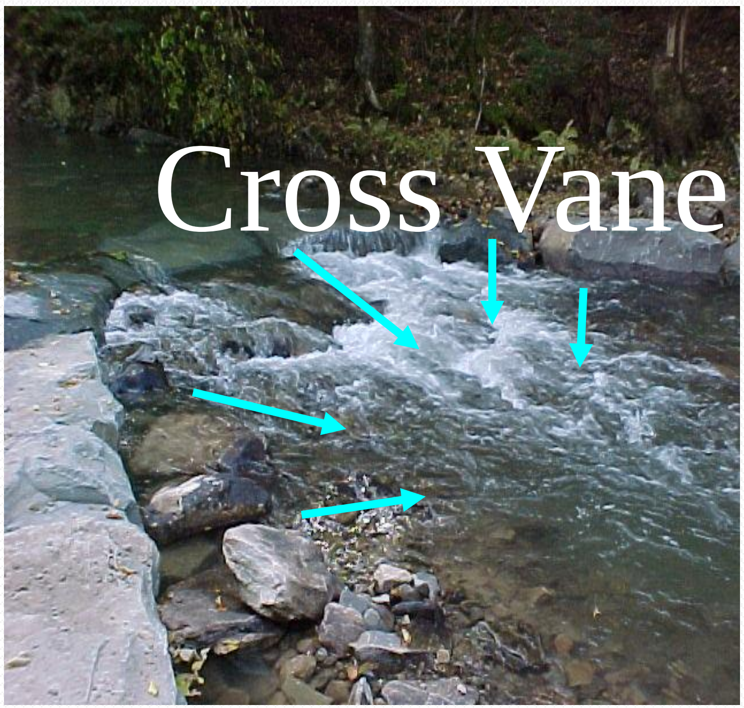
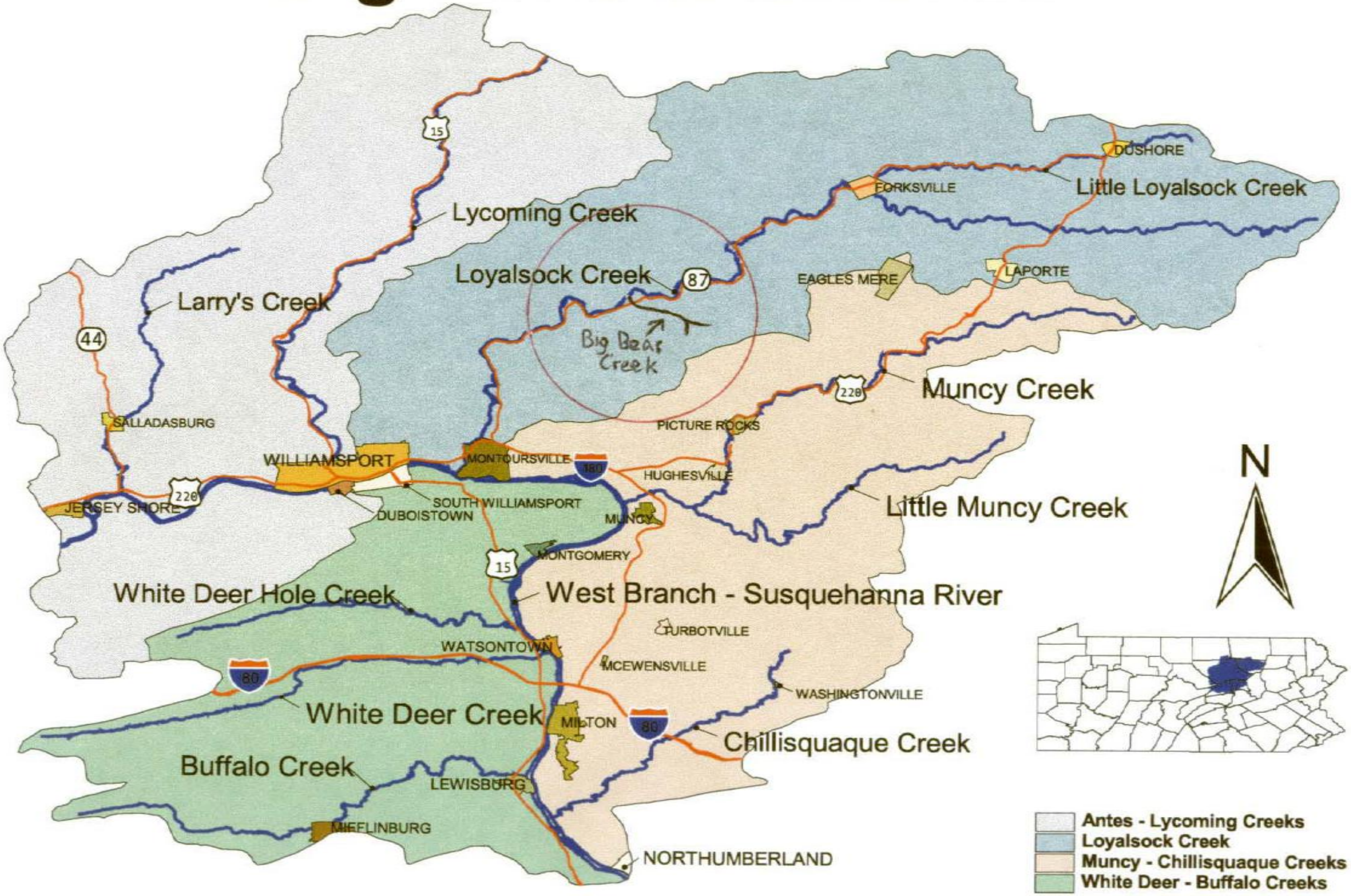
Post Restoration Evaluation of a Natural Stream Channel Design Project

Big Bear Creek (Lycoming County, PA)

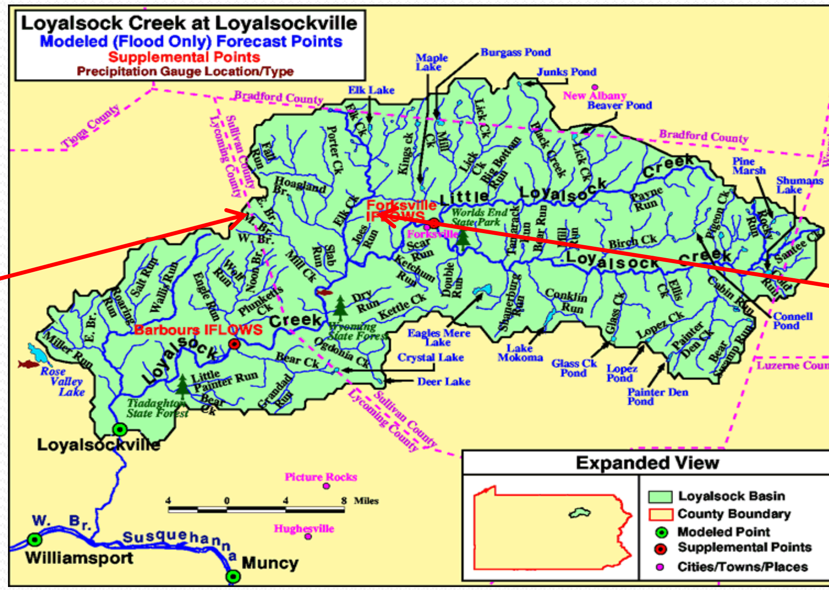
- Dr Mel Zimmerman , Biology Department Lycoming College and CWI



