TUDARE

Driftless Area Symposium

La Crosse, WI

February 7-8, 2017

Evaluating Stream Restoration Benefits: A Case Study at Pine Creek, Wisconsin

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Photo courtesy of Jeanne Kosfeld, Pine Creek Artist in Residence, 2009

Pine Creek Restoration Project: 2007-2011

TROUT UNLIMITED

WEST WISCONSIN LAND TRUST
Preserving Western Wisconsin's Natural Character

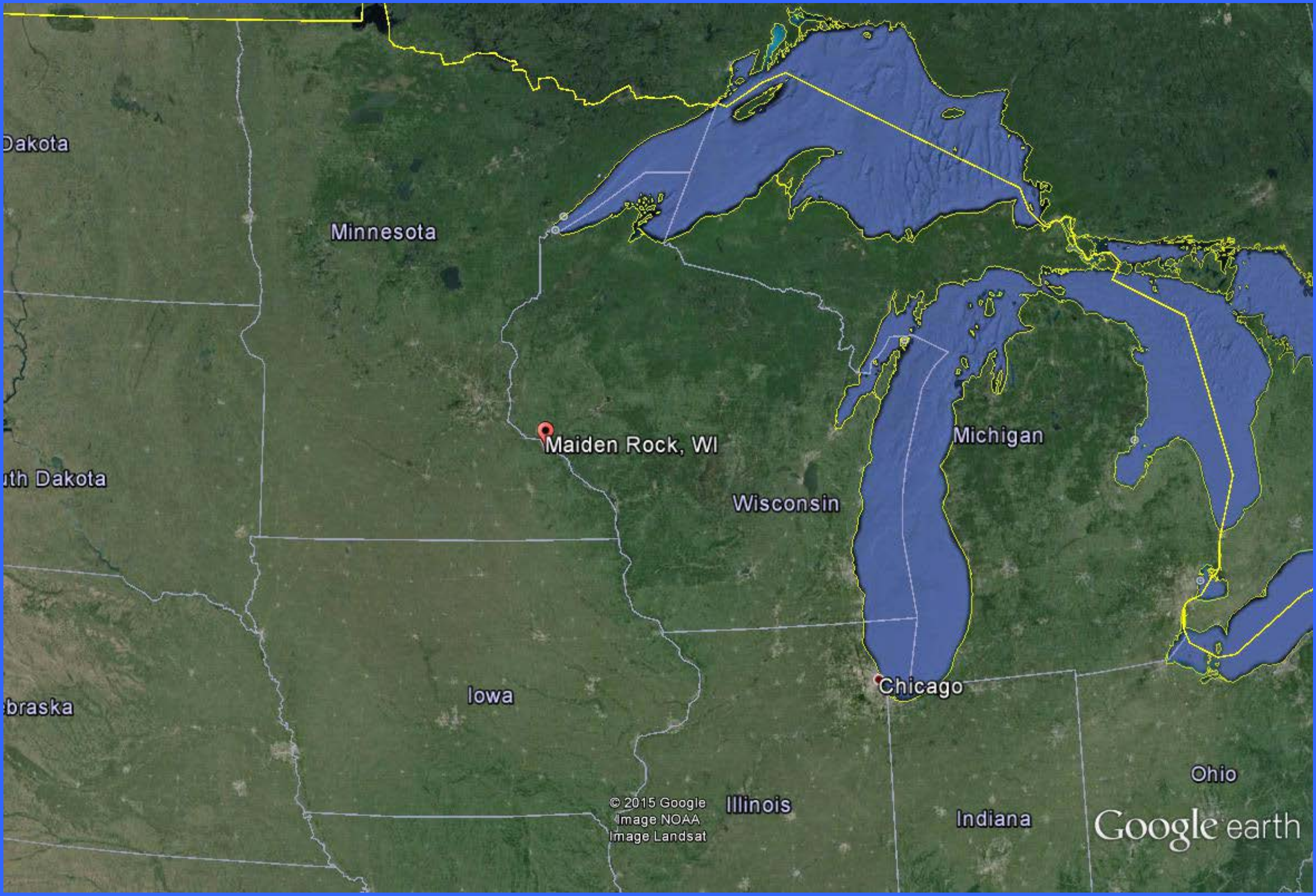
WISCONSIN DEPT. OF NATURAL RESOURCES

Maiden Rock, Wisconsin

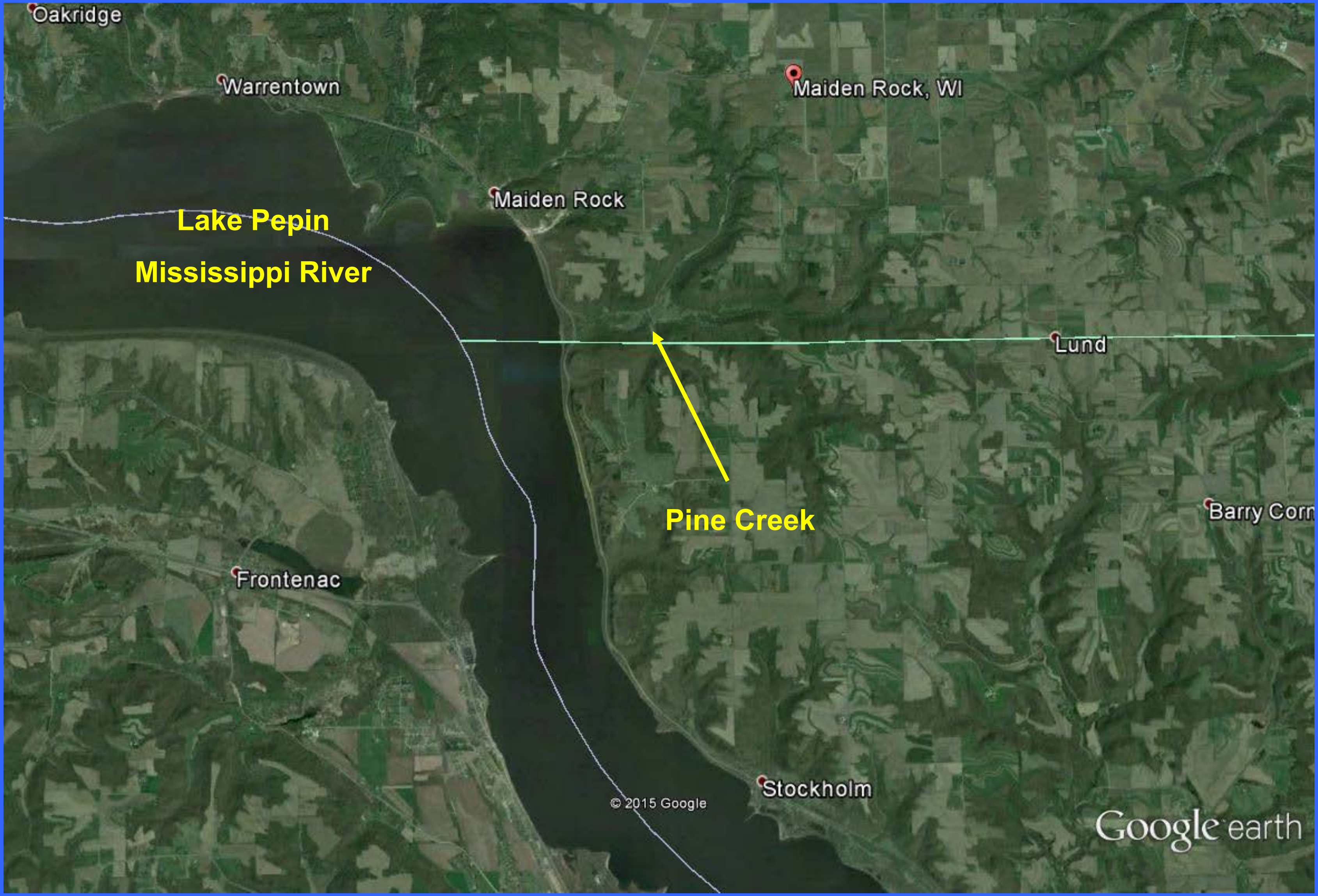
Project Background

- Pine Creek is located in Maiden Rock Township, Pierce County, WI
- Spring-fed creek, with 3 miles of permanent flow
- Drains to Mississippi River at Lake Pepin
- Watershed lies within the karst landscape of the Driftless Area
- Creek supports a wild population of Brook Trout
- Creek had excellent water quality, but severe stream bank erosion, due to poor agricultural practices and overgrazing

Pine Creek at Maiden Rock, WI



Pine Creek and Watershed
Maiden Rock, WI



Pine Creek Restoration Project: 2007-2011 Project Summary

Total Stream Length Restored: 11,167 feet (2.11 miles)

- Upper Pine Creek: 4,365 feet (0.83 mile)
- Lower Pine Creek: 4,378 feet (0.83 mile)
- North Spring Tributary: 914 feet (0.17 mile)
- South Spring Tributary: 1,380 feet (0.26 mile)
- North Branch Tributary: 130 feet (0.02 mile)

Total Restoration Cost: $270,273 ($24/foot)

The New York Times

Science Times

Tuesday, June 24, 2008

“Follow the Silt”

By Cornelia Dean

“Stream restoration is a big business with increasing popularity but patchy success. Since 1990, more than a billion dollars have been spent annually on stream restoration. Scientists wonder if it’s being done right.”
-Cornelia Dean, *New York Times*

