# Fish Occupancy & Stream Temperature:

## Models & metrics for planning and management

NALCC Connecticut River Watershed Pilot Project
Aquatics Subgroup
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USGS Conte Anadromous Fish Research Center
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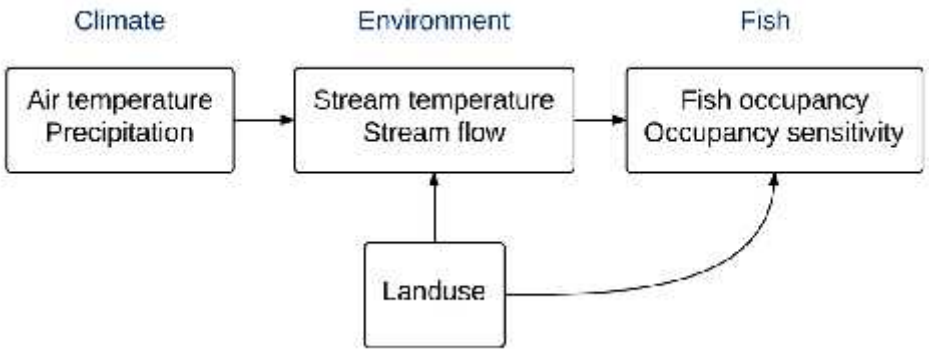
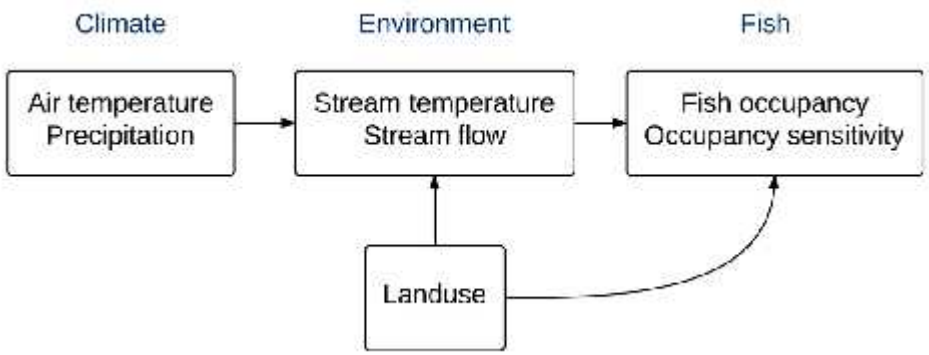
- Understand fish population response to environmental variation
  - Stream and environmental conditions
    - stream temperature
    - stream flow
    - riparian habitat
  - Stream and environmental conditions are driven by
    - basin characteristics, including land use
    - climate, including air temperature & precipitation



# Products: Broad spatial-scale

| | Predictions | Interpreted metrics |
|---|---|---|
| Ecological | • Fish occupancy | • Fish occupancy sensitivity to<br>  • Temperature increase<br>  • Forest cover decrease/increase |
| Environmental | • Daily stream temperature<br>• Mean annual stream flow | • Average maximum temperature<br>• Days exceeding 18˚C<br>• Resistance to air temperature peaks<br>• *Many other possibilities* |



# Suggested Objectives modeled after EBTJV

| EBTJV Conservation Priority | Category | | |
|---|---|---|---|
| **Protect the "best of the best" habitat that supports existing, healthy wild brook trout populations;** | All streams | Rank Locations (within each category) | Set Objectives (within each category) |
| **Focus on critical wild brook trout spawning and early life history habitat in sub-watersheds classified as Intact;**<br><br>**Conserve unique wild brook trout life history strategies (i.e. lacustrine populations, large river populations, and coastal populations)** | Classify stream reaches by stream size, to distinguish *stream-resident* and *fluvial populations* | | |
| **Preserve genetic diversity and strains of wild brook trout populations** | Classify stream reaches by air temperature, to ensure inclusion of populations with genetic *adaptations to warming* | | |

| Other Conservation Priority | | | |
|---|---|---|---|
| **Protect habitat where brook trout are expected to persist under climate warming** | Identify stream reaches that are more resistant to high peaks in air temperature | Rank Locations | Set Objectives |

# Brook trout

- Brook trout and brown trout: most widely and consistently available field observation data of headwater species
- Brook trout is a native species valued by environmentalists and sportsmen
- Brook trout are a good representative of coldwater species
  *(Note: total number of species in headwater habitats is relatively low)*

