change to the system’s hydrologic function may be very difficult to detect.

This hypothesis might seem contrary to the motivation behind the Weeks Act of 1911.

It was motivated by the idea that aggressive forest harvesting was altering hydrology to the detriment of navigable waters.

Report of the Forestry Commission of New Hampshire, 1891

"…all intelligent observers are aware that the water of a heavy shower descends a bare hillside much more rapidly than it does one of equal slope which is covered by a forest. Mountain forests retain the water which falls upon them in rain or snow, and distribute it slowly, the soil being held in place by the pervading mat or network of living roots, which prevents it from slipping down from the rocks when it is heavy with the great quantity of water which it absorbs."

This talk will explore this hypothesis using historical monitoring data and hydrologic modeling informed by experiments.

photo by Ben Kimball, from NH Division of Forests and Lands

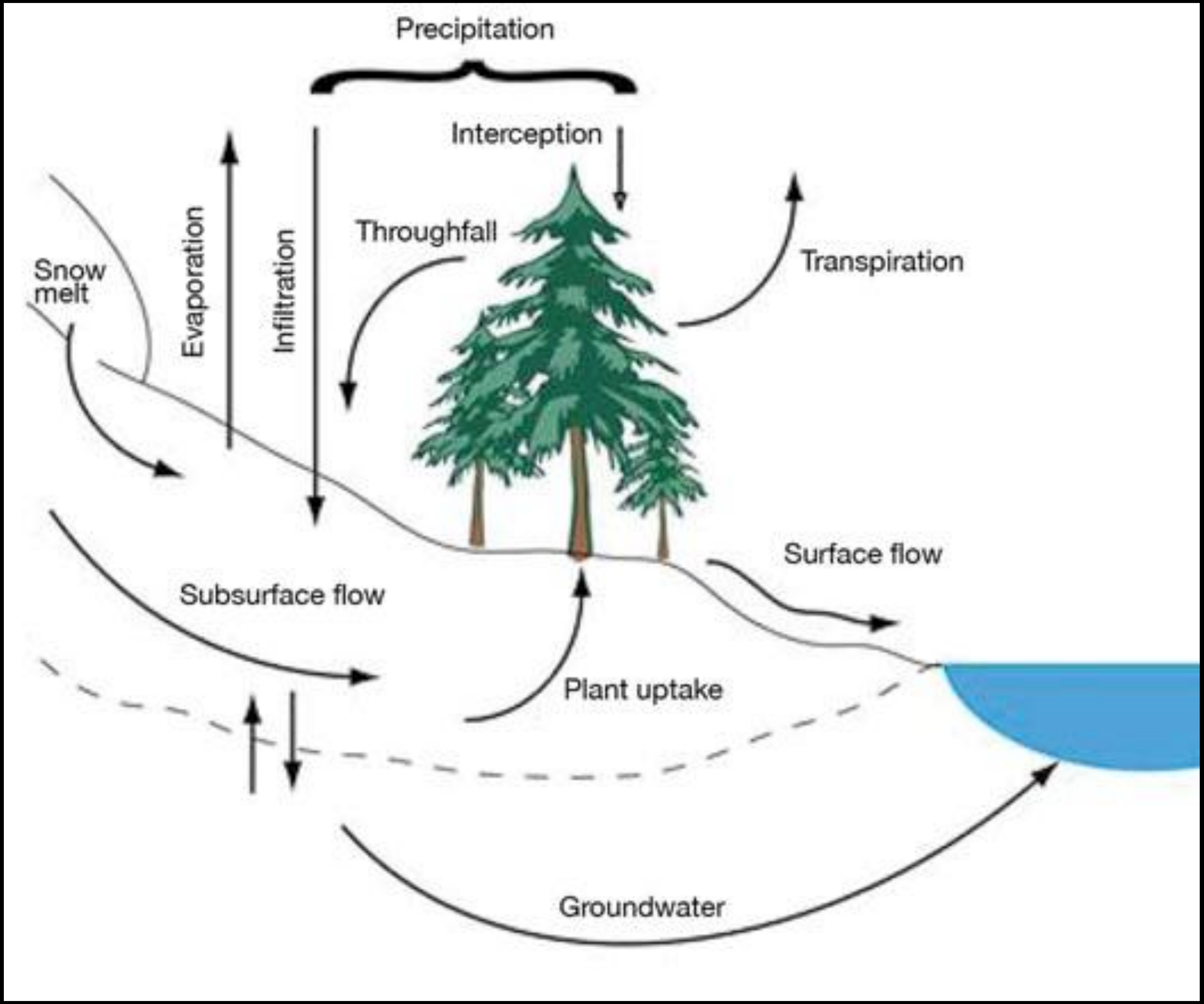
Hydrological resilience is the ability of a catchment to absorb disturbance and maintain or quickly regain hydrologic function.

Disturbance: *an event that disrupts ecosystem structure and resource allocation*

Quickly: *we need to study sites to understand 'normal'*

Hydrologic function: *any flux or store in a forest water budget*

Hydrologic Function

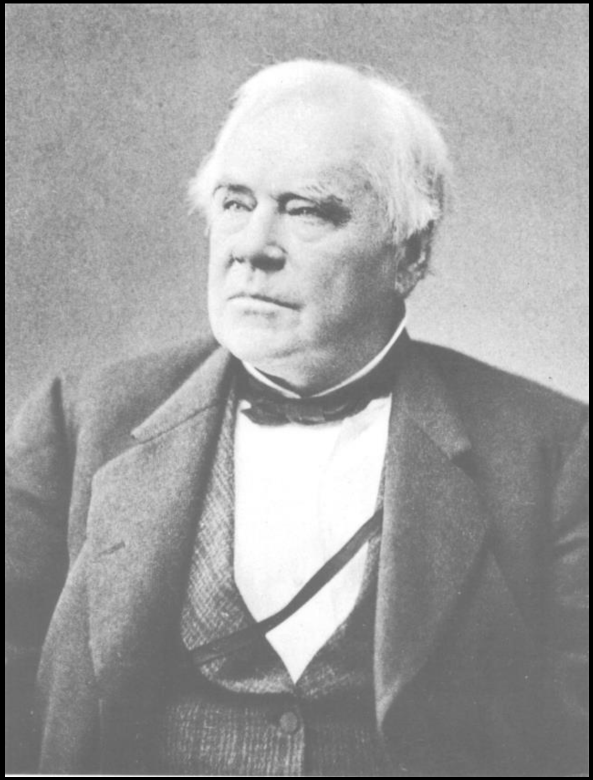


Natural Resources Canada

The Merrimack River Data

The Merrimack River

Are there direct discharge measurements that we can use?



James B. Francis

Locks and Canals Collection, Lowell National Historical Park

Height of gauge in feet above Locks and Canals datum of the Merrimack River back of Boott Mills.
Discharge in cubic feet per second passing gauge.

1848.

Total drainage area = 4097 square miles.