Big Bend Watershed

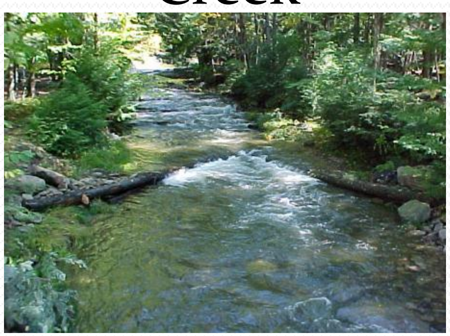


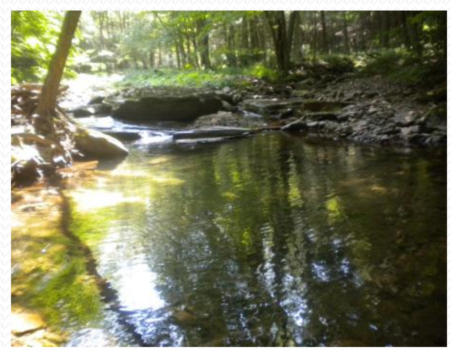
Study Area – Two Streams:



Big Bear Creek

Ogdonia Creek





Lycoming College Involvement in Monitoring at Big Bear Creek

- Brian Schlee – Independent Study – 1999 → Periphyton
- Khalique Ghani – Independent Study – 2000 → Periphyton
- Jud Kratzer – Honors – 2000 → Fish →Leaf Material
- Christopher Fuller – Honors – 2000 → Fish
- Andrew Klinger – Honors – 2000 → Leaf Material
- Emily Strickler – Honors – 2001 → Leaf Material
- Geoffrey Smith – Honors – 2001 → Macroinvertebrates
- Christina Panko – Honors – 2002 → Leaf Material
- Anthony Sowers – Honors – 2003 → Leaf Material
- Nathan Holmes – Honors – 2004 → Fish
- Kirk A. Patten – PSU Graduate Project – 2005 → Fish
- Nicole Rhodes – Honors – 2008 – Post Restoration Evaluation
- Lori Smith – Honors -2011 – Post Restoration Evaluation

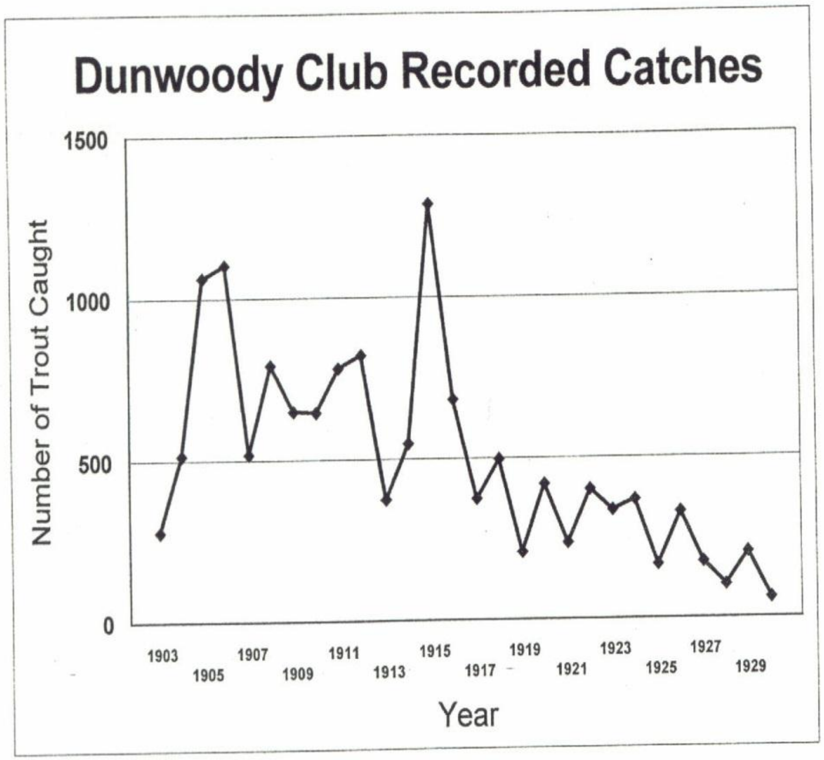
Background

- In 1999, the Dunwoody Big Bear Hunting and Fishing Club pulled together a number of partners (including U.S. Fish and Wildlife, PA-DEP Growing Greener, and others) to restore a 3.8 mile section of Big Bear Creek (Lycoming Co., PA) using Natural Stream Channel Design, which incorporates science of fluvial geomorphology. The Big Bear Creek Watershed is 17-square miles and the project occurred in the lower 4 miles of the stream, ending at its confluence with Loyalsock Creek.
- Over the last half century, instability of Big Bear Creek resulted in a stream with a high width to depth ratio (W/D ratio), large areas of bank erosion (see photos), places where the stream flowed underground (6% of the stream length in 1999), and a depressed fishery dependent on stocking.
- The scope (plan) of the project was to stabilize the banks, restore the proper sinuosity and W/D ratio, as well as improve habitat for the fishery. Over the next three years, after the appropriate design and permitting, a total of 127 rock "cross veins" or "J hooks" were placed in the stream
- Additional habitat improvements (root wads etc.) also added.

- 17 square miles watershed
- Project area lower 3.5 miles

Fish Records

Figure A. Dunwoody Club Trout Catch 1903-1930. Catchable trout were stocked in 1906, 1908, 1913, 1915, and 1918. Fry were stocked in 1921, and annual stocking of catchable trout began in 1923.