- All model methods and predictions can be performed for ***other species***
- All model methods and predictions can be performed for ***communities of species***

- Quality checking and applying metadata standards to produce a consistent, updatable, quality data set has only been performed for brook trout
- Data for other species may be more limited

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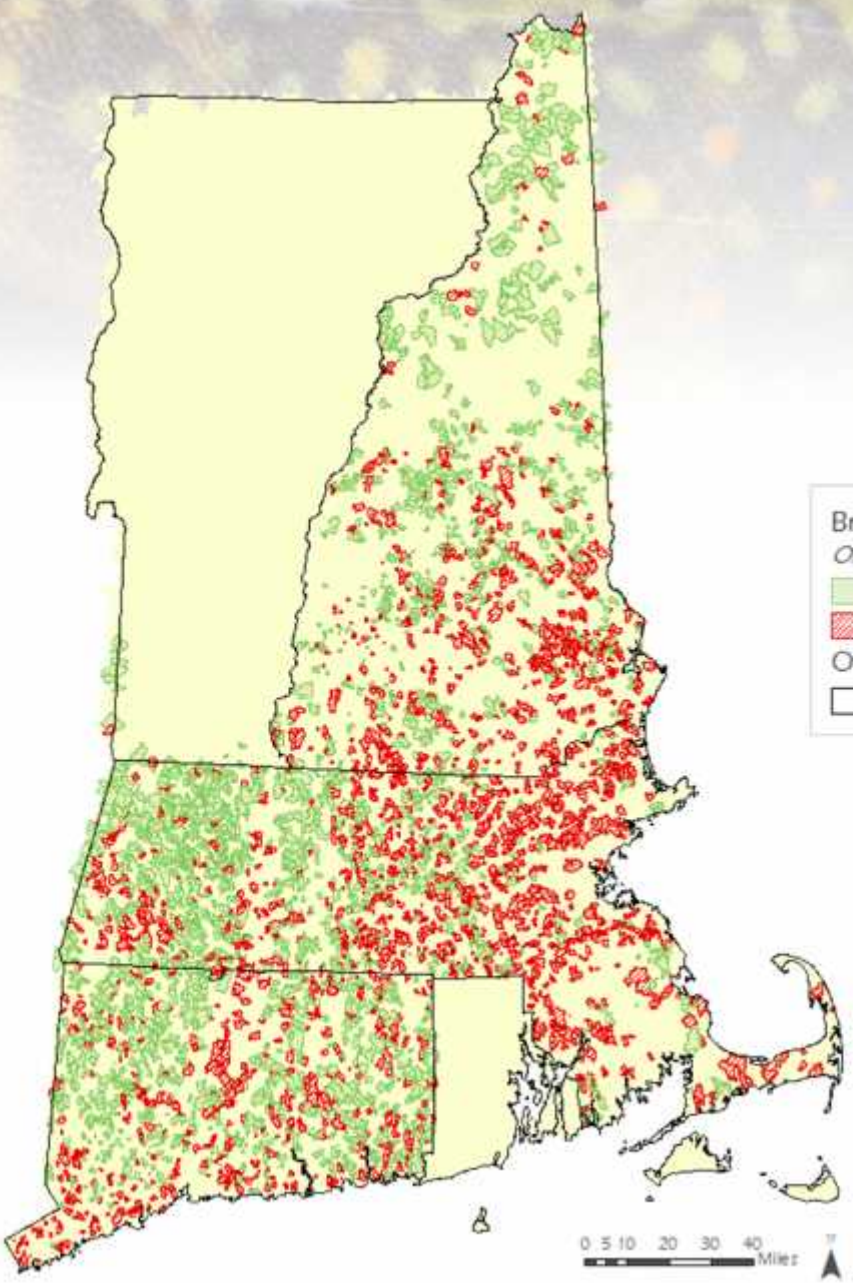
# Brook Trout Presence/Absence Observation Data

