Management of headwater streams in the White Mountain National Forest
White Mountain National Forest

Weeks Act of 1911 authorized the federal government to purchase lands east of the Mississippi River for the National Forest System.

White Mountain National Forest was created in 1918 and consisted of 7000 acres.

Today the WMNF consists of approximately 800,000 acres.
Before the Weeks Act.......
Land Management Today……

2005 Land and Resource Management Plan for the WMNF
Goals:

- Protect, restore, or improve riparian area conditions to benefit riparian dependent resources and values.
- Manage riparian areas to provide coldwater, coolwater, and warmwater aquatic communities within the ecological capability of the landscape.
- Restore and improve self-sustaining indigenous populations and their habitats.
- Provide a range of recreational fishing opportunities (stocked as well as wild trout) in a manner that will protect self-sustaining populations of indigenous fish species.

Objective:

- Restore or improve 5-10 miles of stream habitat per year over the planning period with emphasis on HUC 6 level watersheds.
Time Scales of Recovery from Land Use Conversion

- **Rapid** (< 10 years) - hydrology, chemistry
- **Intermediate** (10 – 100 years) shading/temperature, sediment regime (some aspects)
- **Long** (> 100 years) Large Woody Debris (LWD), Channel Complexity
New Hampshire’s State Freshwater Fish.....
Eastern Brook Trout

Hatchery?

Wild?...... Native?
Where are Wild Brook Trout in the WMNF landscape?

- **10 kg/hect**: 6 sq. miles
- **15 kg/hect**: 3.6 sq. miles
- **35 kg/hect**: 1.6 sq. miles

After flood of 2008
Imagine that.....trout like pools

Brook Trout Biomass vs. %Pool Habitat

\[ y = 0.63x + 15.6 \]
\[ R^2 = 0.3537 \]
Large Woody Debris Creates Pools and Provides Cover

![Graph showing the relationship between Trout Biomass (kg/hectare) and Pieces of LWD / Mile. The graph indicates a positive correlation between the two variables.]

-Trout Biomass (kg/hectare) on the y-axis, ranging from 0 to 45
-Pieces of LWD / Mile on the x-axis, ranging from 0 to 600

The graph suggests that as the number of pieces of LWD per mile increases, the trout biomass also tends to increase.
Threats to Coldwater Streams

- Loss of Riparian Shade
- Sedimentation
- Acid Deposition
- Loss of Instream Habitat
- Stream Habitat Fragmentation
- Climate Change (Higher Temperatures, Floods, Drought, etc)
Acid Deposition – Still a Concern?

Dr. John T. Kelly
Dr. Stephen D. McCormick
USGS, Conte Anadromous Fish Research Center
& University of Massachusetts, Amherst

Dr. Keith H. Nislow
US Forest Service, Northern Research Station
University of Massachusetts, Amherst
How will Climate Change affect WMNF Streams?

- Warmer Streams
- Earlier Spring Run-off
- More intense Floods
- Summer Droughts
Are the wild trout streams at risk to warming temperatures?

Watersheds draining 1.5 to 2.5 square miles - 2008

Water Temperature (F) vs Date and Time

- Blue Brook
- Clear Brook
- EB Baker River
- Hancock Trib
- SB Hancock
- SB Israel Trib
- Jefferson
- WB Mad
- Whitten
- EB Wonalancet
- Wonalancet
- Miles Brook
Promoting Riparian and Stream Habitat Diversity
Will it mitigate effects of climate change?

2005 Forest Plan provides Standards and Guidelines for Management:

- Uneven-aged management in riparian areas.
- 25’ “no-cut” zones on perennial streams to promote natural loading of downed wood.
- Consider relocating existing roads and trails within 100’ of perennial streams
- Limit the % of timber volume harvested from a watershed.
- Span at least “bankfull” channel width on reconstructed stream crossings.
Will Increased Wood Loadings (LWD) in the Future Mitigate Climate Change Impacts Stream Habitats?