- Stocking terminated in spring of 1999
- Catch and Release began in 1999
- Both practices will continued for 5 years
- Limited take today

Big Bear Creek is a type "C3b"

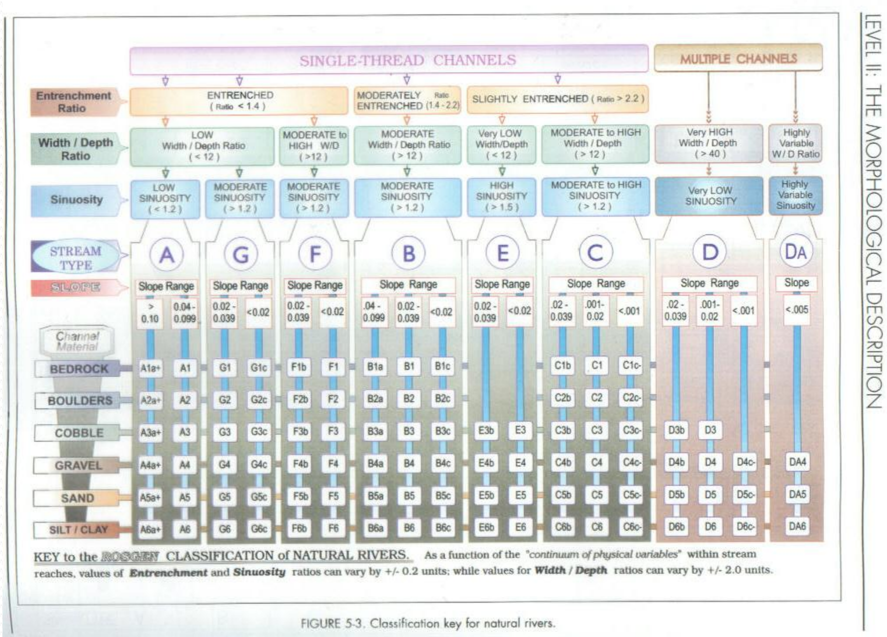


FIGURE 5-3. Classification key for natural rivers.

- Moderately steep streams dominated with riffles and runs and moderately course substrate
- Classified as C3b under Rosgen system

Instability at Big Bear Creek

- Hurricane Agnes
- Hurricane Eloise
- Removal of a 100 year old dam on the main stream and release of large sediment deposits
- The January 19, 1996 flooding
- Sediment from inappropriate road maintenance
- Installation of inappropriate fish habitat structures

Causes of Instability

Severe Bank Erosion at Big Bear

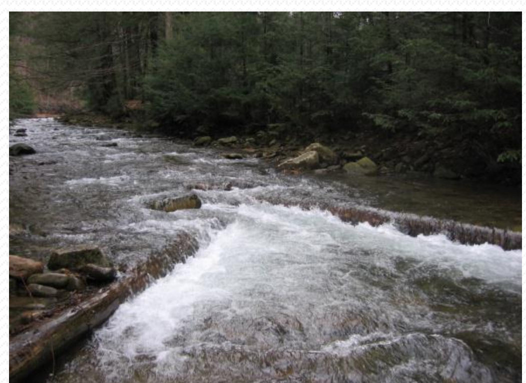
Several Inappropriate Practices

Signs and Symptoms of Instability

Inappropriate Log Placement

- Pre-restoration sediment supply was estimated to be 2,124yard^3/year.
- Over-widened channel – subsurface flow.

- U.S. Fish and Wildlife service along with Dunwoody Sportsman Club used Big Bear Creek as a pilot project for the Natural Stream Channel Design.
- Project began in 1999, took over 4 years, covered 4 miles, and over 200 structures.



A Test Run

Construction Begins

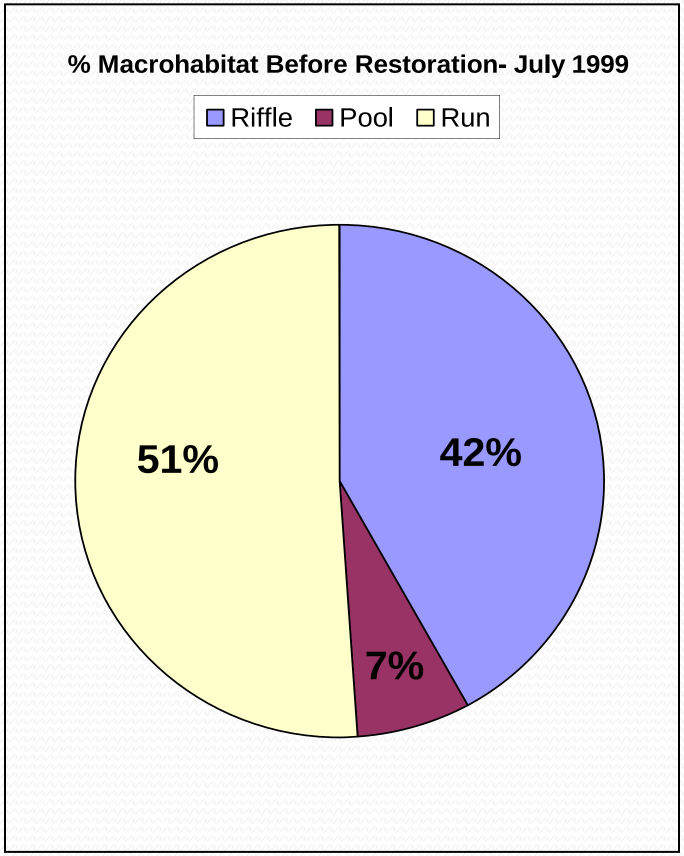
- Thirty-eight rock structures were constructed in September 1999 by U.S. Fish and Wildlife Service Personnel.