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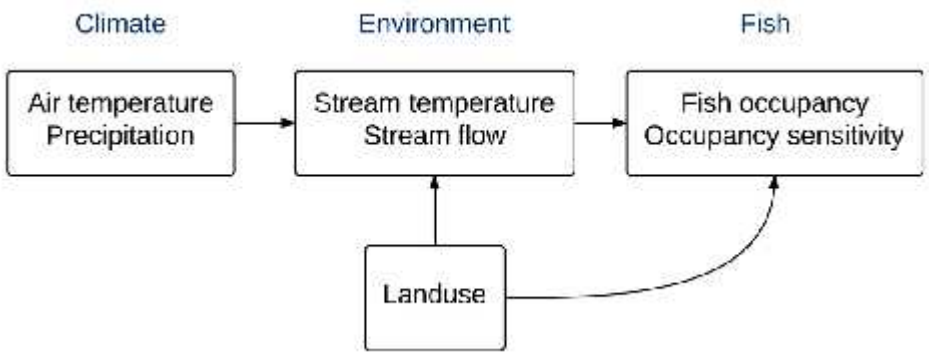

# Occupancy Models for Understanding Effect of Environmental Drivers

- Probability of fish species presence is determined by the *combined effect of multiple environmental drivers* (compared with niche envelope)
- Instead of weighting importance of various drivers, occupancy models use *empirical observations* to estimate the relative effect of environmental conditions
- Requires significant field observation data

- Drivers include
  - Stream flow
  - Stream temperature
  - Forest cover
  - Geology and soils
  - Number of upstream dams
  - Wetlands and open water
- Ties these environmental conditions with *fish sampling field observations*
- Generate predictions under current or altered conditions

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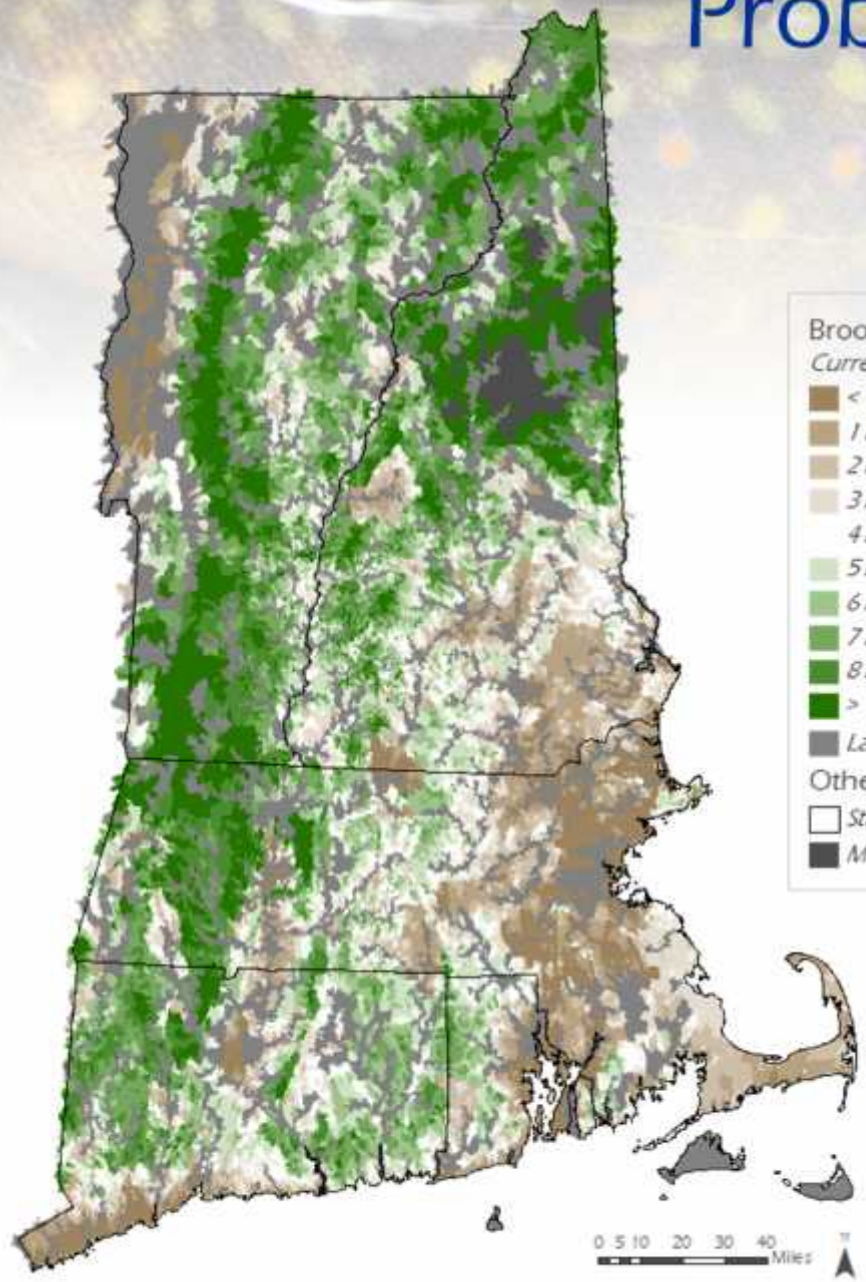
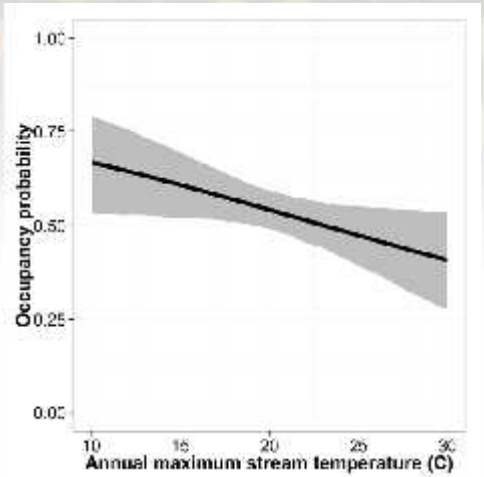
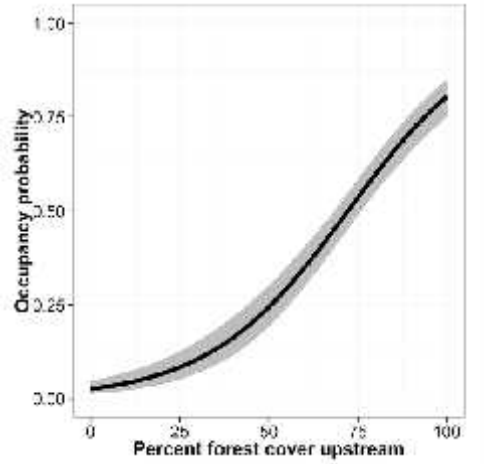
# Probability of Occupancy