Date	January Height	January Disch.	February Height	February Disch.	March Height	March Disch.	April Height	April Disch.	May Height	May Disch.	June Height	June Disch.
1	49.78	9100	49.20	7700	48.37	5790	52.45	16625	48.70	6500	51.07	12560
2	*		49.28	7860	48.18	5360	*		48.85	6850	50.41	10730
3	50.16	10050	48.95	7075	47.95	4900	52.68	17340	49.64	8720	49.85	9275
4	50.03	9725	48.91	6975	48.03	5060	51.45	13625	52.60	17100	*	
5	49.68	8840	48.76	6650	*		50.87	12010	53.70	20900	49.28	7860
6	49.14	7550	*		48.14	5280	#		52.20	15850	49.20	7700
7	48.95	7075	48.95	7075	47.91	4820	50.78	11740	*		49.35	8025
8	48.62	6340	48.95	7075	48.03	5060	50.32	10500	51.39	13470	49.45	8275
9	*		48.68	6460	48.45	5950	*		51.28	13140	49.66	8780
10	48.87	6890	48.62	6340	49.74	9000	49.68	8840	50.78	11740	49.55	8500
11	49.37	8075	48.70	6500	49.91	9425	49.58	8560	50.57	11175	*	
12	48.95	7075	48.60	6300	*		49.60	8600	52.24	15990	48.99	7175
13	48.70	6500	*		50.01	9675	49.62	8660	53.14	18860	48.82	6790
14	48.51	6075	48.45	5950	49.78	9100	49.70	8900	*		48.70	6500
15	48.62	6340	48.53	6125	49.45	8275	50.24	10270	51.62	14150	48.37	5790
16	*		48.51	6075	49.26	7820	*		51.74	14470	48.45	5950
17	51.28	13140	48.37	5790	48.99	7175	49.99	9625	51.20	12900	48.35	5750
18	51.35	13350	48.12	5240	48.87	6890	49.80	9150	51.57	13995	*	
19	50.74	11620	48.18	5360	*		49.70	8900	50.28	10390	48.24	5500
20	50.03	9725	*		48.70	6500	49.62	8660	49.95	9525	48.28	5600
21	49.18	7650	48.20	5400	49.16	7600	49.70	8900	*		48.51	6075
22	49.03	7275	#48.28	5600	50.70	11500	49.45	8275	49.93	9475	48.70	6500
23	*		48.47	5990	51.47	13675	*		50.62	11300	48.53	6125
24	48.87	6890	48.66	6420	51.24	13020	49.28	7860	50.70	11500	48.37	5790
25	48.64	6380	48.72	6550	50.66	11400	49.28	7860	50.32	10500	*	
26	48.62	6340	48.53	6125	*		49.26	7820	50.10	9900	48.14	5280
27	48.74	6600	*		50.16	10050	49.16	7600	49.87	9325	48.03	5060
28	50.30	10450	48.28	5600	50.45	10850	48.95	7075	*		47.95	4900
29	50.53	11075	48.28	5600	51.12	12700	48.82	6790	49.60	8600	47.99	4980
30	*				52.39	16425	*		49.41	8175	48.03	5060
31	49.57	8540			52.66	17280			49.64	8720		
Average		8410		6343		8910		9758		11971		6943
Maximum		13350		7860		17280		17340		20900		12560
Minimum		6075		5240		4900		6790		6500		4900
Average per sq. mi.		2.053		1.548		2.175		2.382		2.922		1.695

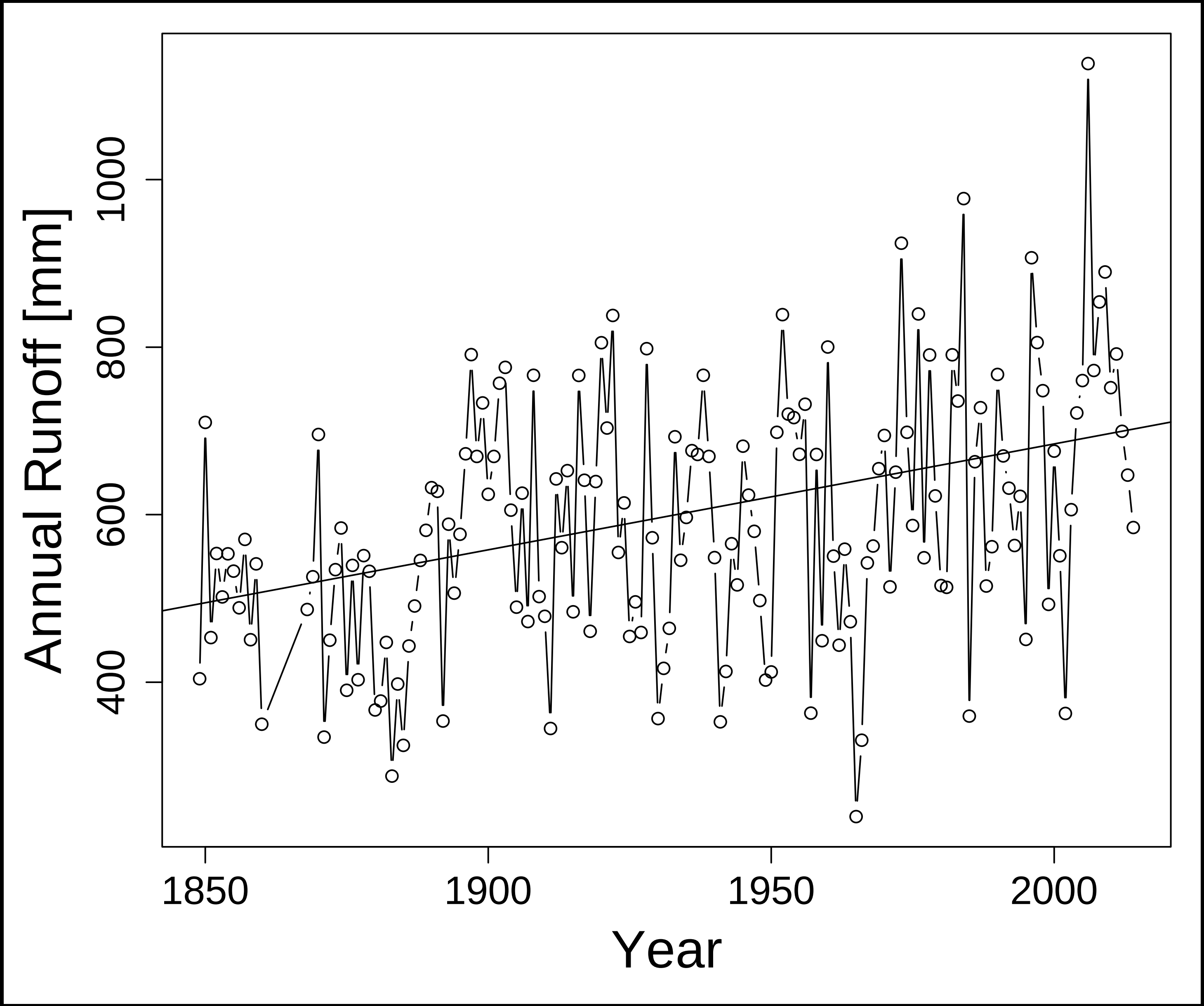
Date	July Height	July Disch.	August Height	August Disch.	September Height	September Disch.	October Height	October Disch.	November Height	November Disch.	December Height	December Disch.
1	48.07	5140	47.93	4860	48.01	5020	*		48.70	6500	48.57	6225
2	*		47.89	4780	47.82	4640	47.85	4700	48.60	6300	48.45	5950
3	48.11	5220	48.24	5500	*		47.99	4980	48.49	6030	*	
4	#		48.10	5200	47.78	4560	49.28	7860	48.12	5240	49.51	8420
5	48.58	6250	47.76	4520	47.70	4400	50.62	11300	*		49.43	8225
6	48.74	6600	*		47.74	4480	49.87	9325	49.66	8780	49.14	7550
7	48.45	5950	47.74	4480	47.70	4400	49.24	7760	51.91	14980	49.45	8275
8	48.28	5600	47.70	4400	47.68	4360	*		50.51	11025	49.78	9100
9	*		47.72	4440	47.66	4360	48.62	6340	49.68	8840	49.78	9100
10	48.03	5060	47.62	4240	*		48.37	5790	49.28	7860	*	
11	47.99	4980	47.57	4140	47.70	4400	48.35	5750	48.93	7025	50.35	10575
12	47.93	4860	47.62	4240	47.64	4280	48.20	5400	*		50.51	11025
13	47.91	4820	*		47.62	4240	48.12	5240	48.57	6225	50.20	10150
14	48.12	5240	47.66	4320	47.53	4060	48.03	5060	48.53	6125	49.70	8900
15	48.10	5200	47.62	4240	47.53	4060	*		48.51	6075	49.51	8420
16	*		47.57	4140	47.51	4020	48.01	5020	48.45	5950	49.35	8025
17	48.07	5140	47.57	4140	*		47.93	4860	48.43	5910	*	
18	47.91	4820	47.55	4100	47.87	4740	47.99	4980	48.37	5790	49.53	8460
19	47.78	4560	47.68	4360	47.87	4740	48.12	5240	*		49.62	8660
20	47.74	4480	*		48.41	5870	49.62	8660	48.28	5600	49.45	8275
21	47.66	4320	49.95	9525	48.45	5950	50.80	11800	48.20	5400	49.30	7900
22	47.58	4160	48.91	6975	48.18	5360	*		48.24	5500	49.20	7700
23	*		48.37	5790	48.16	5320	49.35	8025	48.20	5400	48.45	5950
24	47.70	4400	48.07	5140	*		48.91	6975	48.20	5400	*	
25	47.74	4480	47.95	4900	47.93	4860	48.70	6500	48.28	5600	#	
26	47.82	4640	47.89	4780	47.89	4780	48.55	6175	*		48.82	6790
27	47.80	4600	*		47.89	4780	48.53	6125	49.55	8500	49.16	7600
28	47.78	4560	47.82	4640	47.93	4860	48.45	5950	49.20	7700	48.99	7175
29	48.12	5240	47.82	4640	47.87	4740	*		48.85	6850	48.89	6930
30	*		47.78	4560	47.80	4600	48.32	5690	#		48.82	6790
31	48.12	5240	47.80	4600			48.45	5950			*	
Average		5022		4876		4688		6595		6984		8087
Maximum		6600		9525		5950		11800		14980		11025
Minimum		4160		4100		4020		4700		5240		5950
Average per sq. mi.		1.226		1.190		1.144		1.610		1.705		1.974