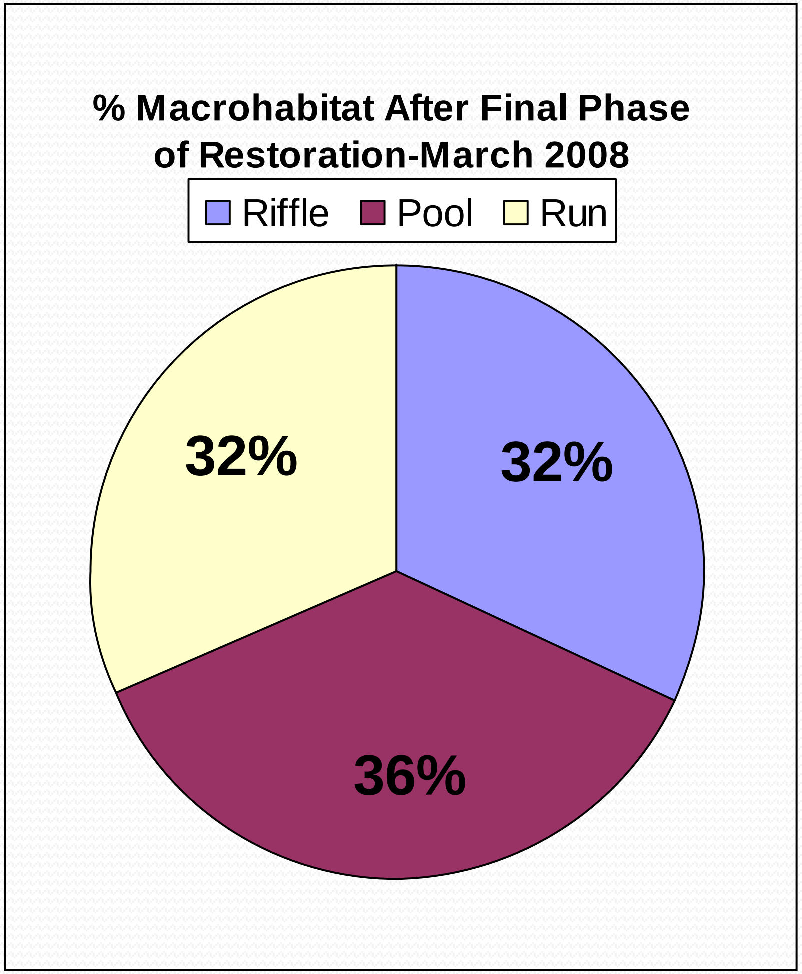
Staking out
a cross-vane

Structures for Stabilization

- Cross Vane
- J-Hook Vane
- Root Wad

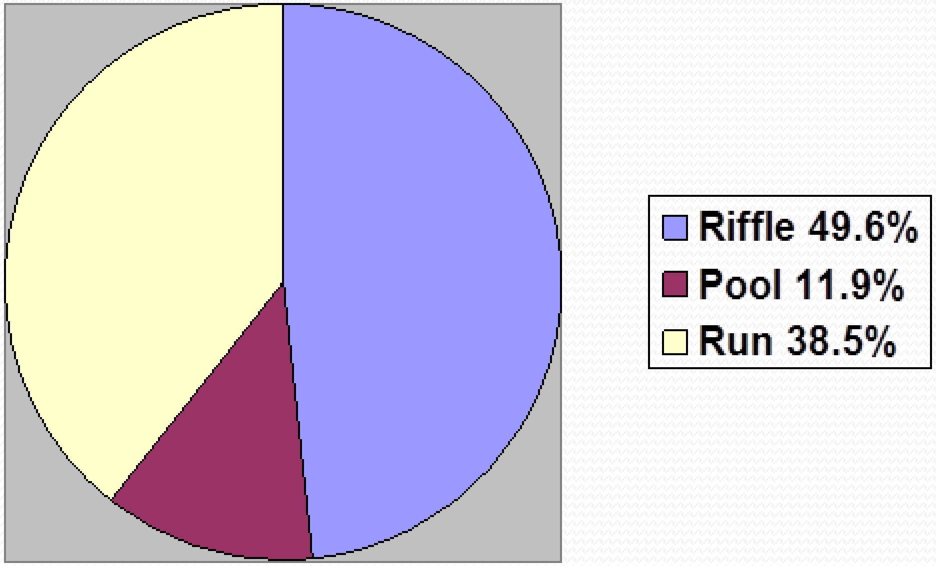
Microhabitat Pre & Post restoration





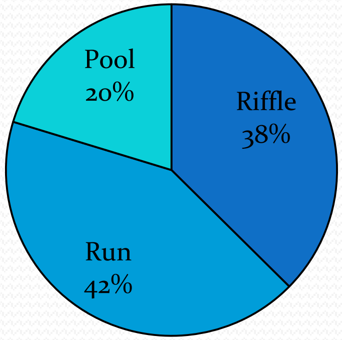
* 6% of Run Section was dried up with subsurface flow

Microhabitat Ogdonia Creek – June 2002



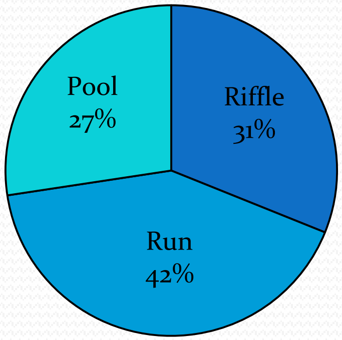
Microhabitat - 2010

Big Bear Creek



Big Bear Creek	
Riffle (m^2)	402.62 ± 109.6
Run (m^2)	453.51 ± 90.5
Pool (m^2)	219.33 ± 39.5

Ogdonia Creek



Ogdonia Creek	
Riffle (m^2)	443.03 ± 132.06
Run (m^2)	592.34 ± 27.7
Pool (m^2)	390.64 ± 94.3

Habitat Assessment- 2010

Big Bear Creek			
	#2	**#11**	**#16**
Epifaunal Substrate/Avaliable Cover	16	19	19
Embeddedness	16	18	12
Velocity/Depth Regime	17	19	15
Sediment Deposition	13	20	19
Channel Flow Status	11	19	13
Channel Alteration	13	8	18
Frequency of Riffles	19	17	17
Bank Stability (Left bank)	9	9	9
Bank Stability (Right bank)	9	8	6
Vegatative Protection (Left Bank)	9	10	4
Vegatative Protection (Right Bank)	9	10	5
Riparian Vegatatvie Zone Width (Left Bank)	10	10	10
Riparian Vegatatvie Zone Width (Right Bank)	9	7	7
Total	**160**	**174**	**154**
	80%	**87%**	**77%**

Ogdonia Creek			
	#1	**#2**	**#3**
Epifaunal Substrate/Avaliable Cover	12	14	17
Embeddedness	18	18	16
Velocity/Depth Regime	17	19	14
Sediment Deposition	19	17	14
Channel Flow Status	9	8	10
Channel Alteration	20	15	18
Frequency of Riffles	19	19	16
Bank Stability (Left bank)	7	7	6
Bank Stability (Right bank)	4	5	8
Vegatative Protection (Left Bank)	10	8	8
Vegatative Protection (Right Bank)	8	8	8
Riparian Vegatatvie Zone Width (Left Bank)	9	4	6
Riparian Vegatatvie Zone Width (Right Bank)	9	9	10
Total	**161**	**151**	**151**
	81%	**76%**	**76%**

Monitoring – Chemical Data: Big Bear Creek

Site #2			
Parameters	**8/6/10**	**9/14/10**	**Mean**
pH (field)	7.76		7.76
pH (lab)	6.64	6.72	**6.69**
Conductivity (ms)	36.1	37.8	**36.95**
Alkalinity (ppm)	7	8	**7.5**
Orthophosphate (ppm)	0.13	0.09	**0.11**
Total Phosphorous (ppm)	0.53	0.49	**0.51**
Nitrate (ppm)	0.8	0.9	**0.85**
Nitrite (ppm)	0.003	0.003	**0.003**
DO (ppm)	9.85	8.75	**9.3**
Temperature (°C)	14.9	11.8	**13.35**
TDS	18.1	19.4	**18.75**