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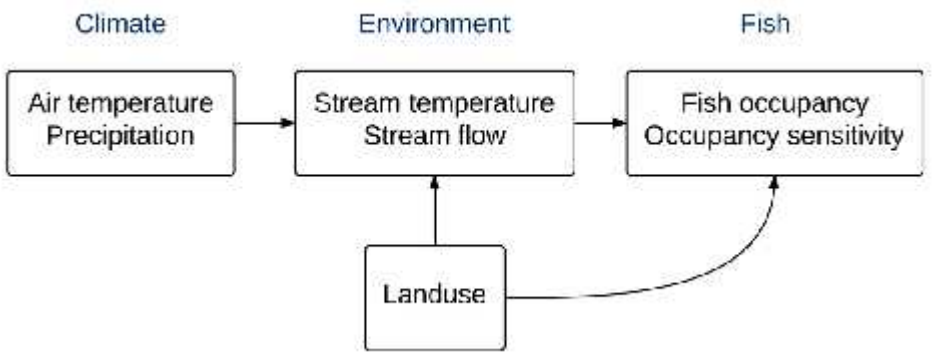
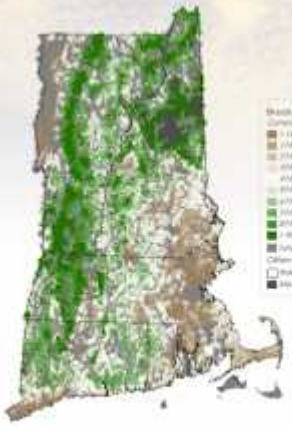


# Occupancy under Warming

Changes from current temperature

current



+2 C

+4 C

+6 C

GCM scenarios

2030

2080

high

low

>50% probability of occupancy “target”

For these stream reaches, how much of an increase in air temperature can be ***tolerated*** such that the stream still meets the 50% probability of occupancy target?