* Sundays
\# Holidays

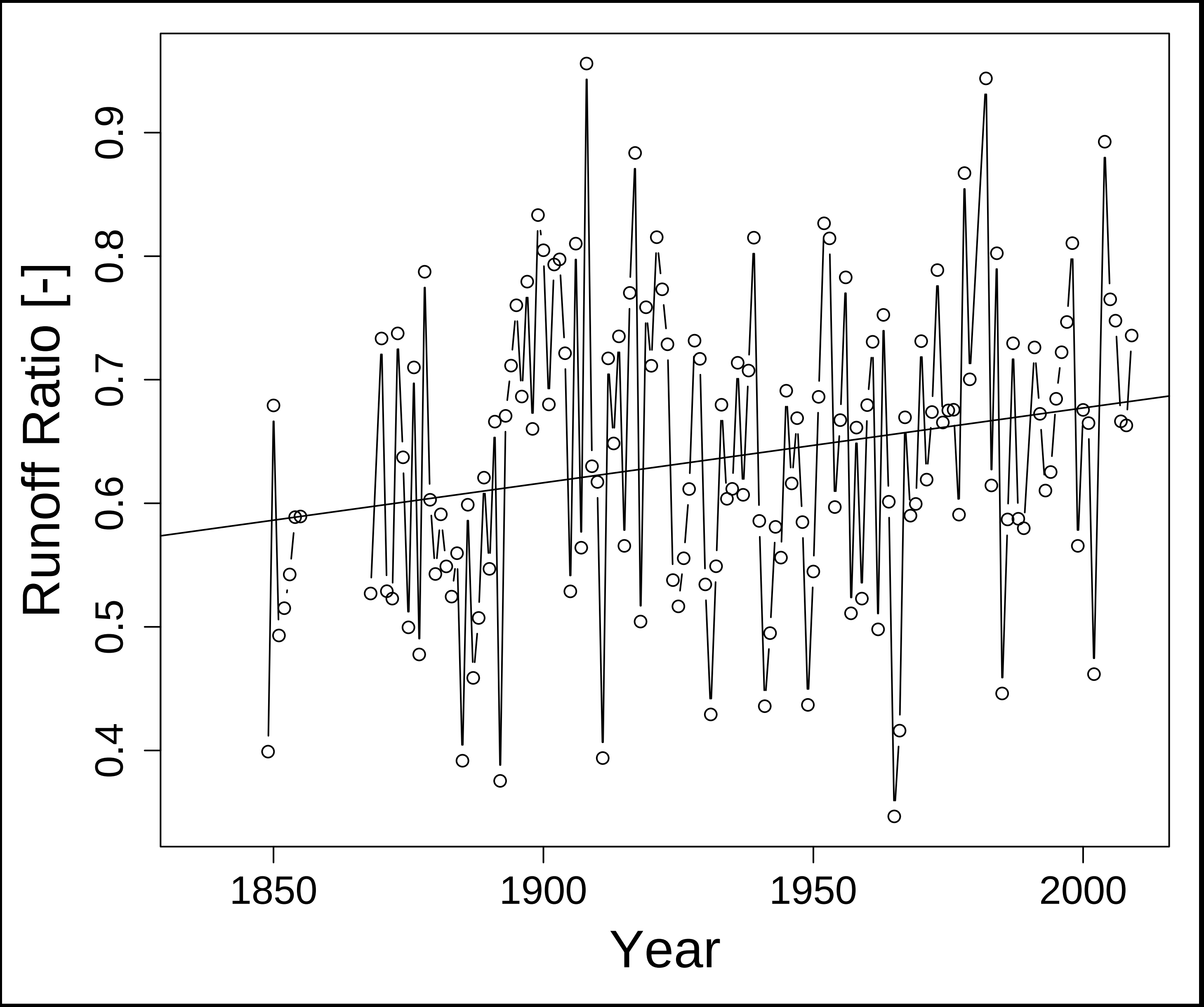
These records are taken at approximately 11:00 A. M. (General scale back of Boott Mills)
Sunday, Holidays and days when there is no running, not included in calculation.

1602

Locks and Canals Collection, Lowell National Historical Park, thanks to Jack Herlihy