“Many hydrologists and geologists say people embark on projects without fully understanding the waterways they want to restore and without paying enough attention to what happens after a project is finished.”
-Cornelia Dean, *New York Times*

“An awful lot of stream restoration, if not the vast majority of it, has no empirical basis. It is being done intuitively, by looks, without strong evidence. The demand is in front of the knowledge. Most agencies want to spend the money making things happen and not spending the money finding out if they work.”
-Dr. William E. Dietrich, Geomorphologist, University of California-Berkeley and NCED

“Unfortunately, we have not done enough monitoring to know what works and what doesn’t.”
-Chris Conrad, Environmental Engineer, United States Geological Survey

“Most people agree that the best approach is to create landforms and water flows that streams can maintain naturally. But how you translate that into action and at this stream rather than that stream really requires a lot of work to figure out.”
-Dr. David R. Montgomery, Geomorphologist, University of Washington

“Efforts are underway to bring more academic rigor to the stream restoration business. Many opportunities to learn from successes and failures, and thus to improve future practices, are being lost.”
-Cornelia Dean, *New York Times*

For Brook Trout, It's All About Temperature

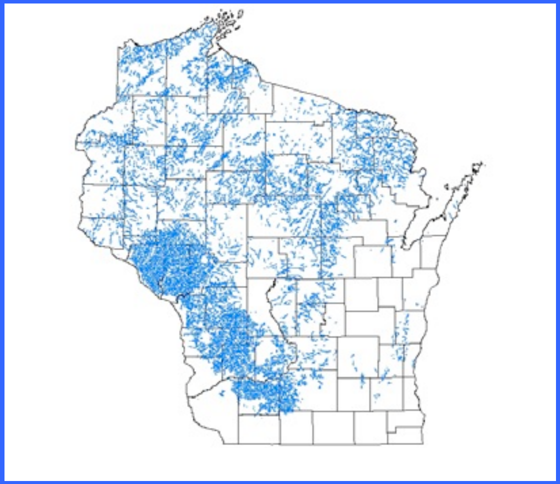
Optimum = 55-61° F (13-16° C)
Upper Thermal Limit (MWAT) = 72-74° F (22-23° C)
Upper Thermal Limit (MDAT) = 75° F (24° C)

MWAT = Maximum Weekly Average Temperature
MDAT = Maximum Daily Average Temperature

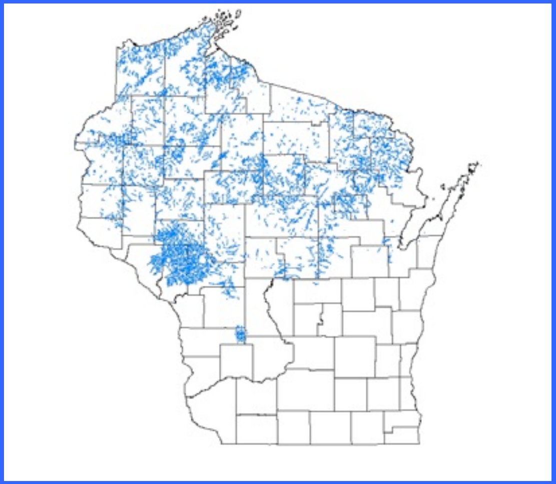
Cunningham, Diebel, Griffin, Lyons, Mitro, and Pohlman. Adaptation Strategies for Brook Trout Management in the Face of Climate Change

Brook Trout

Current climate

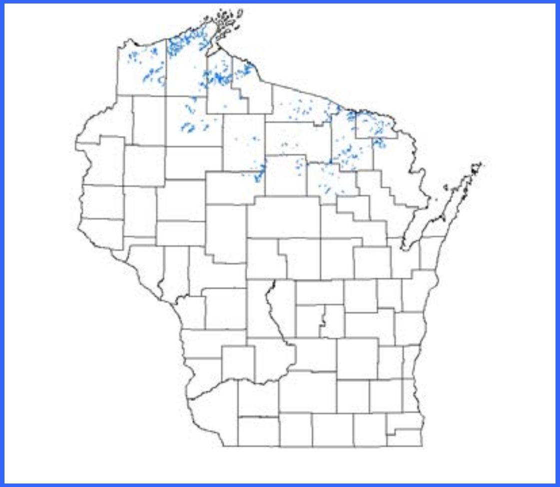


Best case (-43.6%)



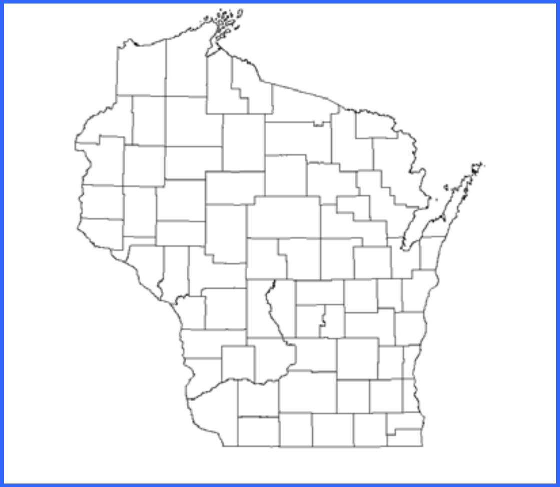
1.0 C (0.8 C)

Moderate case (-94.4%)



3.0 C (2.4 C)

Worst case (-100%)



5.0 C (4.0 C)

Mitro, M., J. Lyons, and S. Sharma. 2011. Wisconsin Initiative on Climate Change Impacts: Coldwater Fish and Fisheries Working Group Report. 31 p

Project Objectives

Measurable project objectives include:

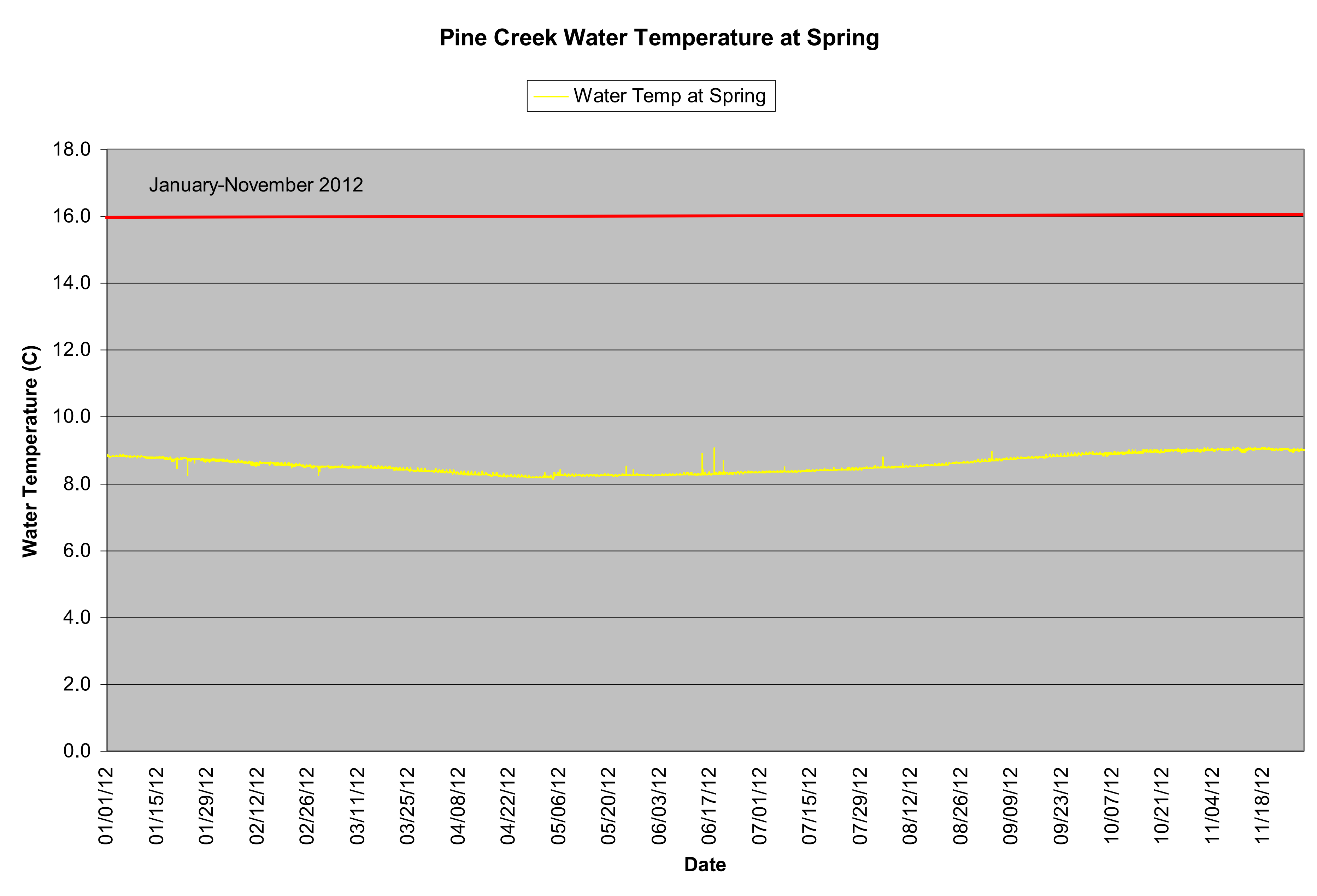
- Improve stream temperature regime and armor for climate change
- Restore 3,500 feet of stream bank and habitat in Pine Creek
- Increase numbers of Brook Trout by 40-50%
- Increase numbers of Brook Trout >/= 10 inches by 50-100%
- Reduce stream bank erosion to 10% of pre-existing conditions
- Reduce fine sediment and increase coarse bottom substrate by 50%
- Increase aquatic macrophyte growth by 25%