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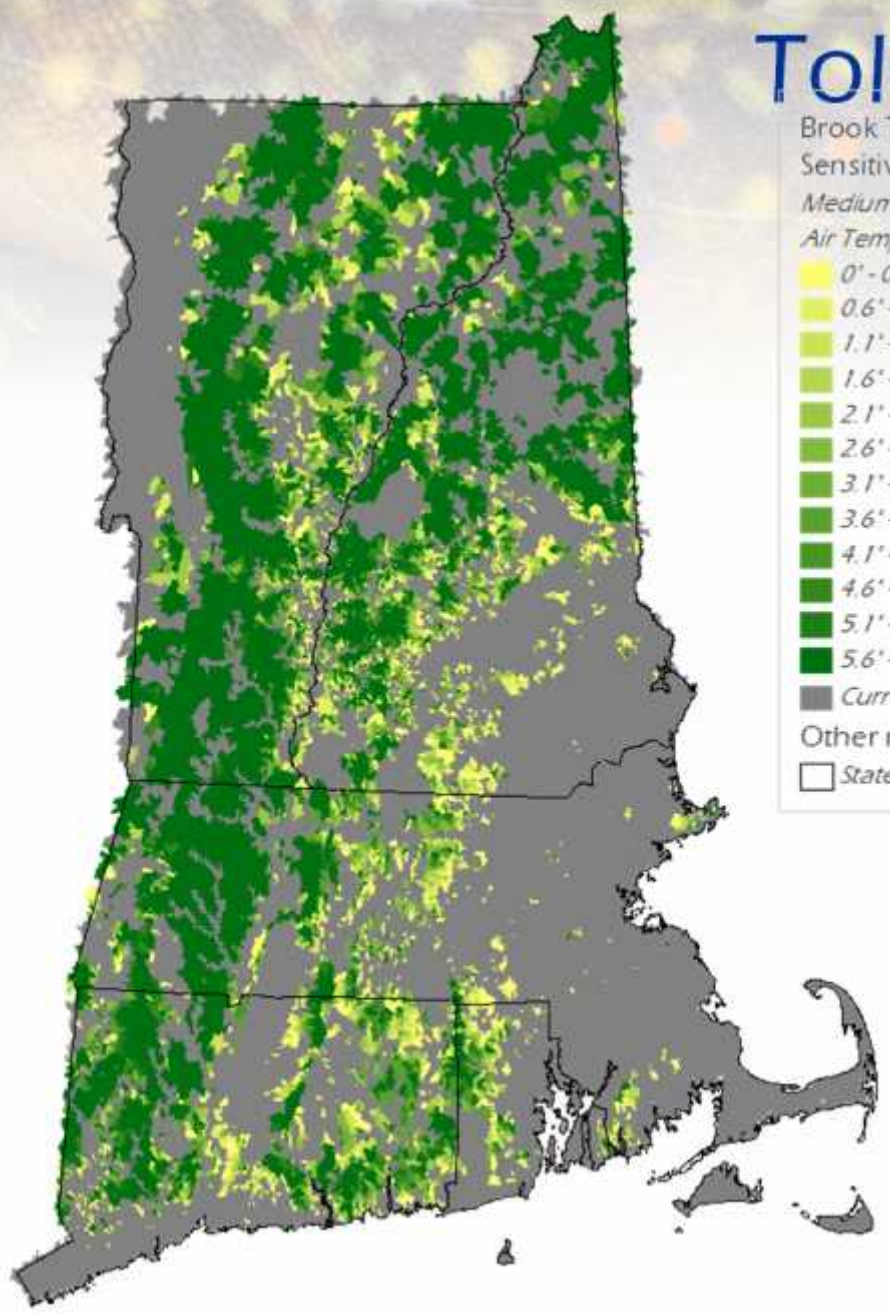
# Tolerance to Warming



Brook Trout Occupancy
Sensitivity to Climate Change
*Medium Occupancy Target*
*Air Temp Increase Tolerated (°C)*

- *0° - 0.5°*
- *0.6° - 1°*
- *1.1° - 1.5°*
- *1.6° - 2°*
- *2.1° - 2.5°*
- *2.6° - 3°*
- *3.1° - 3.5°*
- *3.6° - 4°*
- *4.1° - 4.5°*
- *4.6° - 5°*
- *5.1° - 5.5°*
- *5.6° - 6°*
- *Currently Below Target*