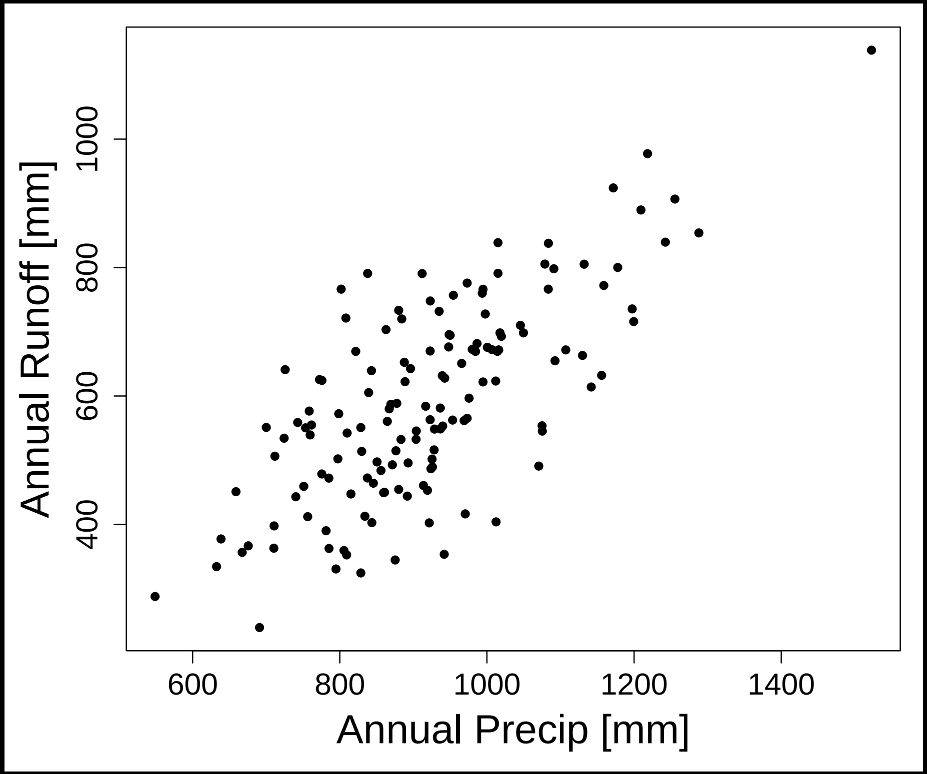


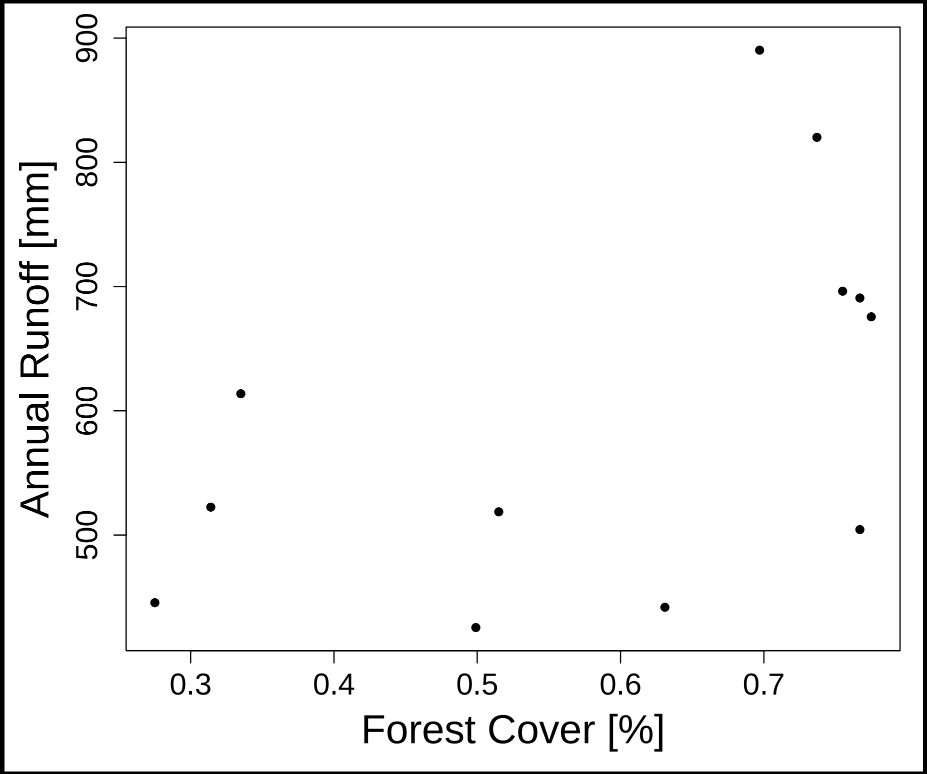
Annual Runoff [mm]
400
600
800
1000
1850
1900
1950
2000
Year



Runoff Ratio [-]
0.4
0.5
0.6
0.7
0.8
0.9
1850
1900
1950
2000
Year

Forest Cover [%]
0
20
40
60
80
100
1850
1900
1950
2000
Year





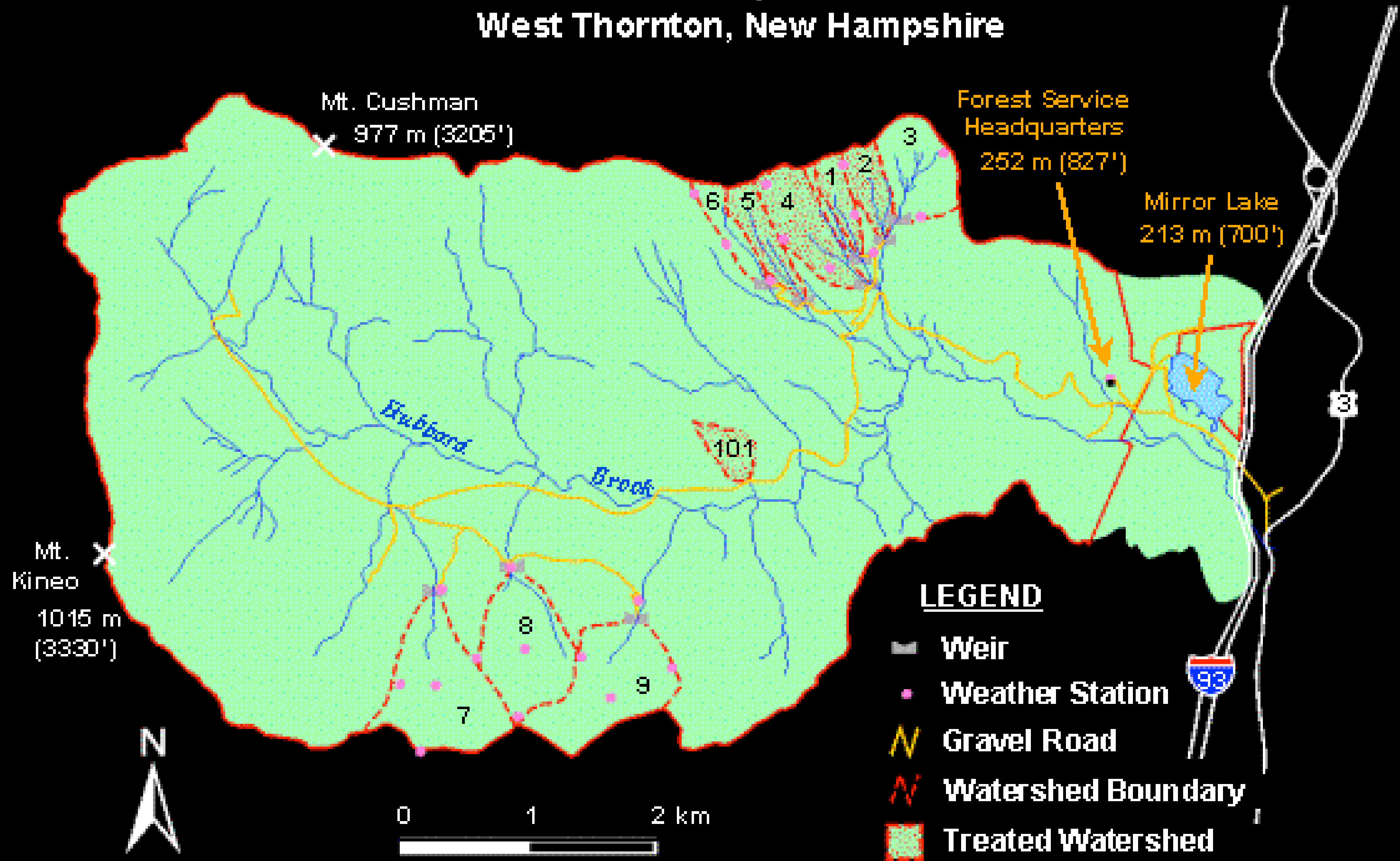
Precipitation from US Historical Climate Network
Hanover, NH