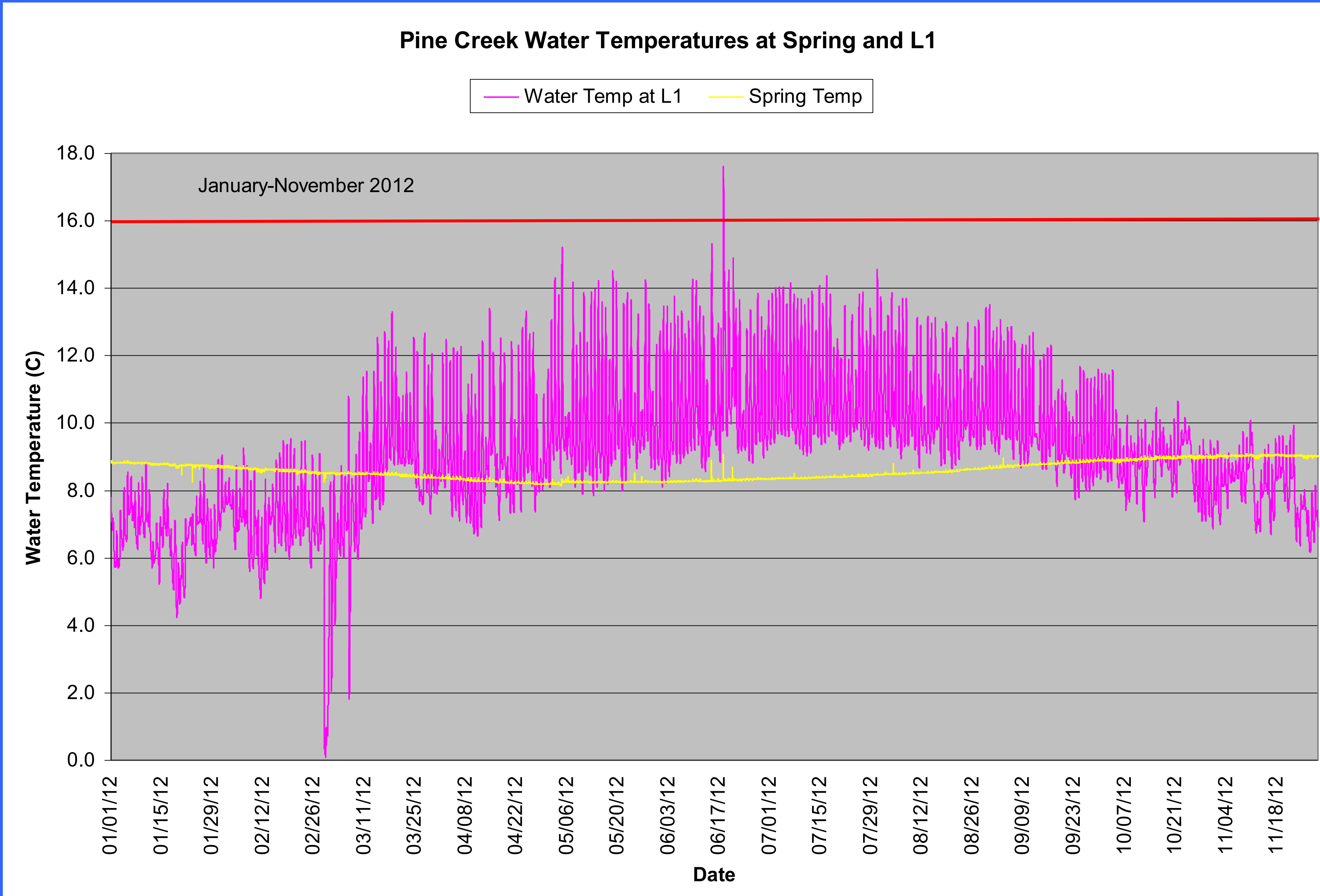
TUDARE Stream Monitoring Protocols

September 2011

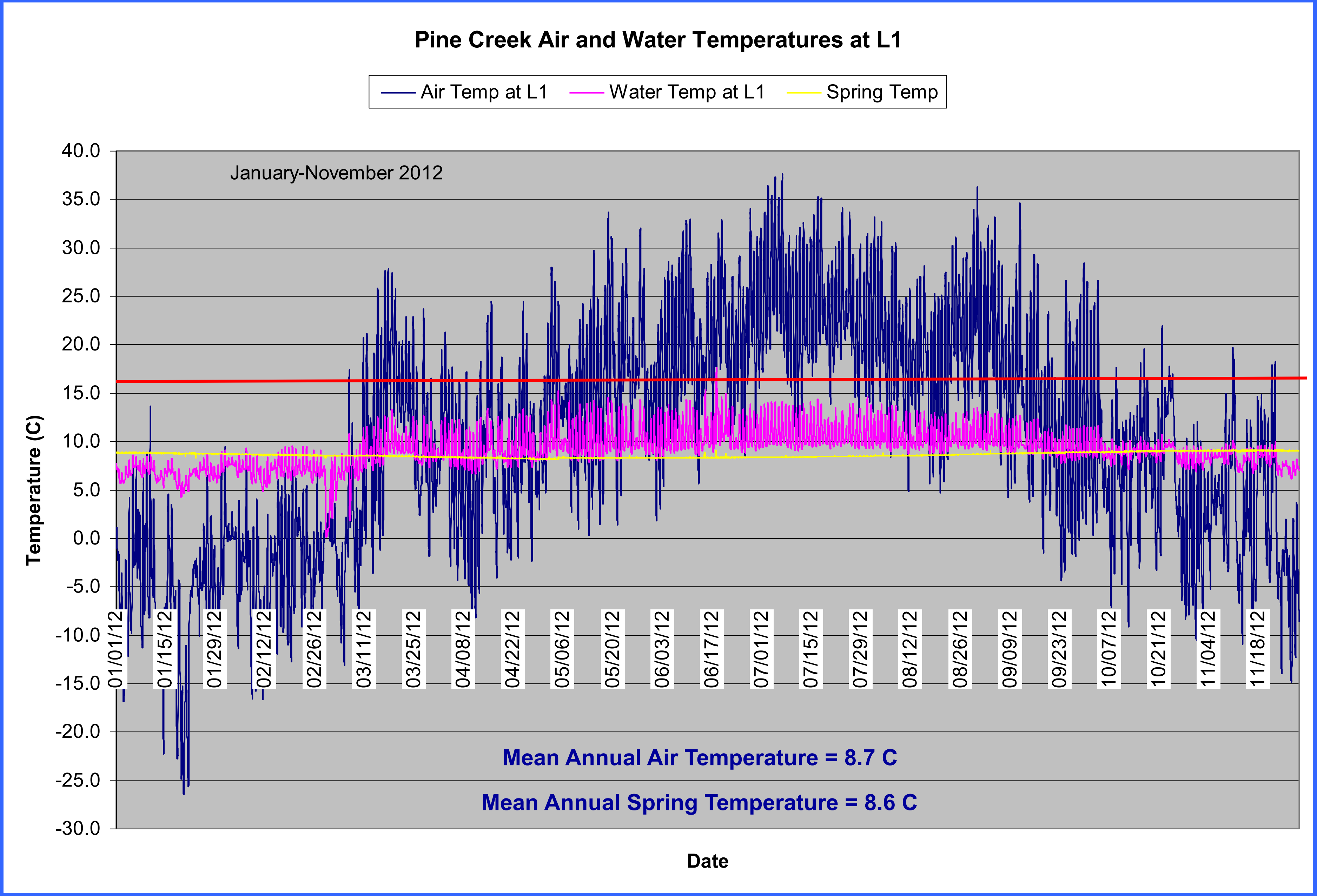
Jeff Hastings, TUDARE Project Manager, Trout Unlimited
Kent Johnson, Kiap-TU-Wish Chapter, Trout Unlimited
Matthew Mitro, Coldwater Fisheries Research Scientist, WDNR