Site #16			
Parameters	**8/6/10**	**9/14/10**	**Mean**
pH (field)			
pH (lab)	6.65	6.6	**6.65**
Conductivity (ms)	41.7	38.7	**40.2**
Alkalinity (ppm)	6	8	**7**
Orthophosphate (ppm)	0.07	0.08	**0.075**
Total Phosphorous (ppm)	0.52	0.37	**0.445**
Nitrate (ppm)	1.1	0.9	**1**
Nitrite (ppm)	0.004	0.004	**0.004**
DO (ppm)	7.64	7.81	**7.725**
Temperature (°C)	16.2	12.3	**14.25**
TDS	20.9	18.3	**19.6**

Site #11			
Parameters	**8/6/10**	**9/14/10**	**Mean**
pH (field)	7.69		7.69
pH (lab)	6.51	6.5	**6.51**
Conductivity (ms)	21.7	26.8	**24.25**
Alkalinity (ppm)	7	9	**8**
Orthophosphate (ppm)	0.11	0.12	**0.115**
Total Phosphorous (ppm)	0.45	0.19	**0.32**
Nitrate (ppm)	1	1.2	**1.1**
Nitrite (ppm)	0.005	0.003	**0.004**
DO (ppm)	7.96	8.4	**8.18**
Temperature (°C)	16.5	12.4	**14.45**
TDS	10.9	13.6	**12.25**

Monitoring – Chemical Data: Ogdonia Creek

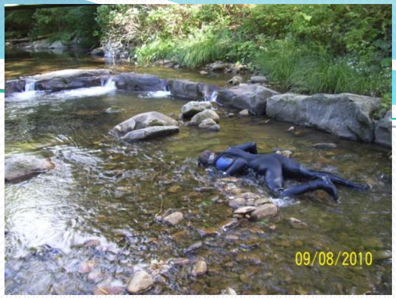
Site #1			
Parameters	**8/6/10**	**9/29/10**	**Mean**
pH (lab)	7.1	7.1	**7.1**
Conductivity (ms)	77.5	78.1	**71.75**
Alkalinity (ppm)	23	23	**23**
Orthophosphate (ppm)	0.09	0.1	**0.095**
Total Phosphorous (ppm)	0.71	0.59	**0.65**
Nitrate (ppm)	0.6	0.9	**0.75**
Nitrite (ppm)	0.005	0.004	**0.0045**
DO (ppm)	8.72	8.53	**8.625**
Temperature (°C)	20.1	13.1	**16.6**
TDS	23		**23**

Site #2			
Parameters	**8/6/10**	**9/29/10**	**Mean**
pH (lab)	6.95	7.2	**6.99**
Conductivity (ms)	43.3	44.6	**43.9**
Alkalinity (ppm)	21	21	**21**
Orthophosphate (ppm)	0.07	0.08	**0.075**
Total Phosphorous (ppm)	0.48	0.21	**0.345**
Nitrate (ppm)	0.4	0.9	**0.65**
Nitrite (ppm)	0.002	0.003	**0.0025**
DO (ppm)	8.19	8.28	**8.235**
Temperature (°C)	20	13.6	**16.8**
TDS	21.7		**21.7**

Site #3			
Parameters	**8/6/10**	**9/29/10**	**Mean**
pH (lab)	6.6	6.7	**6.6**
Conductivity (ms)	63.9	67.2	**65.3**
Alkalinity (ppm)	16	16	**16**
Orthophosphate (ppm)	0.12	0.08	**0.1**
Total Phosphorous (ppm)	0.31	0.21	**0.26**
Nitrate (ppm)	0.4	0.7	**0.55**
Nitrite (ppm)	0.002	0.003	**0.0025**
DO (ppm)	8.44	8.49	**8.465**
Temperature (°C)	19.4	12.8	**16.1**
TDS	30.15		**30.15**

Microhabiat Surveys:

- Snorkeling surveys on two sites at Big Bear Creek and two sites at Ogdonia Creek were completed to determine habitat preferences of both brook and brown trout.
- While snorkeling trout were identified and size class, species, and dominant substrate (at fish's position) were visually estimated.
- After visual estimates were completed a marker was placed in the water indicating the fish's location.
- Later measurements of fish depth (m), focal point velocity (m/s), mean velocity (m/s), distance to structure (m) were taken for each fish located.



Microhabitat Surveys:

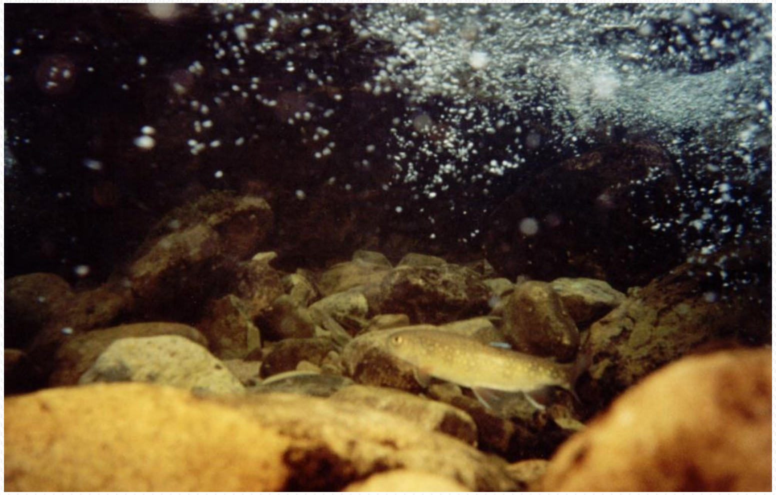
- Independent t-test statistic and Rank Sum Test were used to determine if habitat preference of brook trout and brown trout was significantly different.
  - Independent t-test statistic is a comparative means test.
  - Wilcoxon rank sum test converts primary data into ranks in order to obtain test statistic. This is the most ideal for small sample size.