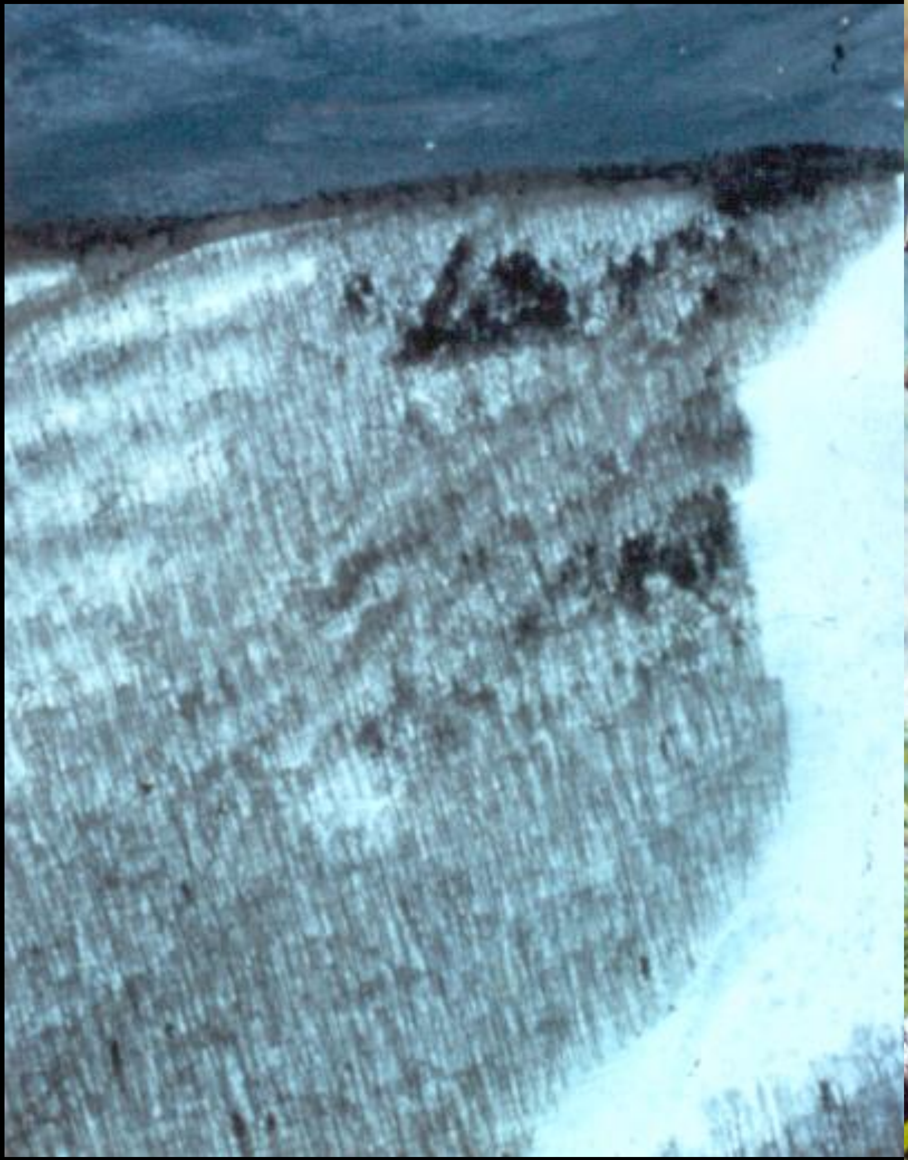
Forest data from the U.S. agricultural census
Counties clipped to Merrimack Watershed

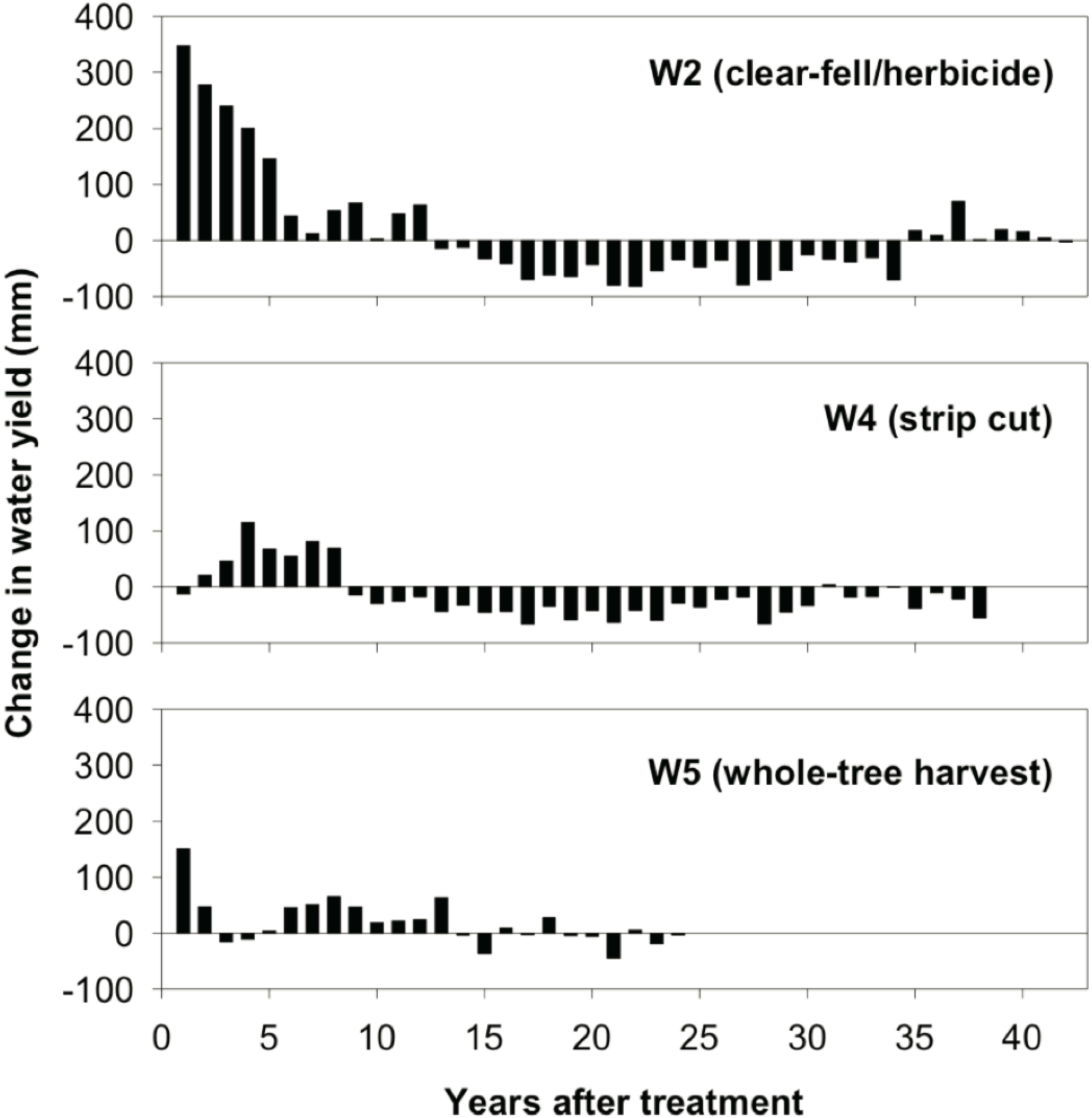
Can we explain such relative insensitivity of runoff to regional reforestation?