Case Study: Great Brook Wood Addition Project

- 1100 acres purchased by WMNF in 1975.
- Valley was home to a farming community in 19th and early 20th century.
- Riparian area mostly 3rd growth hardwood
- Very little in-stream wood
- Main channel appeared to be “over-widened”
- Very little water storage in mid-summer in upper portion of watershed
Project Objectives

1. Create sustainable and highly diverse stream habitat conditions using natural wood and boulder components.

2. Approach 300 pieces of LWD per mile and 30% of surface area in pool habitat.

3. Improve wild trout productivity at least to next higher productivity class (NHFG Wild Trout Classification).
Great Brook Stream Restoration Proposal

- Restore stream habitat by increasing pool habitat and woody cover in approximately 2.5 miles of Great Brook and its tributaries, using whole trees, root wads, and boulders.
## Fish and Habitat Monitoring Stations

Grouped by Drainage Area Size and Channel Type

<table>
<thead>
<tr>
<th>Sample Site</th>
<th>Sample Group</th>
<th>Drainage Area (sq.mi.)</th>
<th>Slope (%)</th>
<th>Rosgen Channel Type</th>
<th>% Pool Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shirley Brook</td>
<td>Treatment</td>
<td>0.6</td>
<td>4.0</td>
<td>B4</td>
<td>7</td>
</tr>
<tr>
<td>Red Rock Brook</td>
<td>Treatment</td>
<td>1.1</td>
<td>3.1</td>
<td>B3</td>
<td>13</td>
</tr>
<tr>
<td>Willard Brook - upper</td>
<td>Control</td>
<td>1.0</td>
<td>3.5</td>
<td>B3</td>
<td>8</td>
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<tr>
<td>Great Brook - upper</td>
<td>Treatment</td>
<td>1.8</td>
<td>2.3</td>
<td>B3</td>
<td>7</td>
</tr>
<tr>
<td>Willard Brook - lower</td>
<td>Control</td>
<td>2.0</td>
<td>3.0</td>
<td>B3</td>
<td>14</td>
</tr>
<tr>
<td>Great Brook - lower</td>
<td>Treatment</td>
<td>3.3</td>
<td>1.6</td>
<td>C4</td>
<td>19</td>
</tr>
<tr>
<td>Great Brook</td>
<td>Control</td>
<td>3.6</td>
<td>2.1</td>
<td>B3/C3??</td>
<td>30</td>
</tr>
</tbody>
</table>
Shirley Brook – Treatment Site

June, 2004

June, 2009
Great Brook – upper Treatment Site

2004

2009
Reconnecting Floodplains?
During high flows...debris jams force water laterally
Great Brook – Lower Treatment Site
“C” Type Channel or Pool-Riffle Channel

2004

2010
Did We Increase LWD Densities > 300 Pieces /Mile?
2004 vs. 2009

Monitoring Station

Shirley  Red Rock  Great Brk-upper  Great Brk-lower  Willard-upper  Willard-lower  Great Brk-control
Did We Create 30% Pool Habitat?
2004 vs. 2009

Monitoring Station

% Pool Habitat

<table>
<thead>
<tr>
<th>Monitoring Station</th>
<th>2004</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shirley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Rock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Great Brk-upper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Great Brk-lower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willard-upper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willard-lower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Great Brk-control</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Brook Trout Population Estimates
Were Changes in Fish Biomass Due to Wood Additions or Other Factors?

“B” Channel Type (1 sq mile or less drainage areas)

*Shirley Brook treated in 2005; Red Rock treated in 2006
Length Distribution of Brook Trout Before and After Treatments

**Shirley Brook**
- 2009-10 (262 fish)
- 2003-04 (30 fish)

**Willard Brook - Upper**
- 2002-04 (78 fish)
- 2008-10 (101 fish)
“B” Channel Type
Draining < 2 square miles

*Upper Great Brook Treated in 2005
C Type Channels
Draining > 3 sq miles

*Lower Great Brook Treated in 2006
Did We Improve NHFG Trout Productivity Class?

- High = >35 Kg/Hectare
- Moderate = >15 and <35 Kg Hectare
- Low = < 15 Kg/Hectare

- Shirley changed from Low to High in some years.

- Red Rock and Upper Great Brook changed from Low Productivity Wild Trout Sites to Moderate Productivity Sites

- Lower Great Brook Remained Moderate Productivity Site

- Control Sites remained the same or dropped.

Changes in Brook Trout Biomass (Kg/Hectare)

- Pre-Treatment 2000-04
- Post-Treatment 2007-10
Increasing LWD Abundance and Climate Change
Lessons from Great Brook

- Increased LWD abundance can result in increased pool habitat.

- Trout populations in small streams with low pool abundance will benefit the greatest from the maturation of WMNF riparian forests.