Mean +/- Std. Dev.		
	Brook Trout N = 12	**Brown Trout N = 20**
Depth (m)	0.362 +/- 0.126	0.389 +/- 0.185
Mean Velocity (m/s)	0.183 +/- 0.179	0.134 +/- 0.124
Focal Velocity (m/s)	0.155 +/- 0.236	0.095 +/- 0.155
Distance to Structure (m)	0.350 +/- 0.272	0.400 +/- 0.465

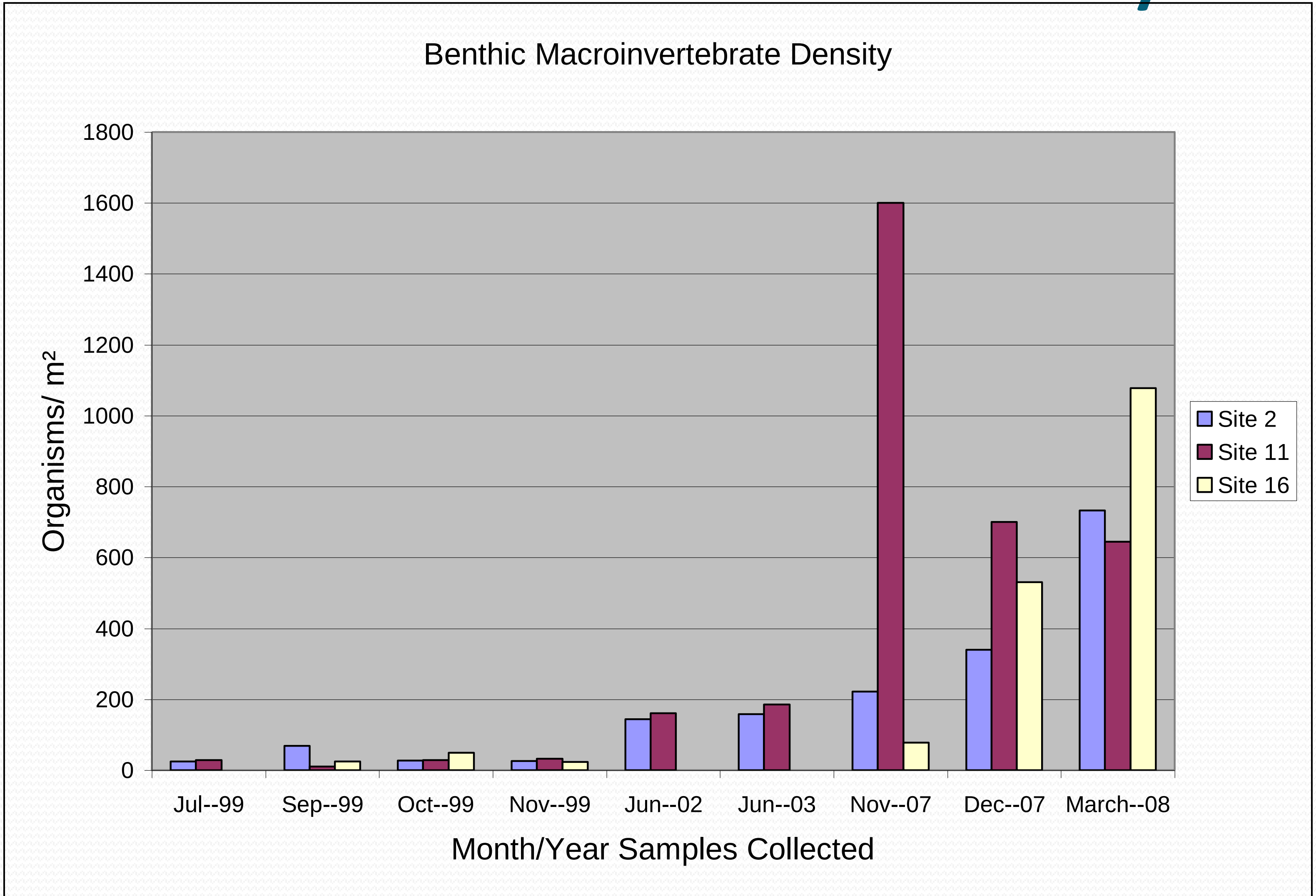
Parameter	**α = 0.05**
Depth (m)	0.6229
Mean Velocity (m/s)	0.4159
Focal Velocity (m/s)	0.4380
Distance to Structure (m)	0.6790

Microhabitat Survey:

- Wilcoxon rank sum test was used to determine if habitat preference of trout (brook and brown) between the two sites was significantly different.
  - Habitat restoration structures vs. unaltered stream.
- Results indicated that both brook trout and brown trout did not differ in habitat selection between the two streams.
- The conclusion that habitat restoration structures process the ability to provide similar habitat for trout as an unaltered stream can be drawn.



Macroinvertebrate Density



Monitoring – Biological Data (2010):

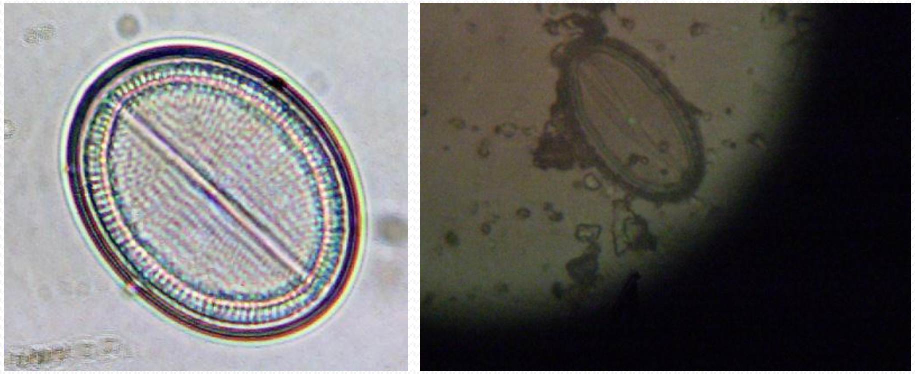
Benthic Macroinvertebrate:

Macroinvertebrate Densities / m²		
Big Bear Creek		
	8/6/2010	9/14/2010
Site #2	1735± 338	1566 ± 240
Site #11	1366± 238	1511 ± 523
Site #16	899 ± 156	834 ± 213

Macroinvertebrate Densities / m²		
Ogdonia Creek		
	8/6/2010	9/14/2010
Site #1	443 ± 141	660 ± 183
Site #2	855 ± 98	520 ± 166
Site #3	223± 70	335± 70

Periphyton:

Site Name	Big Bear Creek	Ogdonia Creek
Periphyton Density (orgs/150mm)	320.0 ± 71.43	468.0 ± 114.94