Hubbard Brook Experimental Forest

West Thornton, New Hampshire

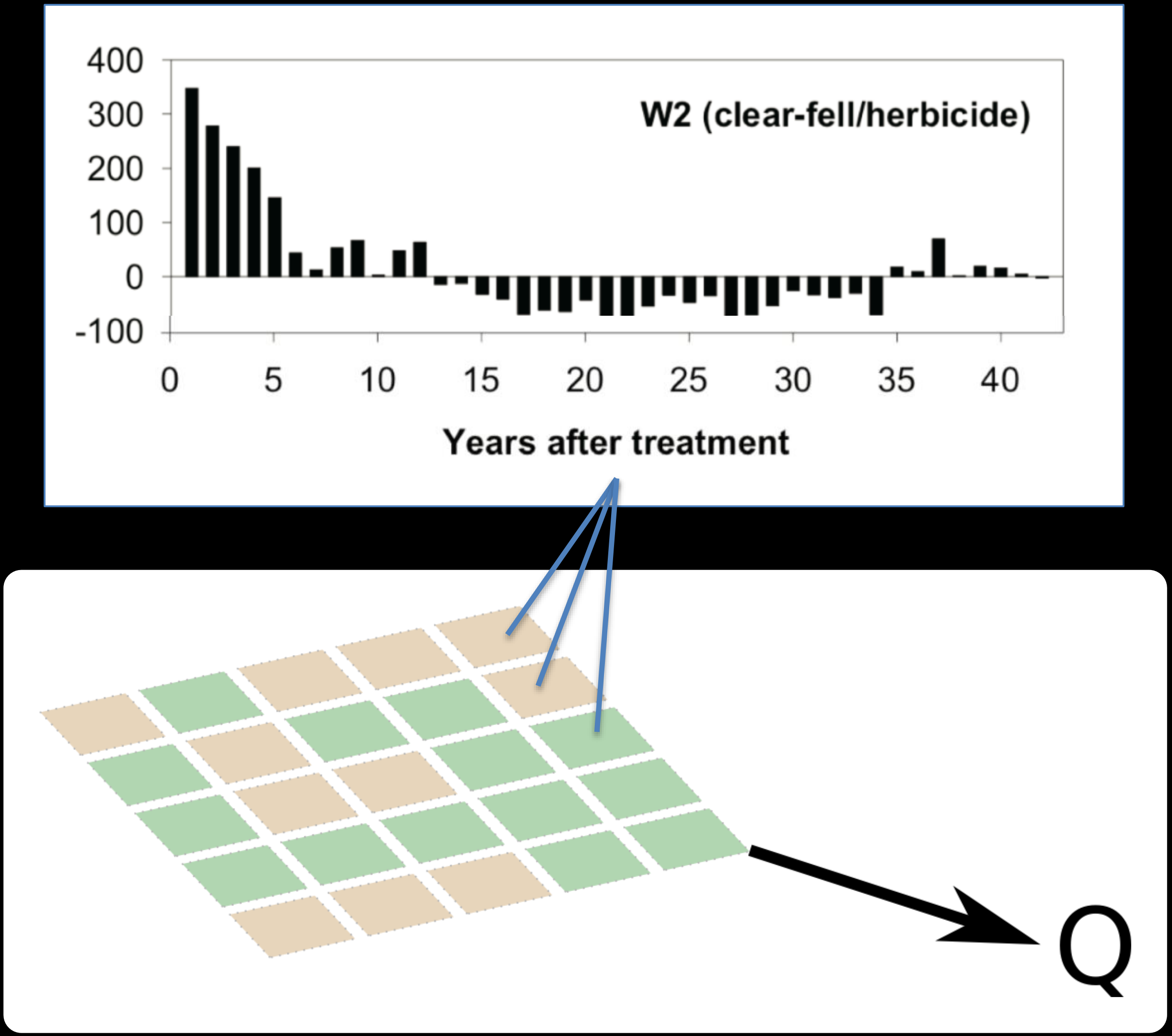




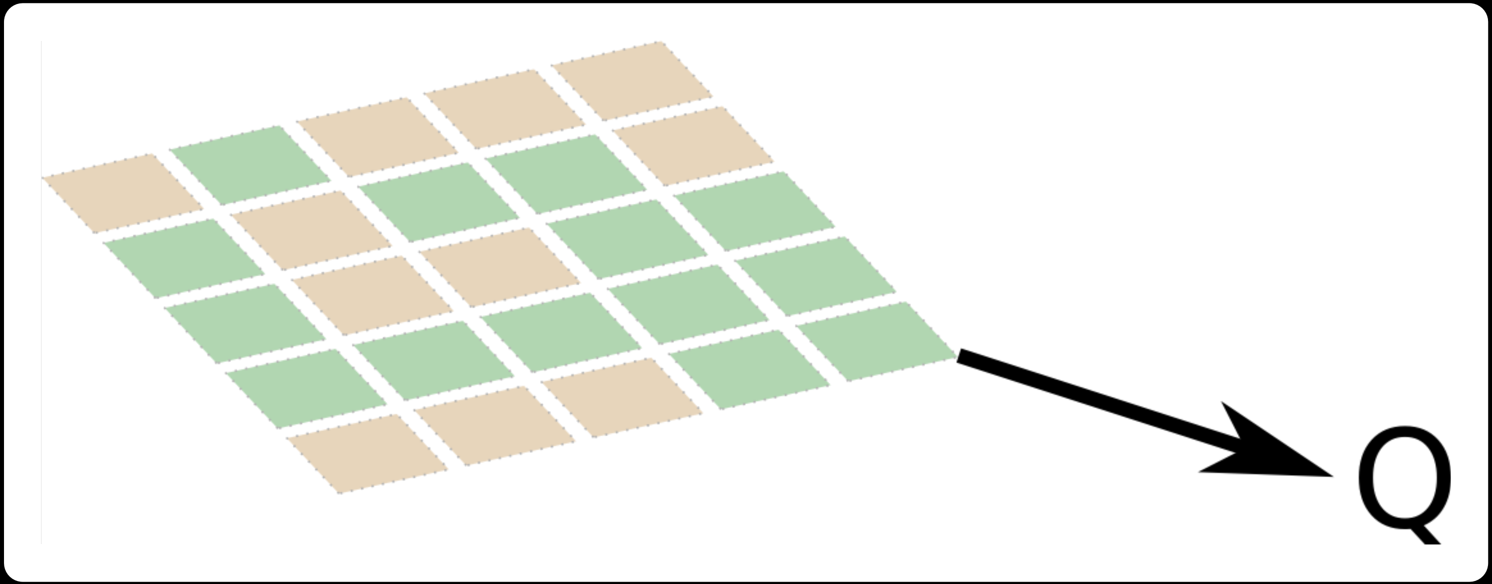



Campbell et al., 2013

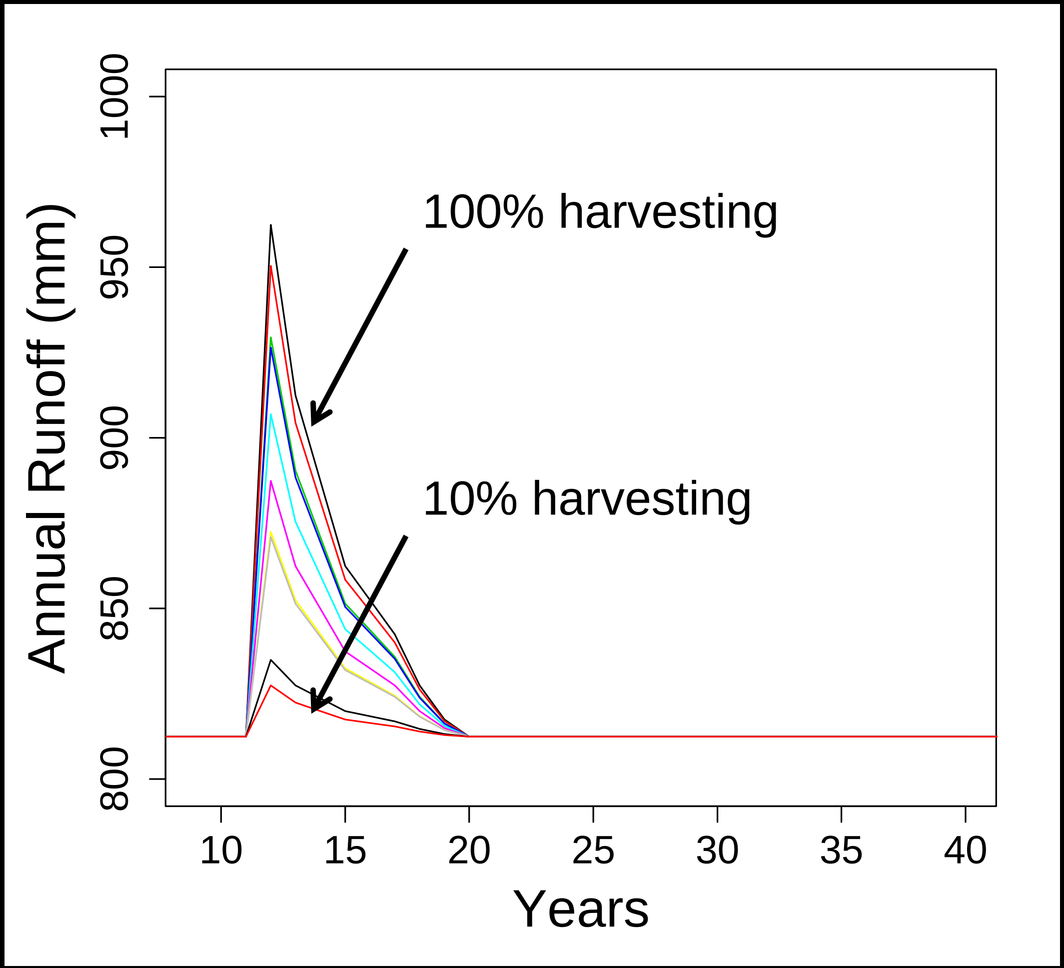
I tested a toy model to see how a large-scale watershed would respond to forest harvesting.