Pine Creek: Stream Temperature Monitoring Sites

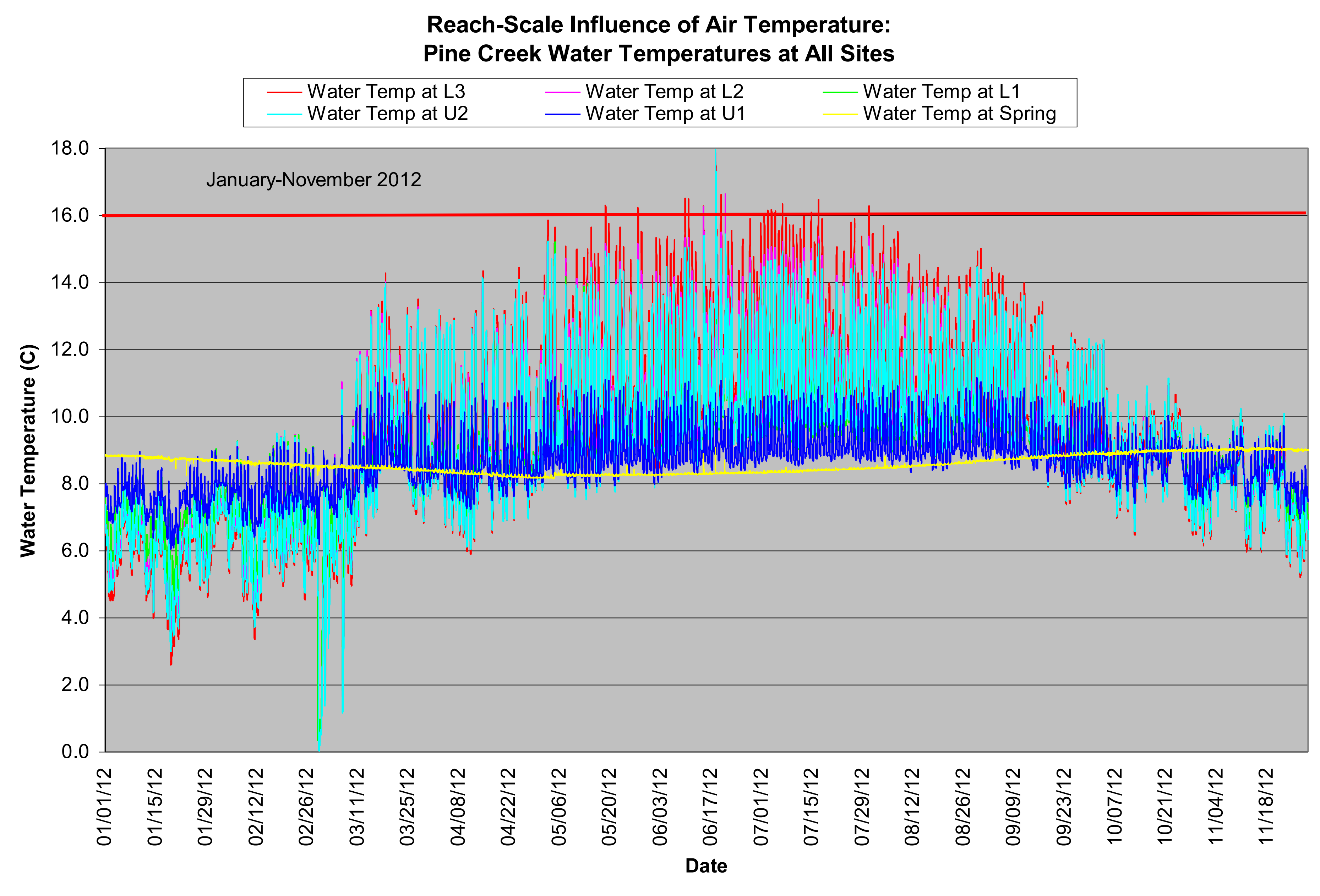

Pine Creek Water Temperature at Spring
Water Temp at Spring
January-November 2012
Water Temperature (C)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
01/01/12
01/15/12
01/29/12
02/12/12
02/26/12
03/11/12
03/25/12
04/08/12
04/22/12
05/06/12
05/20/12
06/03/12
06/17/12
07/01/12
07/15/12
07/29/12
08/12/12
08/26/12
09/09/12
09/23/12
10/07/12
10/21/12
11/04/12
11/18/12
Date



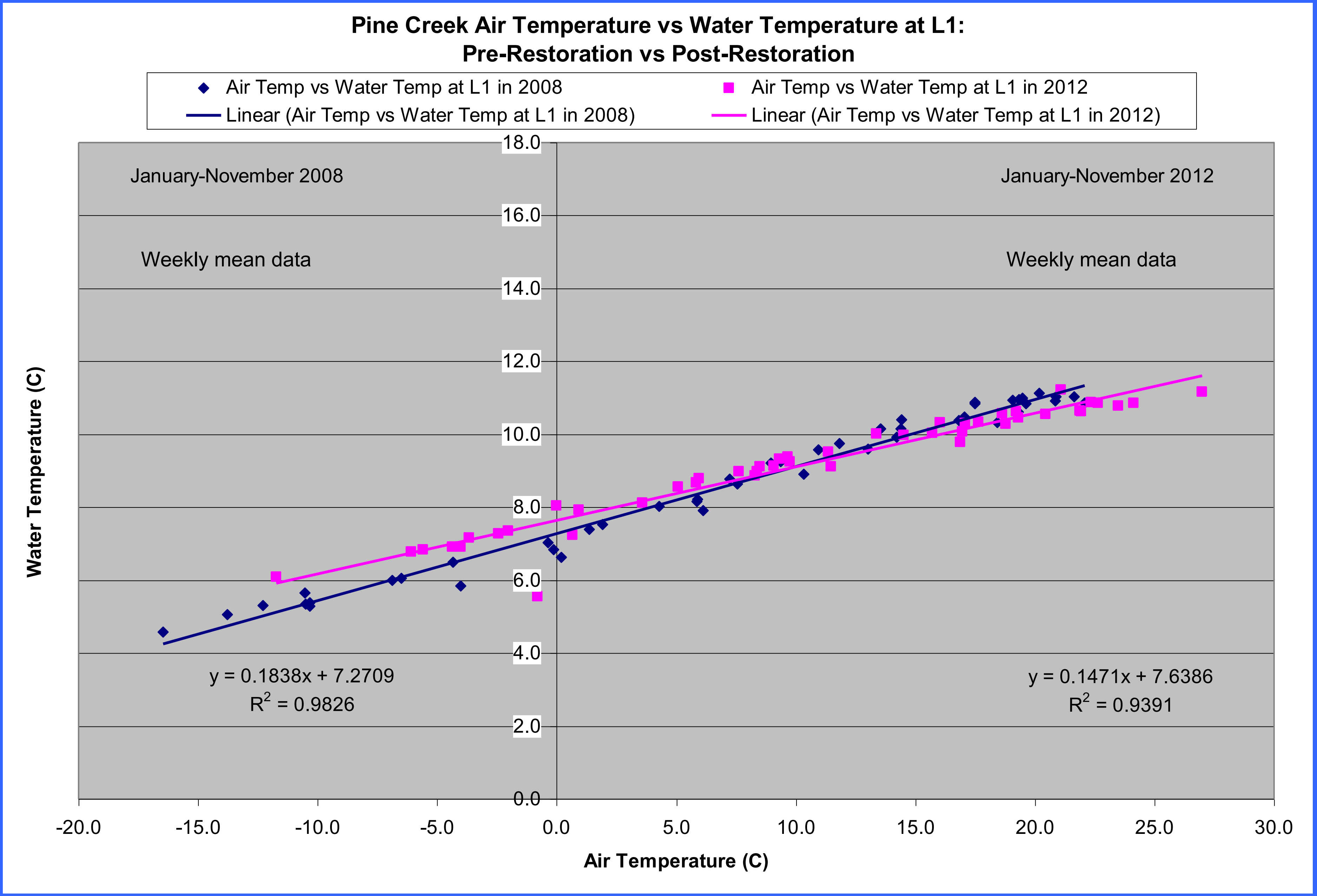
Pine Creek Water Temperatures at Spring and L1
Water Temp at L1
Spring Temp
January-November 2012
Water Temperature (C)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
01/01/12
01/15/12
01/29/12
02/12/12
02/26/12
03/11/12
03/25/12
04/08/12
04/22/12
05/06/12
05/20/12
06/03/12
06/17/12
07/01/12
07/15/12
07/29/12
08/12/12
08/26/12
09/09/12
09/23/12
10/07/12
10/21/12
11/04/12
11/18/12
Date



Pine Creek Air and Water Temperatures at L1
Air Temp at L1
Water Temp at L1
Spring Temp
January-November 2012
Temperature (C)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
01/01/12
01/15/12
01/29/12
02/12/12
02/26/12
03/11/12
03/25/12
04/08/12
04/22/12
05/06/12
05/20/12
06/03/12
06/17/12
07/01/12
07/15/12
07/29/12
08/12/12
08/26/12
09/09/12
09/23/12
10/07/12
10/21/12
11/04/12
11/18/12
Mean Annual Air Temperature = 8.7 C
Mean Annual Spring Temperature = 8.6 C
Date



Reach-Scale Influence of Air Temperature:
Pine Creek Water Temperatures at All Sites
Water Temp at L3
Water Temp at L2
Water Temp at L1
Water Temp at U2
Water Temp at U1
Water Temp at Spring
January-November 2012
Water Temperature (C)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
01/01/12
01/15/12
01/29/12
02/12/12
02/26/12
03/11/12
03/25/12
04/08/12
04/22/12
05/06/12
05/20/12
06/03/12
06/17/12
07/01/12
07/15/12
07/29/12
08/12/12
08/26/12
09/09/12
09/23/12
10/07/12
10/21/12
11/04/12
11/18/12
Date



Krider, L.A. 2012. Air-water temperature relationships in the trout streams of southeastern Minnesota's carbonate-sandstone landscape: implications for climate change, brown trout biological processes, and land management. M.S. Thesis. University of Minnesota. 50 p.