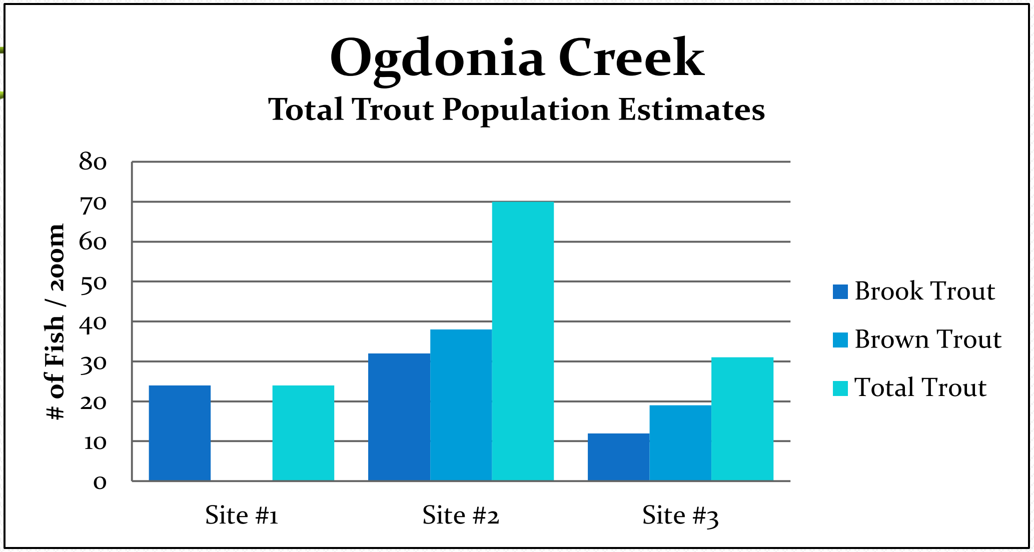
Cocconeis

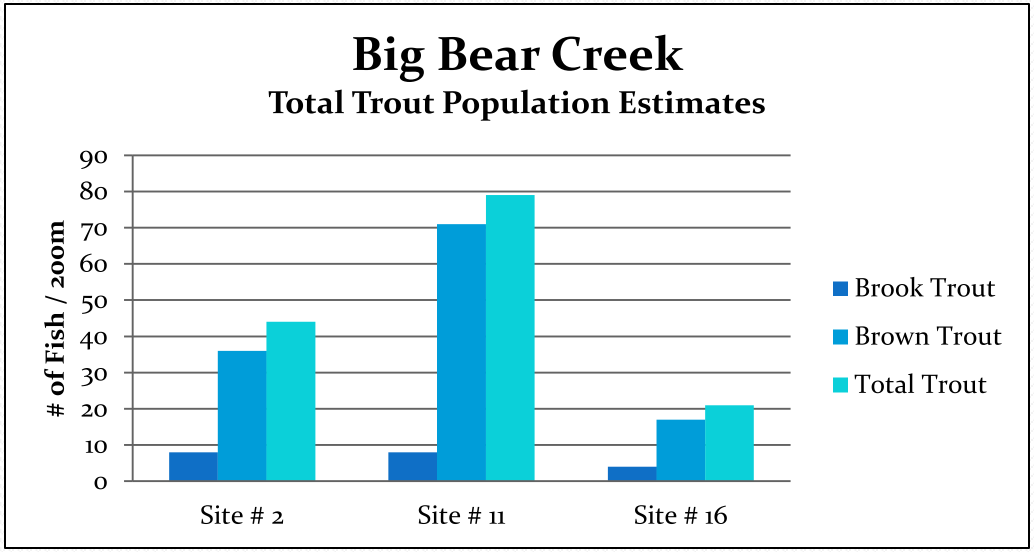
Fish/200 m

	Brown Trout	Brook Trout	Total Trout	Sculpins	Total Fishes
Site 2	110	76	186	686	805
Site 11	560	50	610	3630	4000
Site 16	256	107	363	1779	2200
Mean	309	78	386	2032	2335
2002 Mean	173	73	246		
% increase	56	94	64		


09/05/2010


09/05/2010


Ogdonia Creek
Total Trout Population Estimates
# of Fish / 200m
80
70
60
50
40
30
20
10
0
Site #1
Site #2
Site #3
Brook Trout
Brown Trout
Total Trout


Big Bear Creek
Total Trout Population Estimates
# of Fish / 200m
90
80
70
60
50
40
30
20
10
0
Site # 2
Site # 11
Site # 16
Brook Trout
Brown Trout
Total Trout


09/22/2010


09/05/2010


09/22/2010

Several bank- full events over last decade

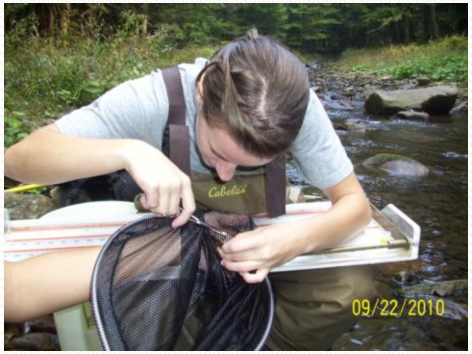
The Rest of the Story – Sept. 2011 flooding from Tropical Storm Lee (500 year event?)- summer 2012– reevaluate project sites

Historical Background:

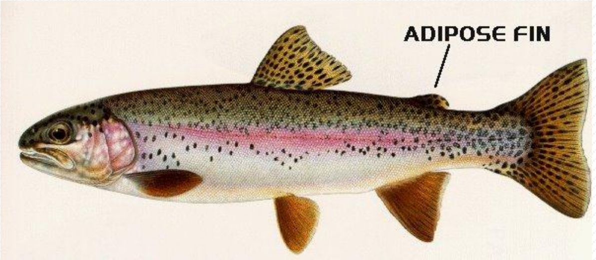
- Two strains of Brown Trout (Salmo trutta) were introduced in the United States between 1883-1884.
- The two strains are known as the Loch Levan (Lake trout), and the Von Behr (German Trout)

- There is strong evidence that because of both strains wide distribution throughout the United States that brown trout in PA are similar in appearance and life history to that of both strains.
- In early 1900's Dunwoody Club began stocking Von Behr strain.
- However, Fish & Boat Commission used Loch Levan strain for stocking purposes most heavily.

Genetic Analysis:



- Adipose fin Clippings were taking from each brown trout subject and preserved in 95% denatured ethanol to be processed for genetic analysis.
- 10 brown trout samples from each stream were taken for a total of 20 fin clippings.



- Genetic analysis was completed at the Northeast Fishery Center's Population Ecology Branch.

Genetic Analysis:

- Genomic DNA extraction from fin clip tissue
- 14 microsatellites were selected and combined into three multiplexes for PCR amplification.
- An ABI Prism 3100 Genetic Analyzer was used for capillary electorphoresis.
- Score Genotypes.

Statistical Analysis:

- Genepop:
  - Hardy–Weinberg Equilibrium test
    - Nothing out of Hardy-Weinberg Equilibrium = normal ending.
  - Pairwise estimates of allele frequency difference among populations.
    - Results indicated differences in allele frequencies among populations = differences between the two populations.
- Geneclass:
  - Maximum likelihood assignment tests.
    - Use to determine the probability of an individual being classified back into the population from which it was collected.
- BIOSYS – 1:
  - Calculated genetic distance between collections using chord distance.