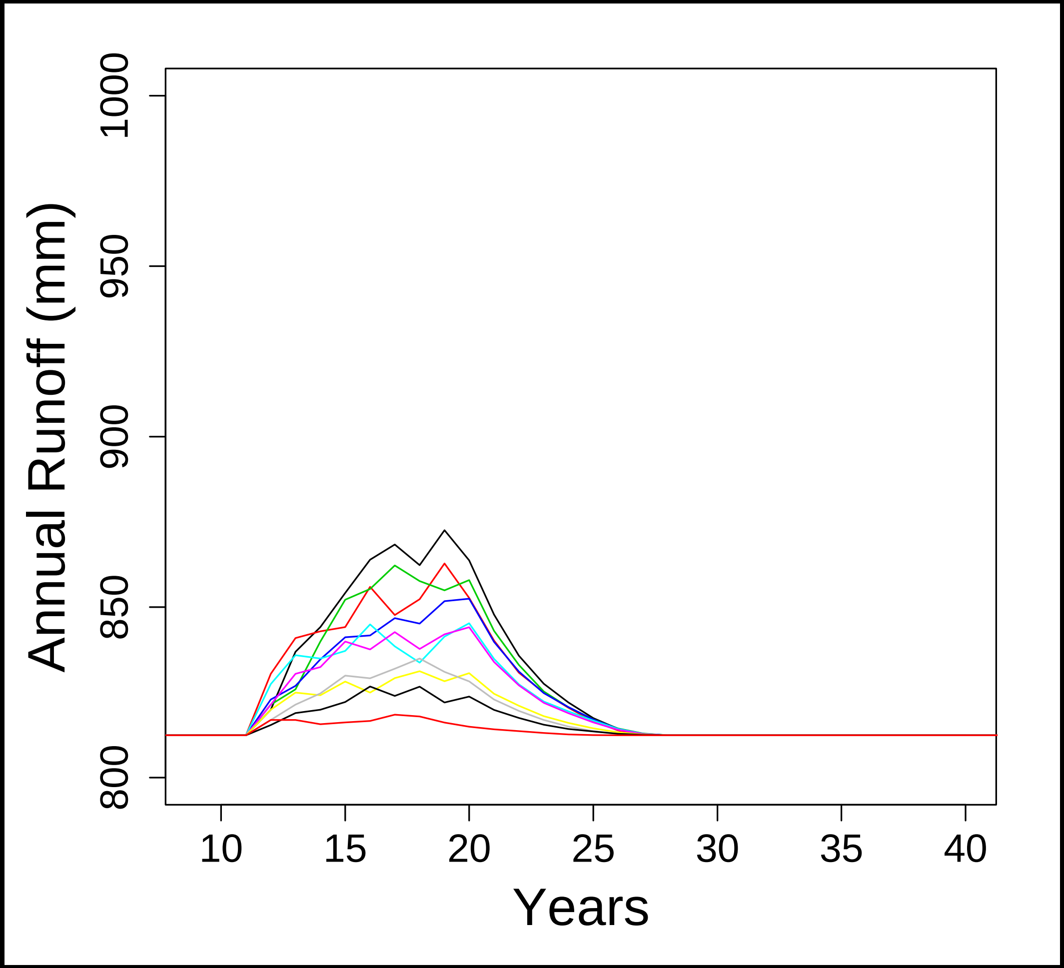
Each grid cell is randomly assigned a forest harvest intensity and year of harvest. The annual runoff is assigned to all grid cells, but can vary from year-to-year.