For Brook Trout, It's All About Temperature

Most Important Factors Controlling Summer Stream Temperatures*:

Inflow of cold groundwater
Shade provided by riparian vegetation
Stream channel width

*Gaffield, Potter, and Wang. 2005. Predicting the summer temperature of small streams in southwestern Wisconsin. Journal of the American Water Resources Association 41 (1): 25-36

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Pre- and Post-Restoration Habitat Assessment Methods

Four Key Habitat Features (Greatest impact on stream temperature):

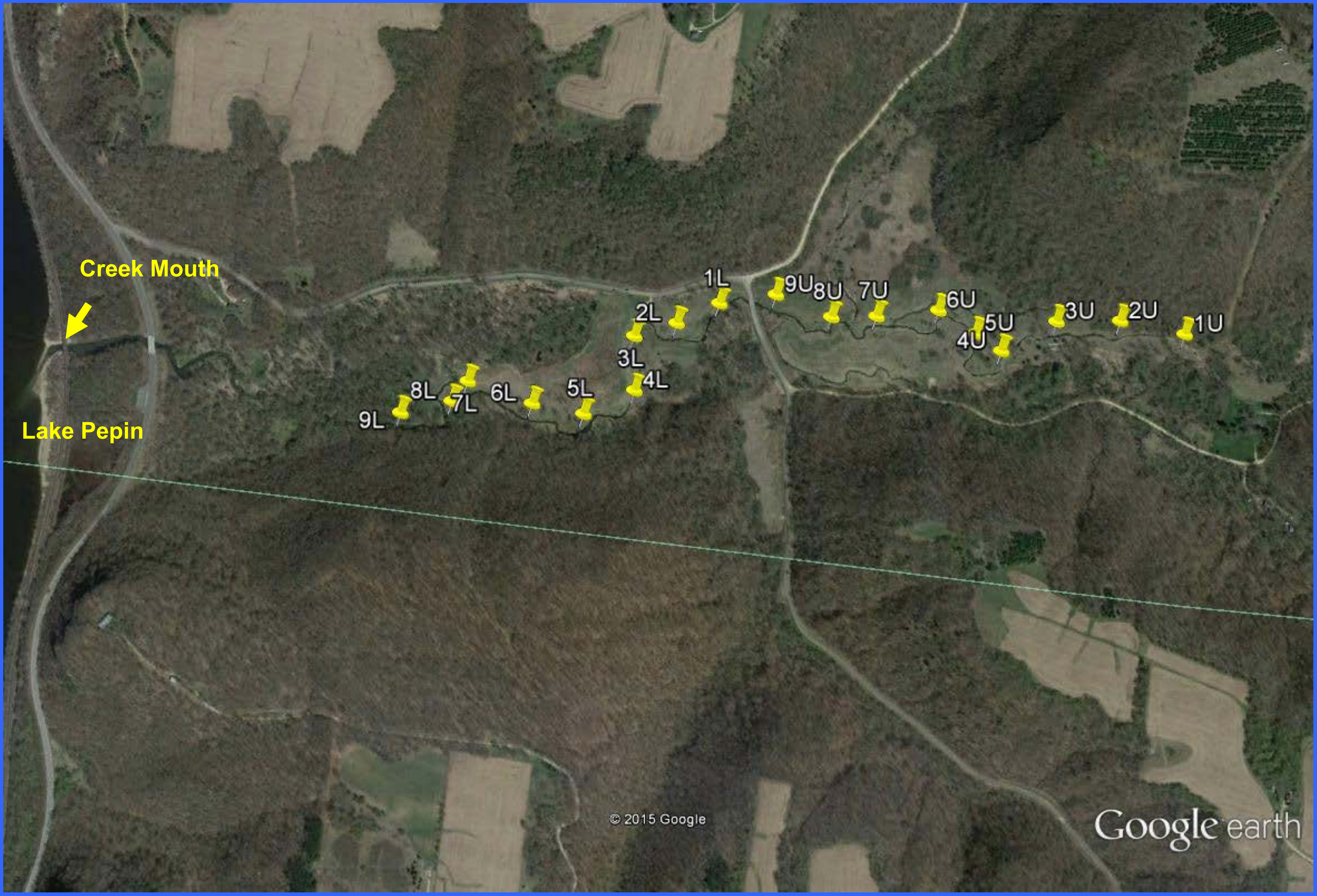
- Stream Width (water's edge to water's edge)
- Water Depth (quarter points + 2 near-bank locations)
- Water Velocity (quarter points + 2 near-bank locations)
- Canopy Cover (4 measurements, facing N, E, S, W)

TUDARE
Pre- and Post-Restoration
Habitat Assessment Methods

Other Key Habitat Features and Biota:

- Stream bank height, depth, slope, soil type, vegetation
- Stream bed substrate composition and embeddedness
- Presence of aquatic vegetation (macrophytes and periphyton)

Pine Creek: Habitat Assessment Sites



Can Stream Restoration Provide Resilience to Climate Change?

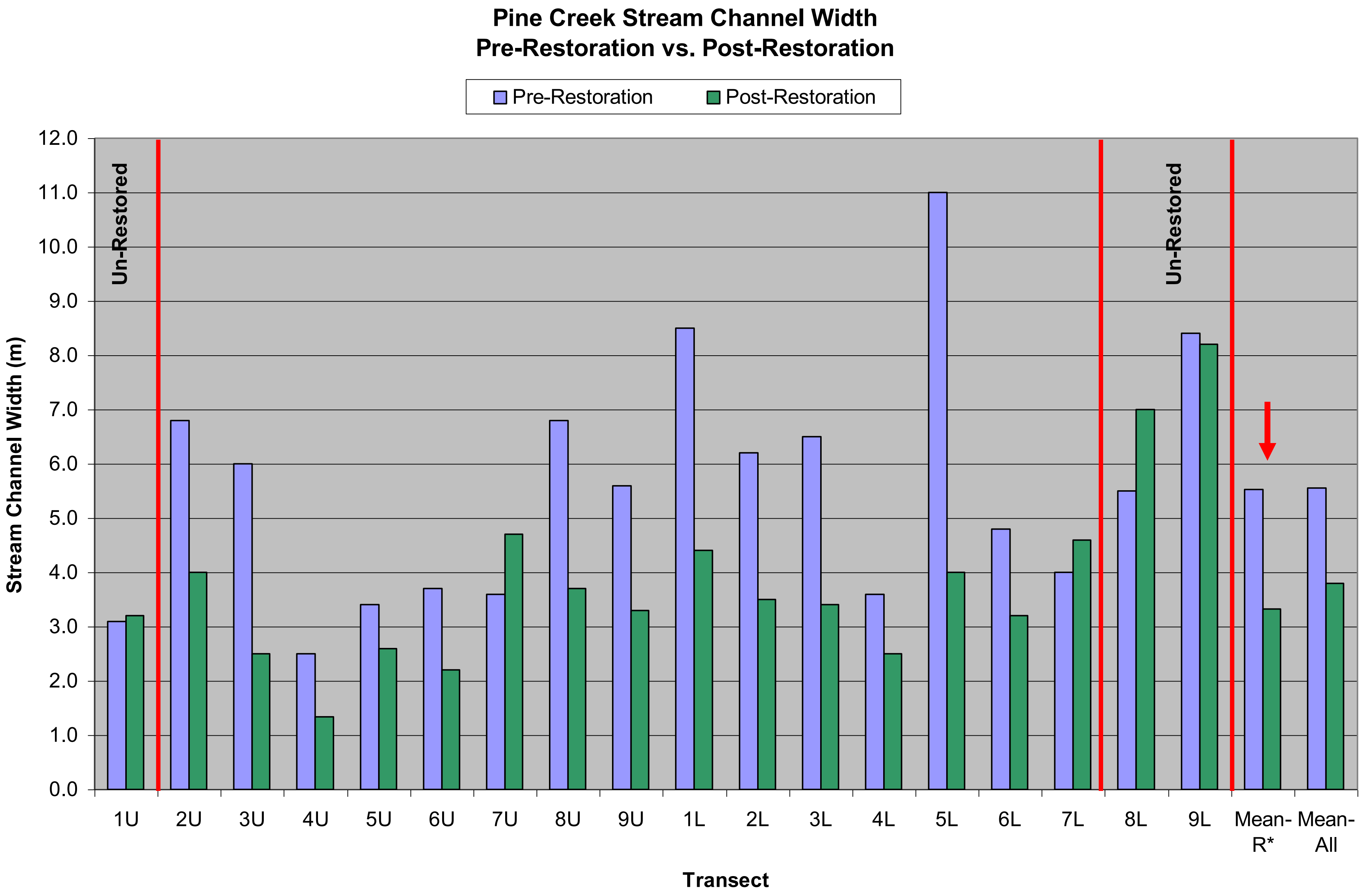
Improve stream temperature regime by facilitating groundwater flow through the restoration reach, thereby minimizing air temperature exposure:

- Narrowing the stream channel
- Deepening the stream channel
- Increasing current velocity and reducing travel time
- Providing canopy cover