Assignment Test - "Leave One Out Method"

1 LORI-001 [BIG BEAR CREEK]
2 LORI-002 [BIG BEAR CREEK]
3 LORI-003 [BIG BEAR CREEK]
4 LORI-004 [BIG BEAR CREEK]
5 LORI-005 [BIG BEAR CREEK]
6 LORI-011 [BIG BEAR CREEK]
7 LORI-012 [BIG BEAR CREEK]
8 LORI-013 [BIG BEAR CREEK]
9 LORI-014 [BIG BEAR CREEK]
10 LORI-015 [BIG BEAR CREEK]

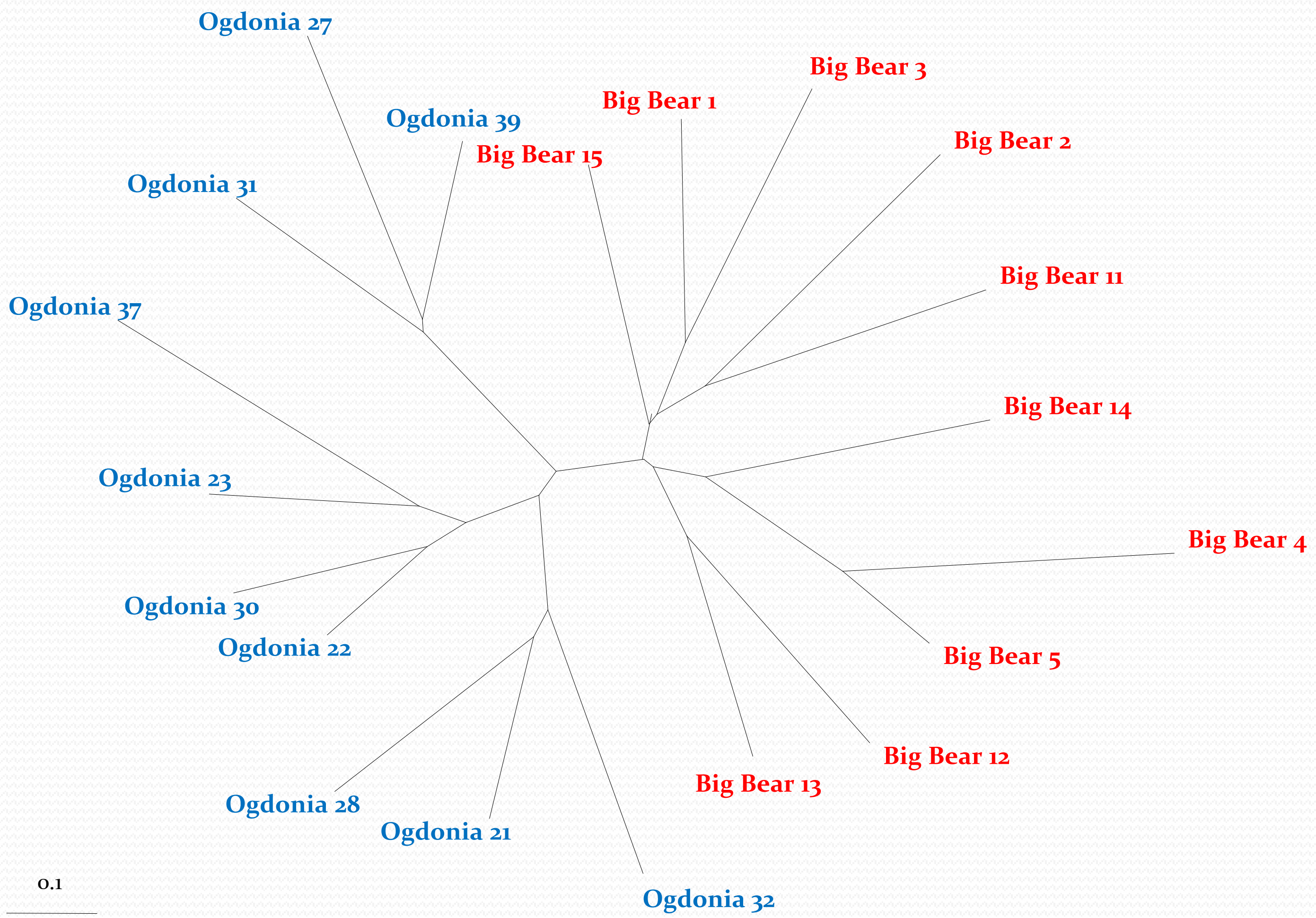
Big Bear Creek

11 LORI-021 [OGDONIA CREEK]
12 LORI-022 [OGDONIA CREEK]
13 LORI-023 [OGDONIA CREEK]
14 LORI-027 [OGDONIA CREEK]
15 LORI-028 [OGDONIA CREEK]
16 LORI-030 [OGDONIA CREEK]
17 LORI-031 [OGDONIA CREEK]
18 LORI-032 [BIG BEAR CREEK]
19 LORI-037 [BIG BEAR CREEK]
20 LORI-039 [OGDONIA CREEK]

Ogdonia Creek

18 individuals on 20 correctly identified (90.00%)

Proportion Shared Tree:



Allele Frequency:

	Locus and sample size													
	85	408	410	438	2213	2216	C86	C115	D71	D75	D190	STR15	STR60	STR73
Allele	10	8	10	9	10	9	10	9	10	10	10	10	9	10
1	.650	.125	.100	.056	.200	.389	.300	1.000	.000	.550	.050	.450	.333	.750
2	.300	.063	.050	.278	.000	.389	.700	.000	.050	.000	.050	.350	.667	.250
3	.000	.188	.050	.167	.050	.167	.000	.000	.050	.350	.200	.100	.000	.000
4	.050	.313	.050	.500	.150	.000	.000	.000	.050	.050	.200	.050	.000	.000
5	.000	.188	.050	.000	.150	.056	.000	.000	.100	.000	.350	.050	.000	.000
6	.000	.063	.000	.000	.350	.000	.000	.000	.350	.050	.150	.000	.000	.000
7	.000	.063	.050	.000	.000	.000	.000	.000	.250	.000	.000	.000	.000	.000
8	.000	.000	.100	.000	.100	.000	.000	.000	.050	.000	.000	.000	.000	.000
9	.000	.000	.100	.000	.000	.000	.000	.000	.100	.000	.000	.000	.000	.000
10	.000	.000	.050	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
11	.000	.000	.050	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
12	.000	.000	.050	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
13	.000	.000	.050	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
14	.000	.000	.250	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
H	.485	.805	.885	.642	.780	.667	.420	.000	.785	.570	.770	.660	.444	.375
H(unb)	.511	.858	.932	.680	.821	.706	.442	.000	.826	.600	.811	.695	.471	.395
H(D.C.)	.700	.875	.900	.667	.800	.667	.400	.000	.700	.500	.900	.700	.444	.300