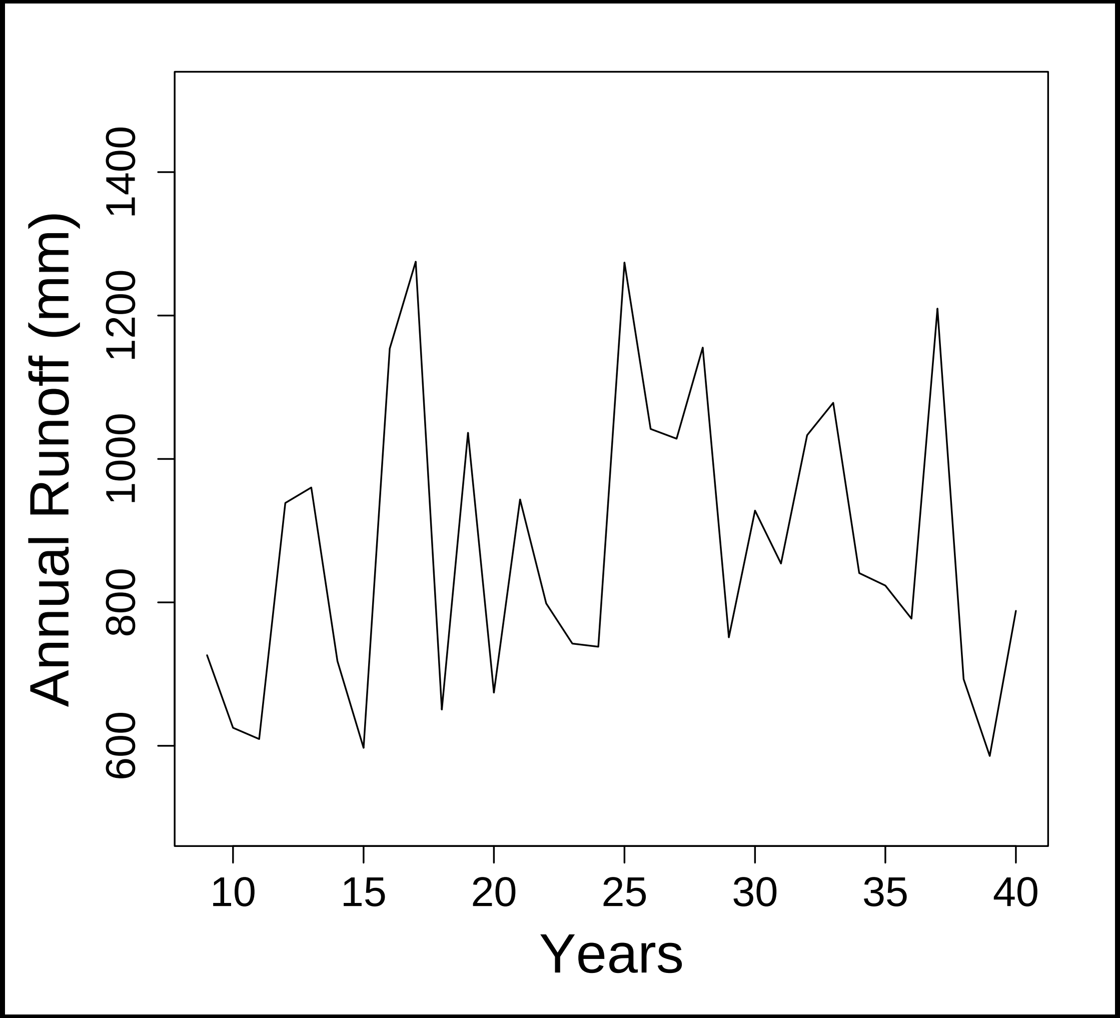
Forest harvest intensity



Synchrony of harvesting

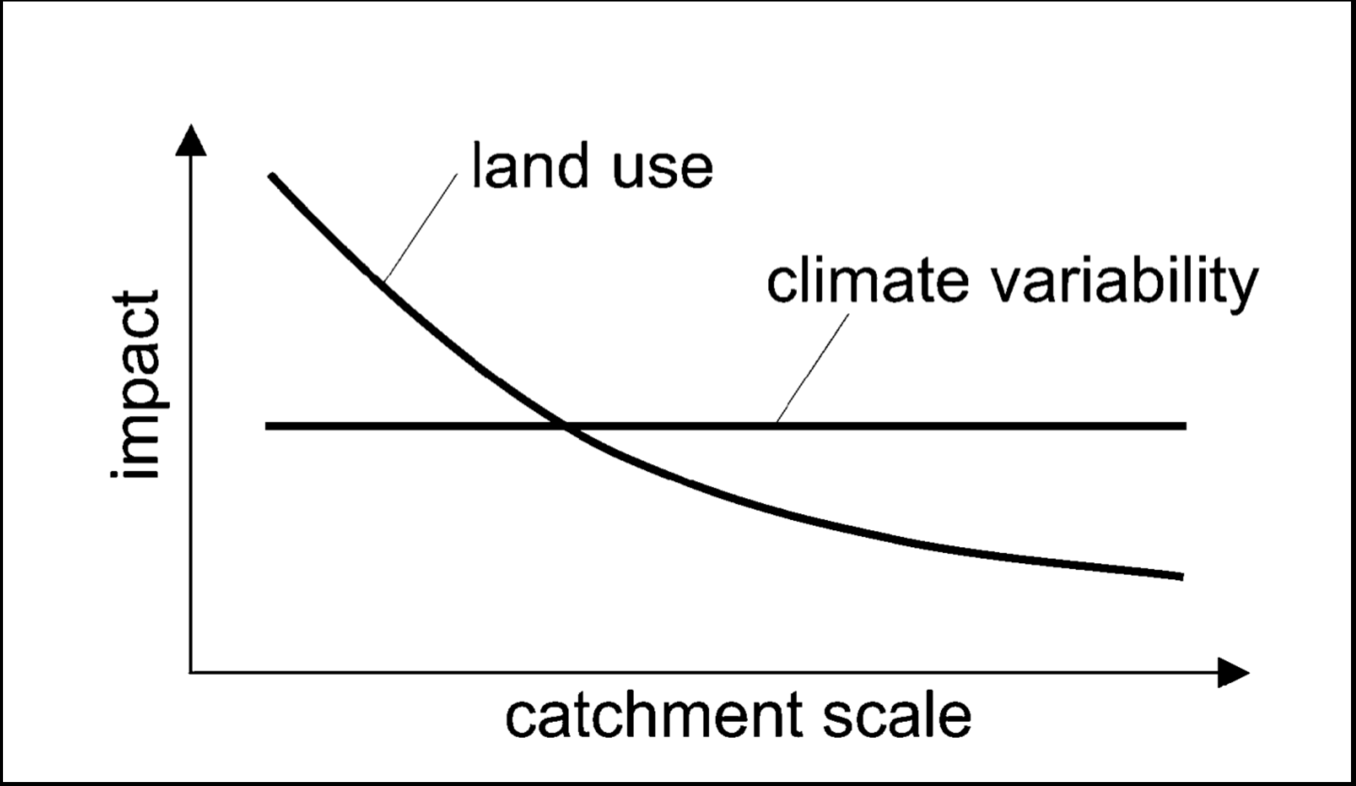


Inter-annual variability masks scenarios of asynchronous, full harvest intensity.



INVITED COMMENTARY
HP TODAY
HYDROLOGICAL PROCESSES
Hydrol. Process. **21**, 1241–1247 (2007)
Published online 14 March 2007 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hyp.6669

At what scales do climate variability and land cover change impact on flooding and low flows?



Bloschl et al. 2007

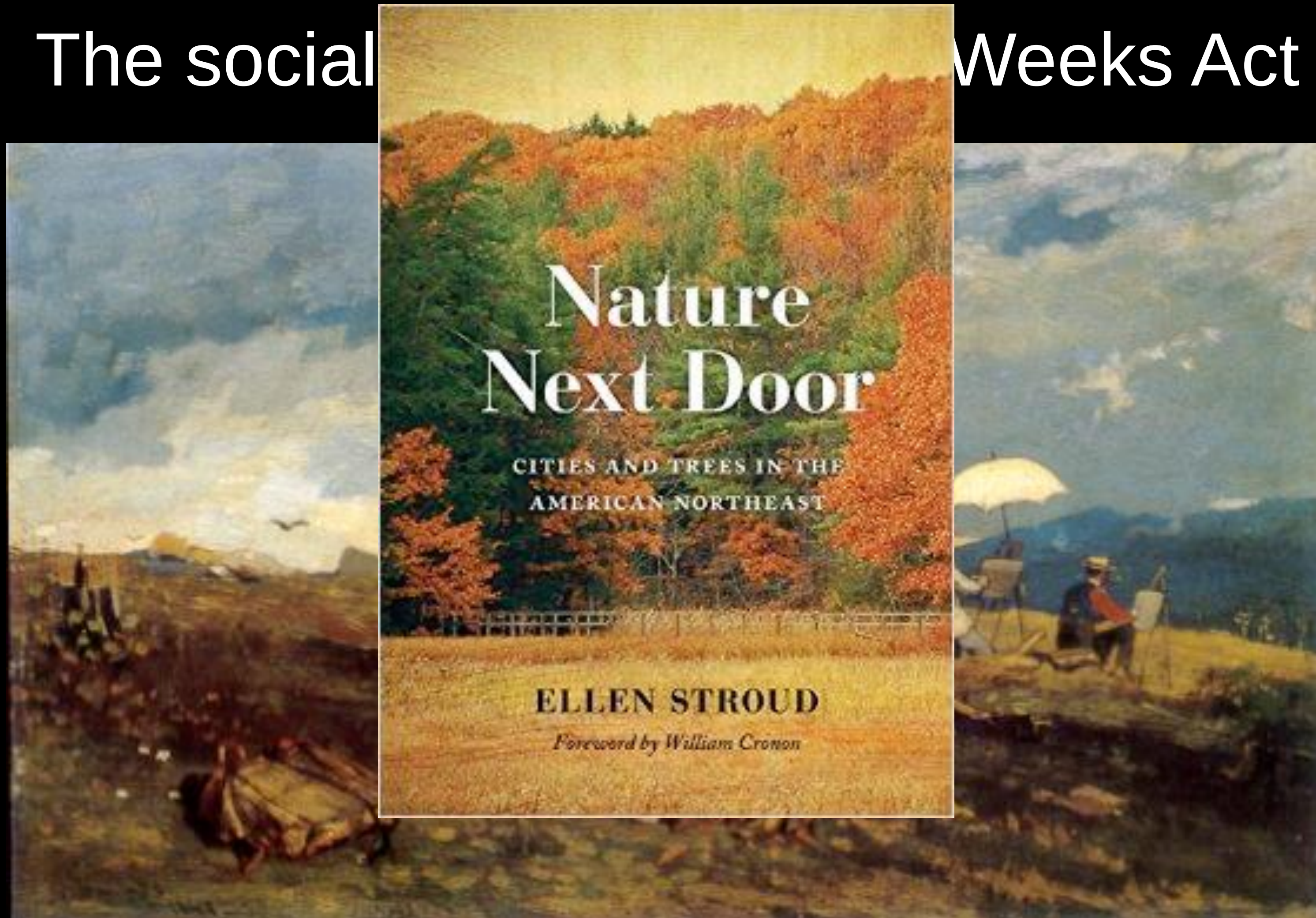
The Weeks Act, 1911

Image from PSNH archive

The Amoskeag Manufacturing Co., Manchester, New Hampshire: A History. 1915. George Waldo Browne.

“A warm rainstorm which prevailed throughout the greater portion of New England, and was especially severe in the Merrimack valley, began about noon Saturday, February 28, 1896. The rainfall continued with unceasing volume through Saturday afternoon and night, Sunday and Sunday night, and Monday morning, lasting for almost forty hours and then turned to snow. There was considerable snow on the ground at the beginning, and this had been quickly melted by the warm rain, which soon converted the brooks into rivers and the rivers into raging torrents.”

The social Weeks Act



Winslow Homer, Artists Sketching in the White Mountains, 1868.
Portland Museum of Art, Bequest of Charles Shipman Payson, 1988.55.4

Conclusions

- Resilience hypothesis cannot be rejected based on analysis of the recovery time of annual runoff. NH watersheds have been resilient.

- Climate is the driver of annual runoff and this is clear in the long term records.

These forest may look different, but they have similar hydrologic function.

Looking forward…

- Maintaining that resilience should be our focus; don’t take the system for granted.

- Longer lasting legacies arise from system structural changes: geomorphology and new vegetation species.

Acknowledgements

Jon Duncan (UNC)

John Campbell (USFS)

Dan Bain (U Pitt)

Nobu Ohte and Tomoki Oda (Kyoto U; U Tokyo)

Jack Herlihy (Lowell National Historical Park)


Thank you