- Deep scour pools created by woody debris jams may become the limiting habitat feature determining brook trout presence in headwater streams if droughts become more common.
Promoting Stream Connectivity in the Headwaters……
Will it Mitigate Effects of Climate Change?
Road-Stream Crossing Inventory

Results to Date:

- 392 stream crossings
- 196 culverts on intermittent streams
- 58 bridges over perennial streams
- 138 culverts on perennial streams
Level I Survey

- Determine if stream is perennial, intermittent, or unknown.

- Document crossing features on survey form

- Estimate bankfull width of stream at nearby stable stream section

- Photo document inlet, outlet, and stream above and below crossing.
Level II Survey – Fish Passage Assessment
Coarse Filters Predict if Passable for Groups of Fish Species

White Mountain National Forest
Level II: Aquatic Organism Passage Survey

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Impassible/Passible</th>
<th>Distance</th>
<th>Height of</th>
<th>Elevation</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>P1</td>
<td>13”</td>
<td>100</td>
<td>10.84</td>
<td>89.16</td>
<td>Upstream grade control</td>
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<tr>
<td>P2</td>
<td>29”</td>
<td></td>
<td></td>
<td>88.85</td>
<td>Bottom of pipe at inlet</td>
</tr>
<tr>
<td>P3a</td>
<td>29”</td>
<td></td>
<td>6.15</td>
<td>93.85</td>
<td></td>
</tr>
<tr>
<td>P3b</td>
<td>32”</td>
<td></td>
<td>5.43</td>
<td>91.57</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>41”</td>
<td></td>
<td>5.35</td>
<td>94.65</td>
<td>Center of road surface</td>
</tr>
<tr>
<td>P4a</td>
<td>53”</td>
<td></td>
<td>5.34</td>
<td>94.66</td>
<td></td>
</tr>
<tr>
<td>P4b</td>
<td>69”</td>
<td></td>
<td>7.24</td>
<td>93.76</td>
<td></td>
</tr>
<tr>
<td>P4c</td>
<td>69”</td>
<td></td>
<td>14.24</td>
<td>85.76</td>
<td>Bottom of pipe at outlet</td>
</tr>
<tr>
<td>P5</td>
<td>64”</td>
<td></td>
<td>16.16</td>
<td>85.84</td>
<td>Not well defined pool</td>
</tr>
<tr>
<td>P6</td>
<td>68”</td>
<td></td>
<td>15.81</td>
<td>84.19</td>
<td>Pool tail crest not well defined</td>
</tr>
<tr>
<td>P7</td>
<td>81”</td>
<td></td>
<td>17.03</td>
<td>82.97</td>
<td>Downstream grade control</td>
</tr>
</tbody>
</table>

Outlet Drop: 1.31
Culvert Slope: 4.5%
Culvert Length: 31

Inlet Depth: 2.66
Slope x Length: 105.5

Coarse Filter A: indeterminable
Coarse Filter B: impassable
Coarse Filter C: impassable

Outlet Drop: P4 elevation - P6 elevation
Culvert Slope: P2 elevation - P4 elevation
Culvert Length: P4 distance - P2 distance, X 100
Inlet Depth: P4 elevation - P2 elevation

P1 - upstream grade control
P2a - top of culvert inlet
P2n - upstream road shoulder
P2 - culvert inlet bottom
P3n - center of road surface
P3a - downstream road shoulder
P4a - top of culvert
P4 - culvert outlet bottom
P4n - downstream road shoulder
P5 - Pool maximum depth
P6 - outlet pool tail crest
P7 - channel point downstream of tailwater control
Status of Stream Crossing Inventory and AOP Assessment
All Perennial Streams 2007-10

Red = Barrier to some life stage of brook trout

Green = passable culvert or bridge
Majority of WMNF Culverts on Small Streams

Cumulative Frequency of Drainage Area Size for Culverts on Perennial Streams

Percent

Drainage Area (sq. miles)
Priorities for Stream Connectivity Restoration

- Is fish passage the driving concern?
- Are culverts failing?
- Are there concerns about road failures and downstream habitat or infrastructure impacts?
- Is the Road Profile going to change?
Headwaters of the Upper Ammonoosuc River

- Over 50 miles of perennial stream……maybe more?
- Godfrey Dam – Berlin water supply
- Dam isolates heavy fish stocking downstream from wild fish above.
- Western slopes are some of most enriched soils of WMNF…..buffering acid deposition.
- 16 mile Forest Service Loop road has long history of providing access for hunting, fishing, dog trials, and forest products.
- Road bisects all of the major tributaries of the main stem river.
Headwaters of Upper Ammonoosuc River
2005 Fish Inventory

West Branch of Keenan Brook

Upper Ammo River – above FR15

Keenan Brook

Upper Ammo River – above Godfrey Dam
Are they really Intermittent Streams?