Other map elements

- *State outlines*

*Degrees of increase tolerated*

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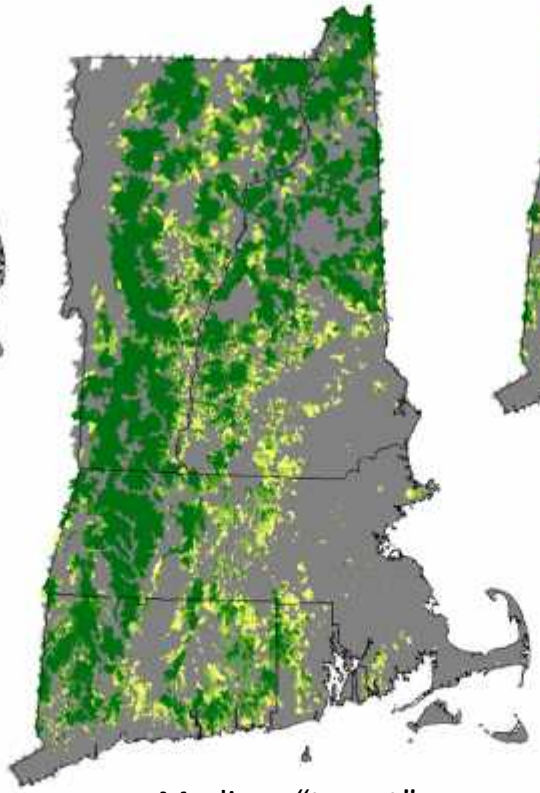
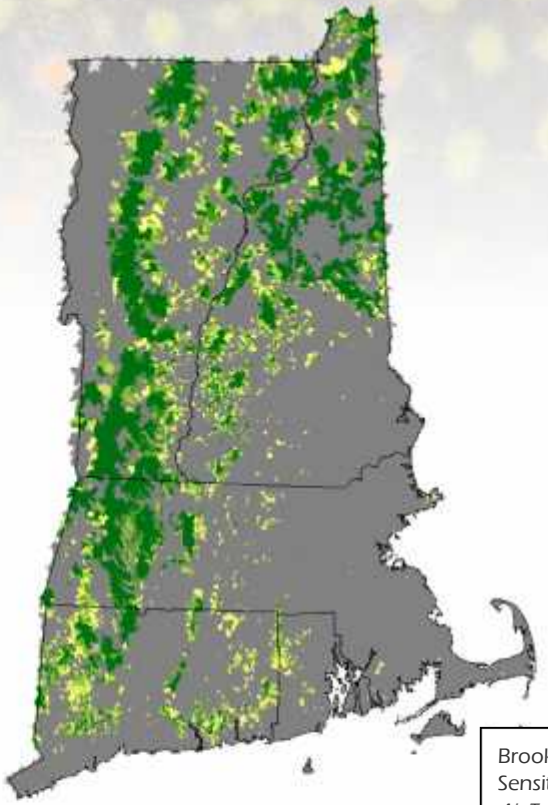
# Tolerance to Warming

Low “target”



Medium “target”



High “target”