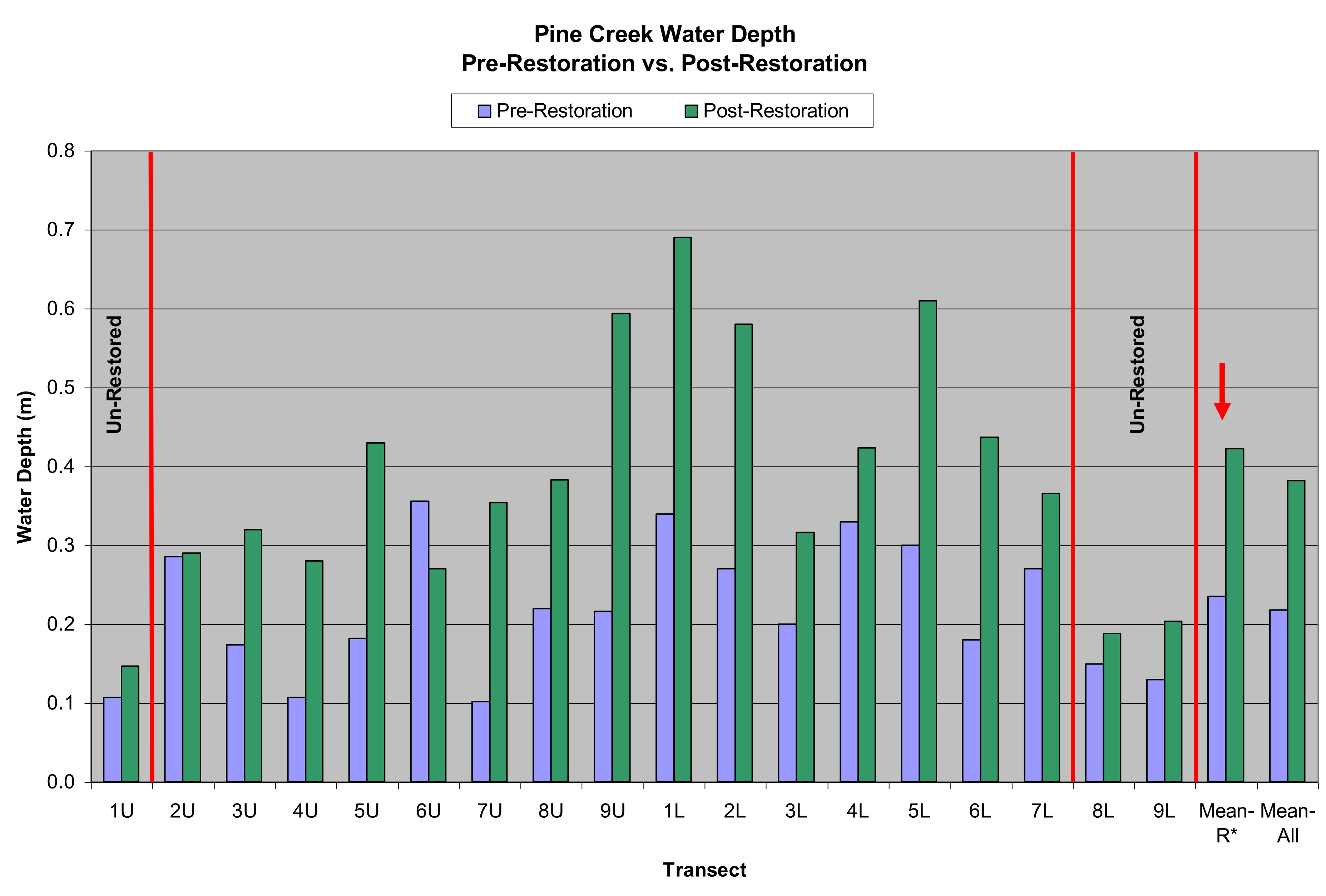
Promote Groundwater Conveyance

Before

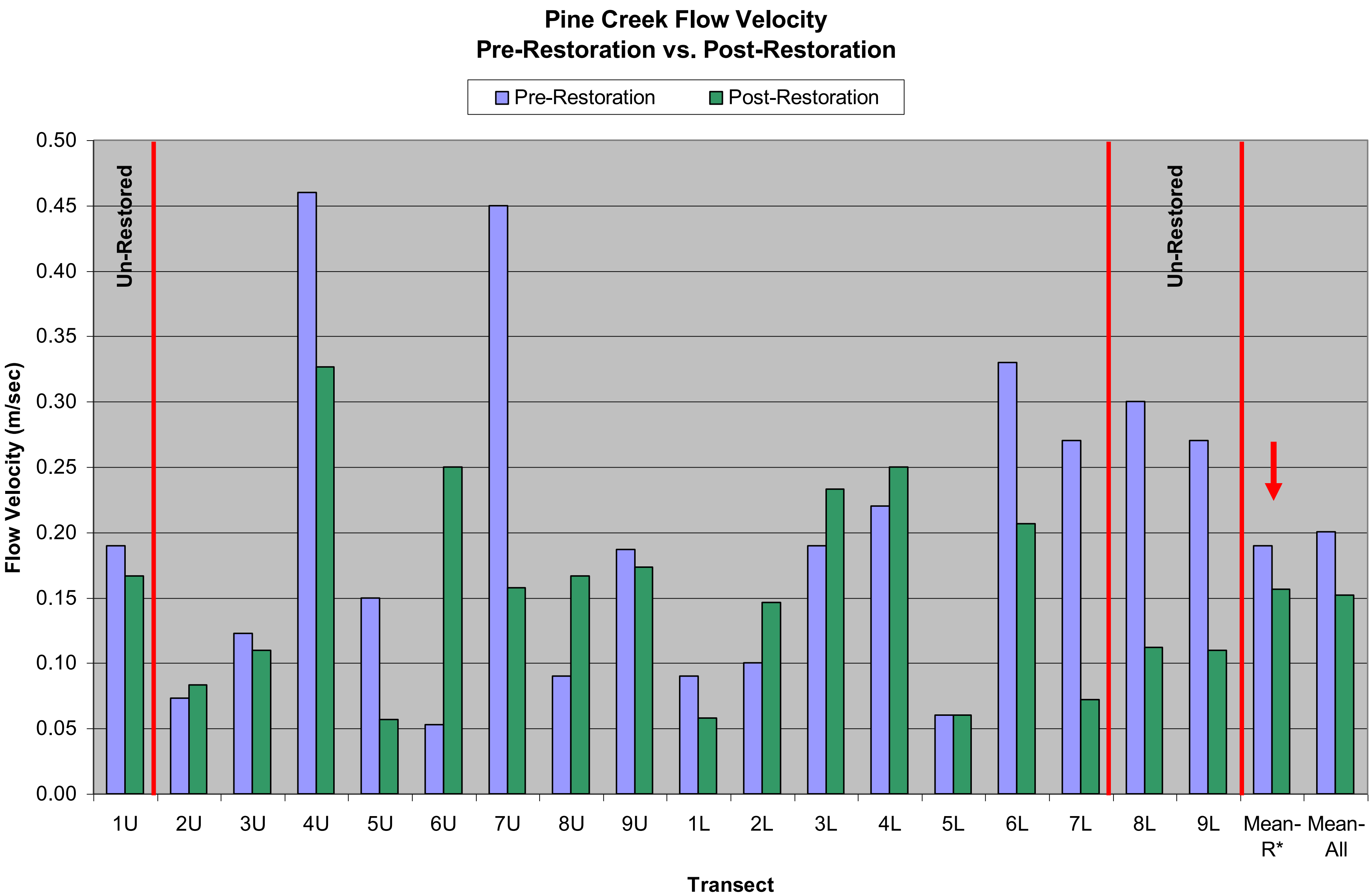
After



Pine Creek Stream Channel Width
Pre-Restoration vs. Post-Restoration
Pre-Restoration
Post-Restoration
Stream Channel Width (m)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Un-Restored
Un-Restored
1U
2U
3U
4U
5U
6U
7U
8U
9U
1L
2L
3L
4L
5L
6L
7L
8L
9L
Mean-R*
Mean-All
Transect



Pine Creek Water Depth
Pre-Restoration vs. Post-Restoration
Pre-Restoration
Post-Restoration
Water Depth (m)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Un-Restored
Un-Restored
1U
2U
3U
4U
5U
6U
7U
8U
9U
1L
2L
3L
4L
5L
6L
7L
8L
9L
Mean-R*
Mean-All
Transect