<table>
<thead>
<tr>
<th>Year</th>
<th>Site ID</th>
<th>Bankfull Width (ft.)</th>
<th>pH</th>
<th>Fish Above?</th>
<th>Fish Below?</th>
<th>Adult Trout</th>
<th>Juvenile Trout and Dace</th>
<th>Sculpins</th>
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<tbody>
<tr>
<td>2009</td>
<td>FR15UpAmmoT2</td>
<td>6</td>
<td>6.3</td>
<td>no</td>
<td>yes</td>
<td>indeterminate</td>
<td>impassable</td>
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<tr>
<td>2009</td>
<td>FR15UpAmmoT3</td>
<td>4.5</td>
<td>6.4</td>
<td>no</td>
<td>no</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2009</td>
<td>FR15UpAmmoT5</td>
<td>3</td>
<td>6.4</td>
<td>yes</td>
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<td>indeterminate</td>
<td>impassable</td>
<td>impassable</td>
</tr>
<tr>
<td>2009</td>
<td>FR15UpAmmoT6</td>
<td>3.5</td>
<td>6.5</td>
<td>yes</td>
<td></td>
<td>indeterminate</td>
<td>impassable</td>
<td>impassable</td>
</tr>
<tr>
<td>2009</td>
<td>FR15UpAmmoT7</td>
<td>4</td>
<td>6.5</td>
<td>yes</td>
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<td>indeterminate</td>
<td>impassable</td>
<td>impassable</td>
</tr>
<tr>
<td>2009</td>
<td>FR15UpAmmoT8</td>
<td>4</td>
<td>6.4</td>
<td>yes</td>
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<tr>
<td>2009</td>
<td>FR15UpAmmoT10</td>
<td>3</td>
<td>6.6</td>
<td>yes</td>
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<td>impassable</td>
<td>impassable</td>
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<tr>
<td>2009</td>
<td>FR15UpAmmoT11</td>
<td>3</td>
<td>6.7</td>
<td>no</td>
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<td>n/a</td>
<td>n/a</td>
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</table>
Reconnecting Small Headwater Streams
Tributary #2 of Upper Ammonoosuc River - 2010
Brandy Brook- Larger Stream

Structure Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Bankfull/1.2 BF</td>
<td>11.3/13.5′</td>
</tr>
<tr>
<td>Stream Slope</td>
<td>12.8%</td>
</tr>
<tr>
<td>Q2</td>
<td>52.8 cfs</td>
</tr>
<tr>
<td>Q100</td>
<td>293 cfs</td>
</tr>
<tr>
<td>Existing Pipe Span</td>
<td>9'-4'</td>
</tr>
<tr>
<td>Existing Pipe Rise</td>
<td>5'6&quot;</td>
</tr>
<tr>
<td>Min. Bridge Length</td>
<td>18'</td>
</tr>
<tr>
<td>Bridge Skew</td>
<td>10°</td>
</tr>
<tr>
<td>Plate Arch Span</td>
<td>14'</td>
</tr>
<tr>
<td>Plate Arch Rise</td>
<td>5'-1 1/2&quot;</td>
</tr>
<tr>
<td>Plate Arch Length</td>
<td>58'</td>
</tr>
</tbody>
</table>
Designing Stream Simulation Crossings
Level III Survey
Longitudinal Profile

- Determine the slope of the new culvert
- Determine how deep to embed a culvert
- Determine how to restore the stream channel above and below the crossing
- Locate reference sites for cross sections
Reference Cross Section

Determine bankfull width

Determine stream morphology and size of stream substrate
Construct Step-Pool Channel at 4% Gradient
Innovation
Fill in the Gaps!
Stream Simulation
Stream Connectivity and Climate Change

- Incorporating stream simulation techniques into stream crossing designs may allow small headwater streams experiencing drought to be re-populated by aquatic species.

- Implementing stream simulation as a standard stream crossing practice may reduce the number of culvert and road failures from flood events.
Adaptive Land Management to Promote Ecosystem Resiliency

Connecting headwater streams to lower watersheds

Restoring high quality stream habitat

Conserving Coldwater Ecosystems
Thanks to all who made this possible.....
Many Forest Service Employees
New Hampshire Fish & Game....US Fish & Wildlife Service....Trout Unlimited