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Sensitivity to Climate Change
*Air Temp Increase Tolerated (°C)*
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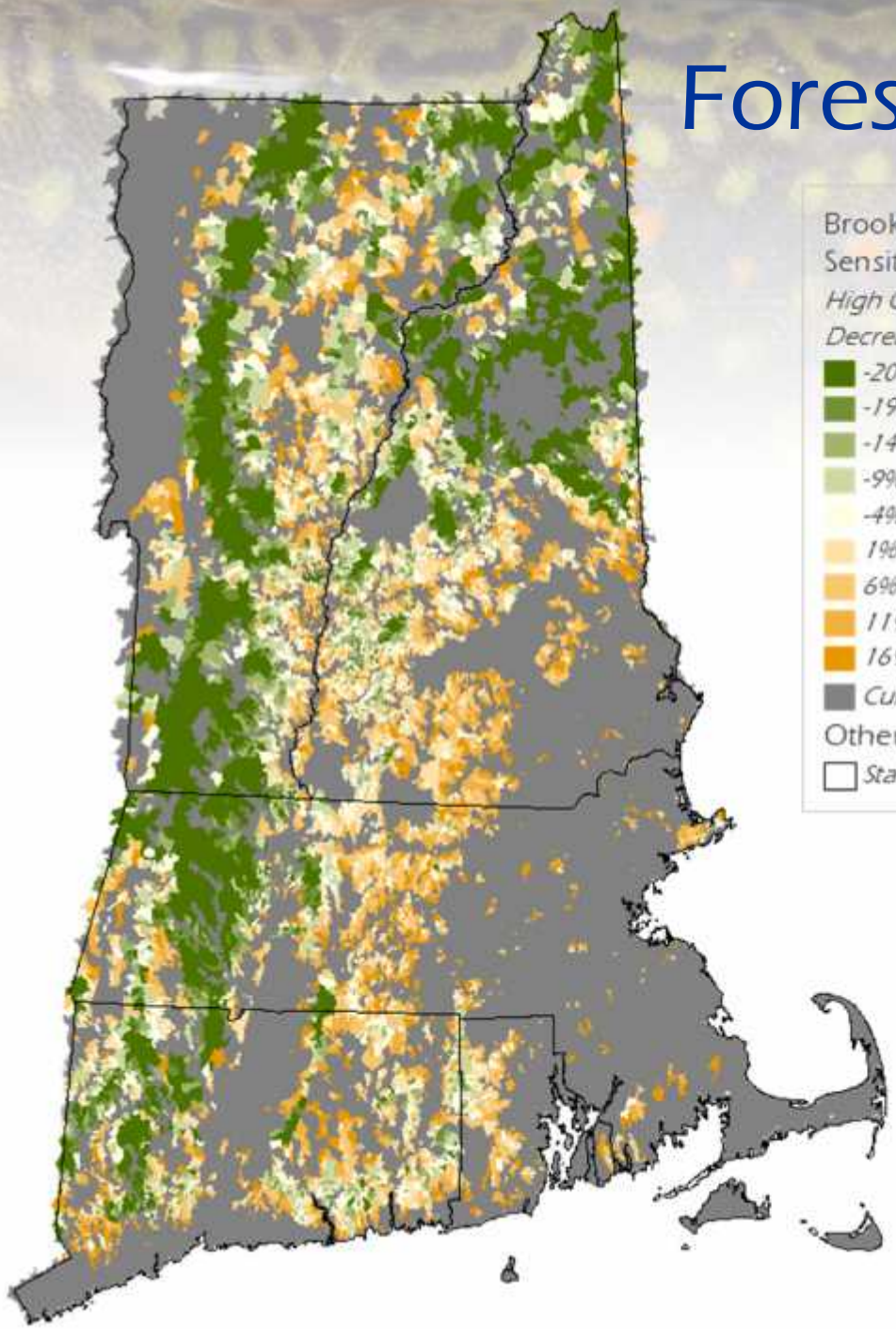
- *4.6° - 5°*
- *5.1° - 5.5°*
- *5.6° - 6°*
- *Currently Below Target*

Other map elements
- *State outlines*

# Forest Cover Change



Brook Trout Occupancy
Sensitivity to Change in % Forest Cover
*High Occupancy Target*
*Decrease Tolerated or Increase Required*