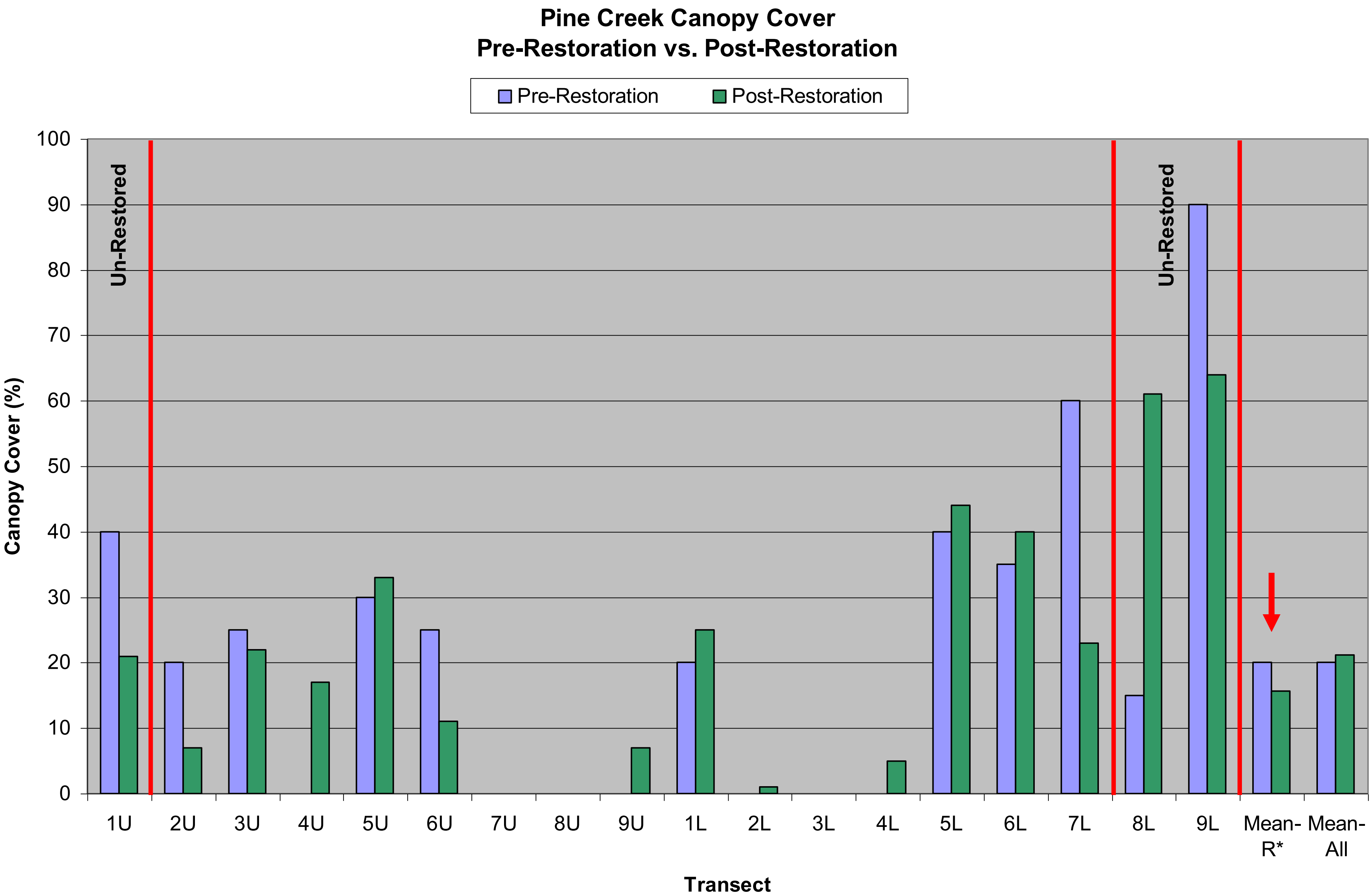


Pine Creek Flow Velocity
Pre-Restoration vs. Post-Restoration
Pre-Restoration
Post-Restoration
Flow Velocity (m/sec)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Un-Restored
Un-Restored
1U
2U
3U
4U
5U
6U
7U
8U
9U
1L
2L
3L
4L
5L
6L
7L
8L
9L
Mean-R*
Mean-All
Transect

Post-Restoration Factors Influencing Flow Velocity in Pine Creek

Boulders at Site 6L

Macrophytes at Site 7L



Pine Creek Canopy Cover
Pre-Restoration vs. Post-Restoration
Pre-Restoration
Post-Restoration
Canopy Cover (%)
100
90
80
70
60
50
40
30
20
10
0
Un-Restored
Un-Restored
1U
2U
3U
4U
5U
6U
7U
8U
9U
1L
2L
3L
4L
5L
6L
7L
8L
9L
Mean-R*
Mean-All
Transect

Pine Creek Macroinvertebrate Assessment

Kick Sampling (Pre- and Post-Restoration)

6 Sites in Upper and Lower Pine Creek

2 Sites in North and South Tributaries

Pine Creek Macroinvertebrate Assessment

Mini-LUNKERS (Post-Restoration)

Dimensions: 8" W x 11.5" L x 2" T

SA = Hester-Dendy Artificial Substrate

2 "Mini-LUNKERS" per LUNKER

4 LUNKER Structures

Pine Creek: Trout Survey Sites

Wisconsin Department of Natural Resources*

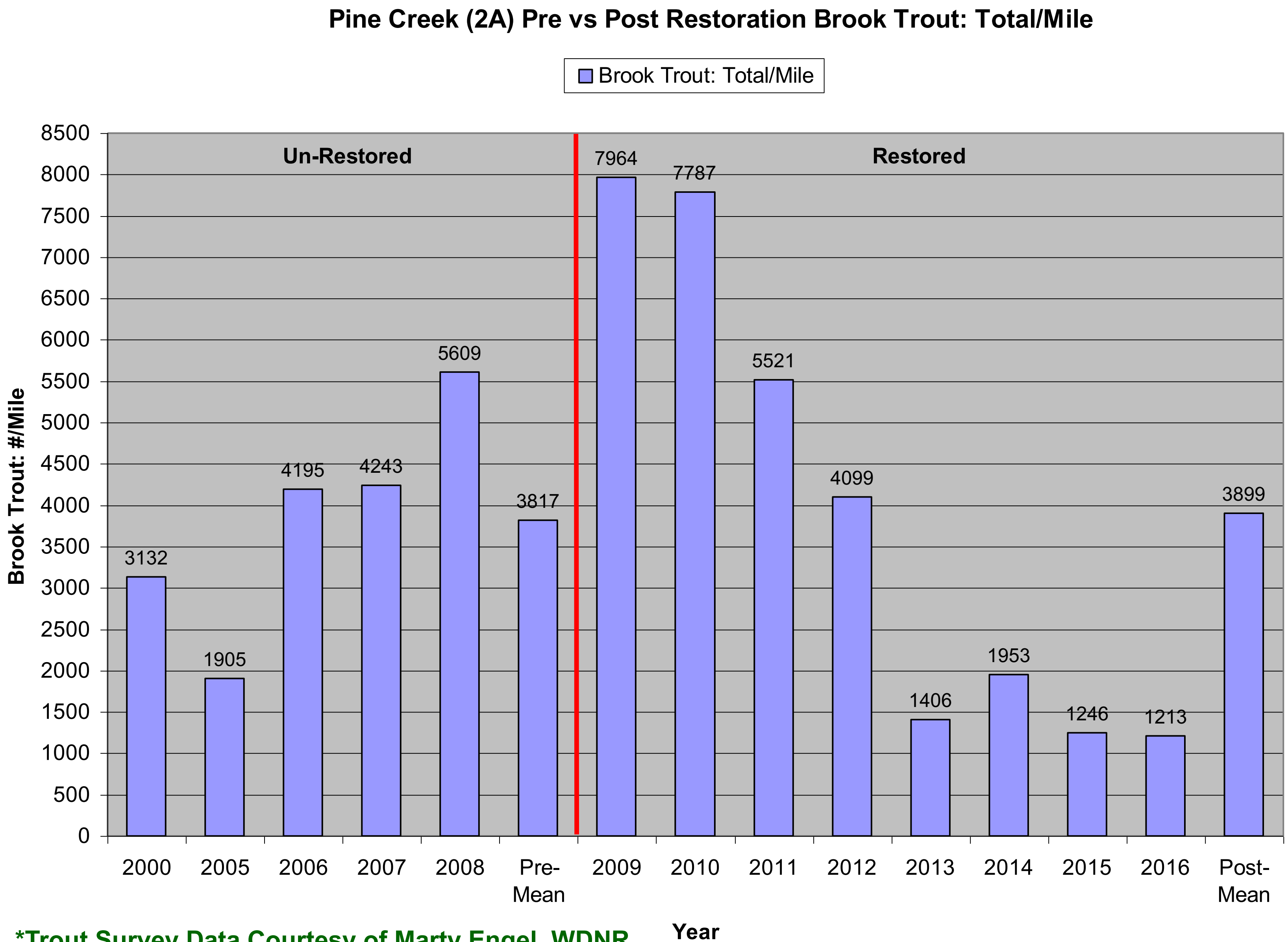
*Trout Survey Data Courtesy of Marty Engel, WDNR

Project Objectives

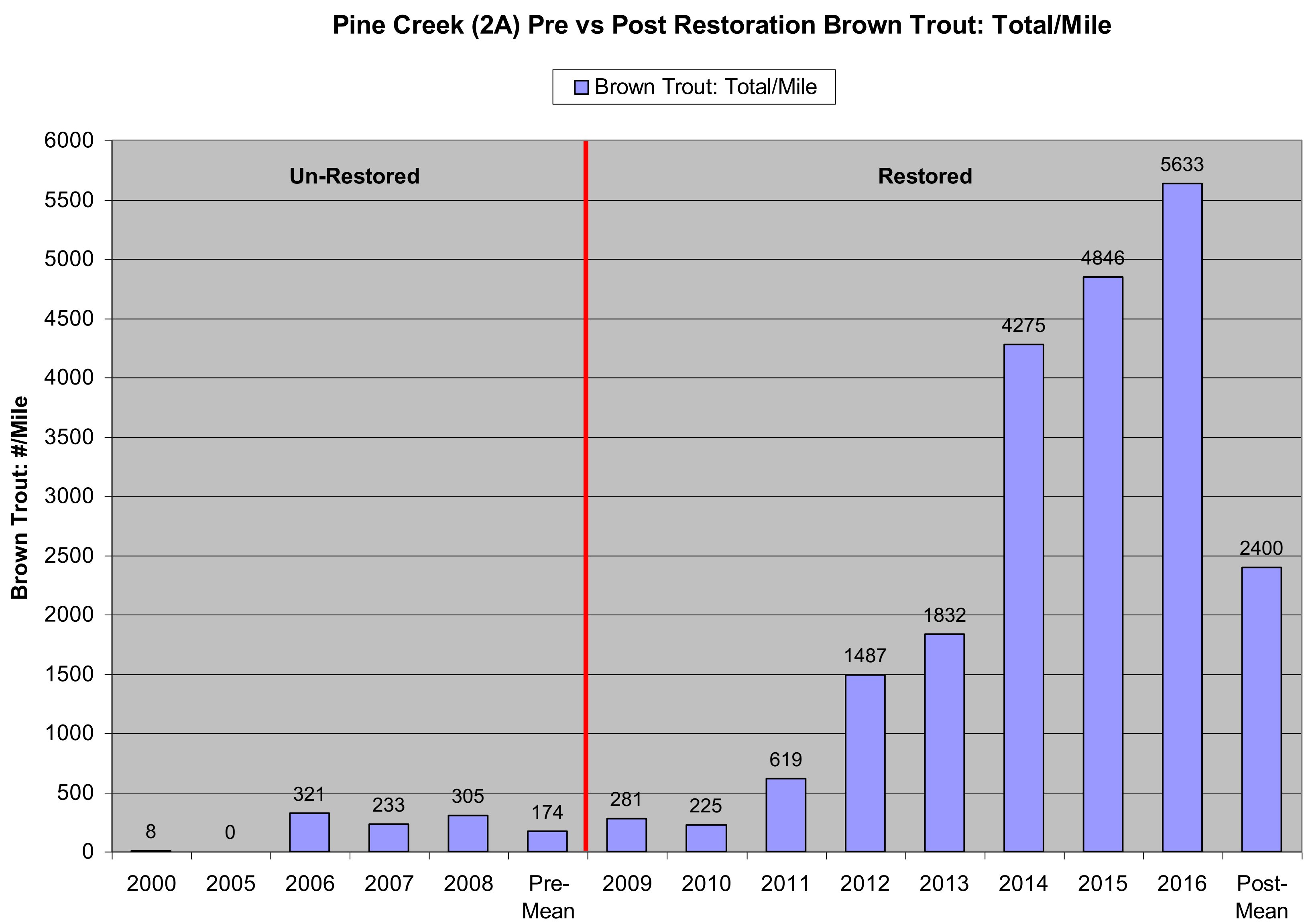
Measurable project objectives include:

- Restore 3,500 feet of stream bank and habitat in Pine Creek
- Increase numbers of Brook Trout by 40-50%
- Increase numbers of Brook Trout >/= 10 inches by 50-100%
- Reduce stream bank erosion to 10% of pre-existing conditions
- Reduce fine sediment and increase coarse bottom substrate by 50%
- Increase aquatic macrophyte growth by 25%

Project Objective: Increase numbers of Brook Trout by 40-50%

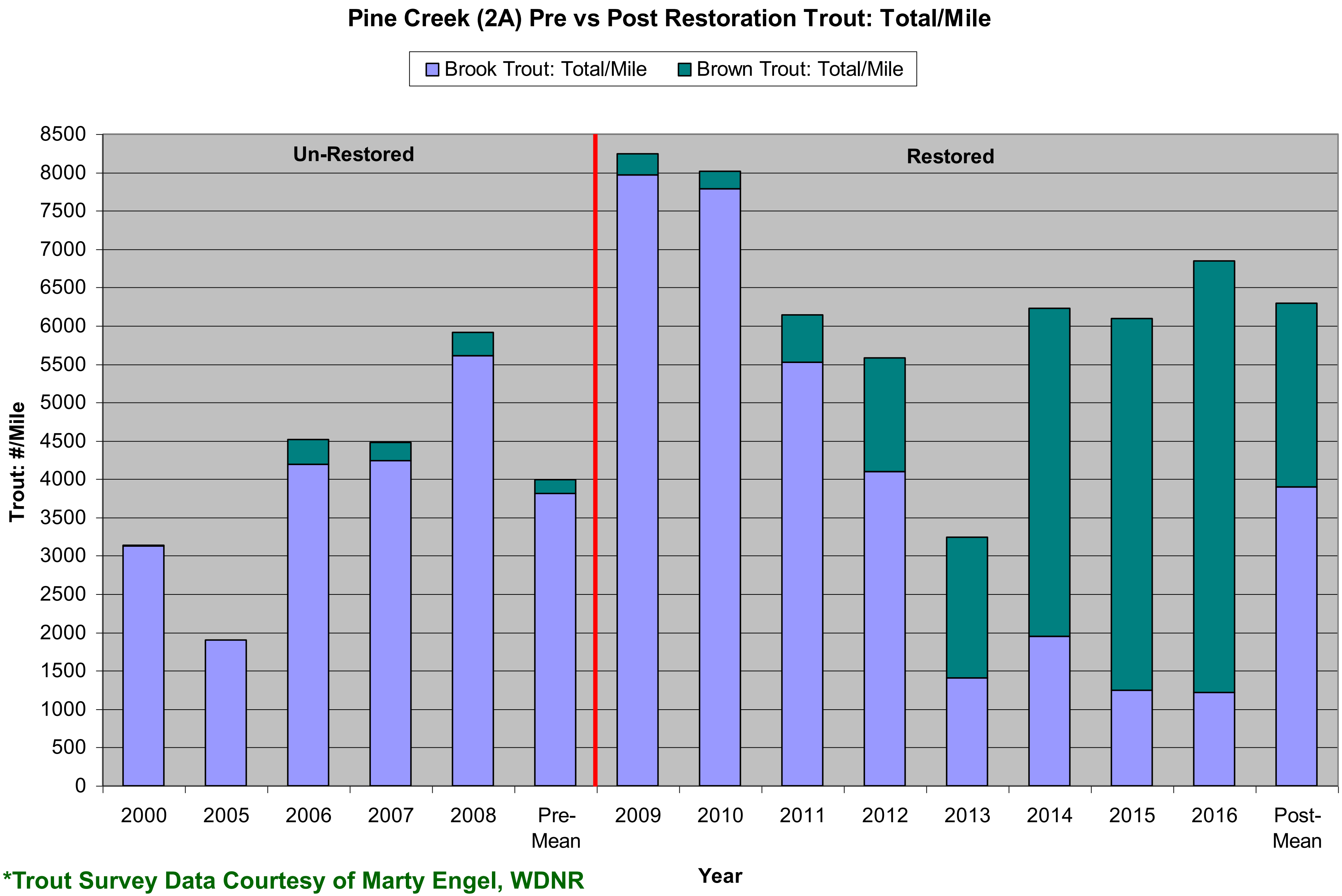


*Trout Survey Data Courtesy of Marty Engel, WDNR



*Trout Survey Data Courtesy of Marty Engel, WDNR

Project Objective: Increase numbers of Brook Trout by 40-50%



*Trout Survey Data Courtesy of Marty Engel, WDNR

Evaluating Stream Restoration Benefits: A Case Study at Pine Creek, Wisconsin

Conclusions

Temperature:

- Groundwater temperature varies annually within a small range (8.2-9.1^{o} C), with a delayed response to air temperature
- Summer temperatures below 16^{o} C (top of optimum temperature range for Brook Trout) indicate strong groundwater influence
- In spite of strong groundwater inputs, reach-scale impacts of air temperature on water temperature are significant
- Restoration project resulted in stream temperature improvements, providing a buffer against future climate change impacts

Evaluating Stream Restoration Benefits: A Case Study at Pine Creek, Wisconsin

Conclusions

Habitat:

- 40% decrease in stream channel width
- 75% increase in water depth
- 15% decrease in stream velocity, due to post-restoration presence of macrophytes and in-stream structures
- 20% decrease in canopy cover
- 60% decrease in stream bank height
- Pre: 40% coarse stream substrate Post: 65% coarse stream substrate

Evaluating Stream Restoration Benefits: A Case Study at Pine Creek, Wisconsin

Conclusions

Trout

- **Pine Creek restoration project has resulted in a significant Brown Trout invasion of a native Brook Trout stream**

- Brook Trout Total/Mile: -70% (Goal: +40-50%)
- Brook Trout Adults (10”+)/Mile: -75% (Goal: +50-100%)

- Brown Trout Total/Mile: +3100%
- Brown Trout Adults (15”+)/Mile: 0 (Pre-Restoration) to 32 (2016)

- Brook Trout/Brown Trout (%):

  Pre: 96%/4% (5-Year Mean)

  Post: 18%/82% (2016)

Recommendations

Stream Restoration:

- Manage for a future shaped by climate change, informed by past and present conditions. Stream temperature should be a primary restoration target.

  Restoration of riparian vegetation is one of the most effective management activities for improving stream temperature and mitigating the effects of climate change (Blann et al., 2002).

- WICCI* concept of triage (Mitro, Lyons, and Sharma, 2011):

  Which coldwater fisheries will persist without management? Establish refugia to protect native coldwater species (brook trout)?

  Which coldwater fisheries will be dependent on management? Pre-restoration stream temperature monitoring can be very helpful for prioritizing project locations, setting project objectives, and anticipating project outcomes.

  Which coldwater fisheries will not persist, even with intensive management?

- Brook trout-friendly habitat restoration techniques?

Recommendations

Stream Restoration Monitoring:

Sentinel monitoring sites should be established to evaluate long-term climate change impacts on streams throughout the Driftless Area (one reference reach per restoration project, or strategically selected on a regional scale)

- Air temperature and precipitation monitoring (annually, year-round)
- Stream temperature monitoring (annually, year-round)
- Groundwater temperature monitoring (annually, year-round)
- Habitat Assessment (5-10 year intervals, depending on project stability): Water depth, stream channel width, stream velocity, canopy cover, stream bed substrate, stream bank height, and stream bank cover
- Biology is dynamic, restoration benefits may not be fully realized for years*: Trout (annually); macroinvertebrates (2-3 year intervals); macrophytes and riparian vegetation (5-year intervals).

***E. M. Hasselquist, C. Nilsson, J. Hjältén, D. Jørgensen, L. Lind, L. E. Polvi. 2015. Time for recovery of riparian plants in restored northern Swedish streams: a chronosequence study. *Ecological Applications* 25 (5)**


Lower Pine Creek
Post-Restoration Brookie
Questions?