- -20%
- -19% - -15%
- -14% - -10%
- -9% - -5%

*tolerance to development*

- -4% - 0%
- 1% - 5%
- 6% - 10%
- 11% - 15%
- 16% - 20%

*potential for restoration*

- *Currently Below Target*

Other map elements

- *State outlines*

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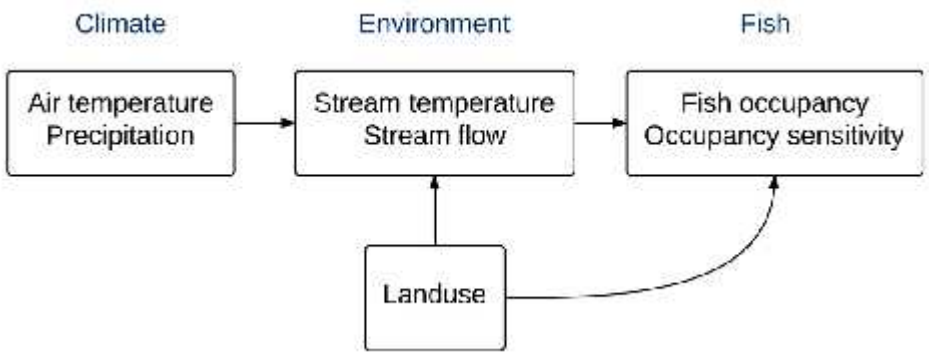
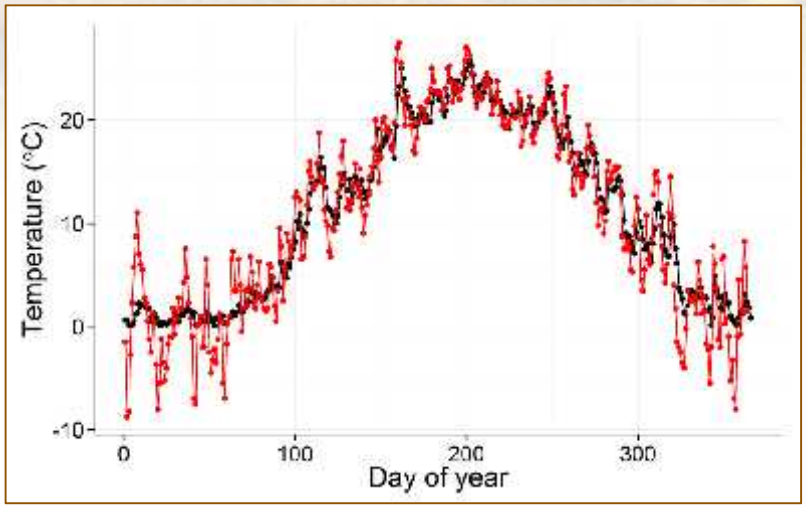
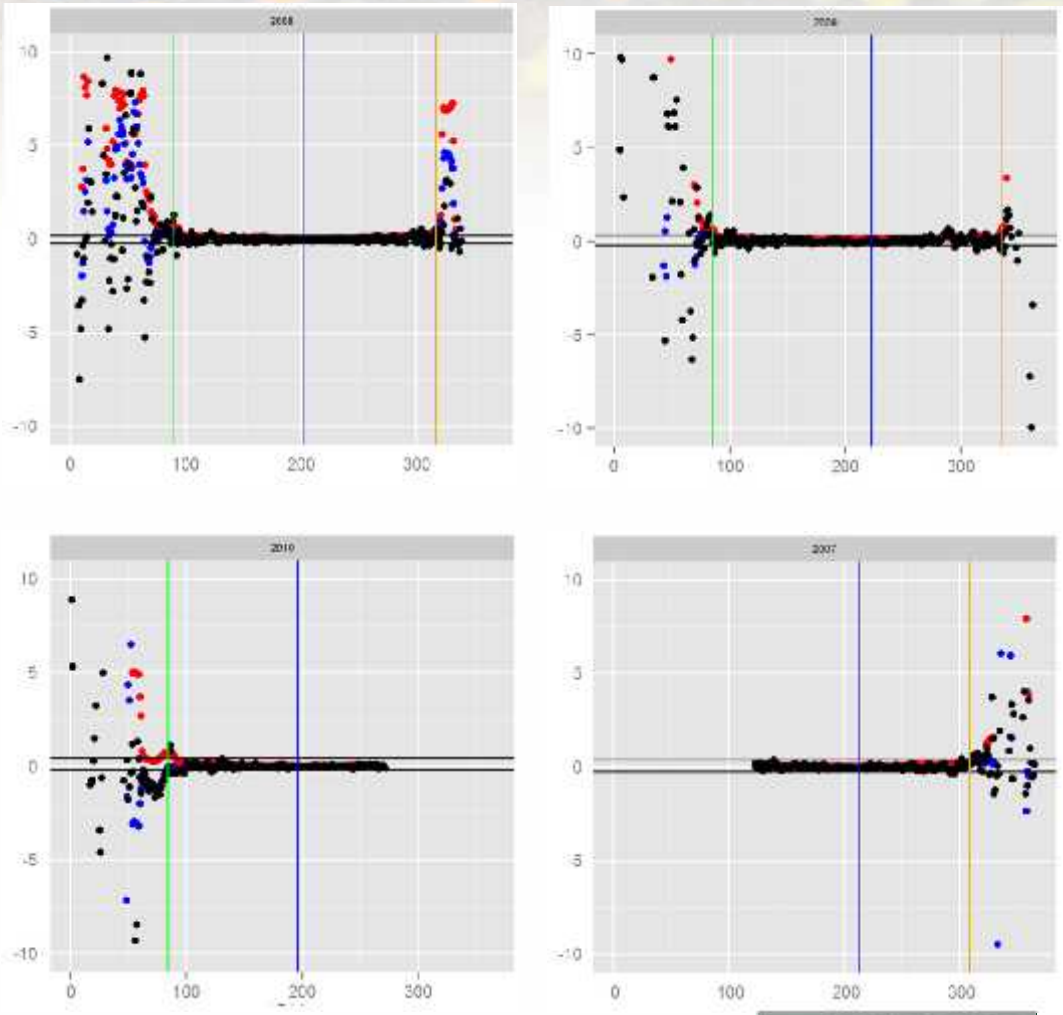


# Stream Temperature

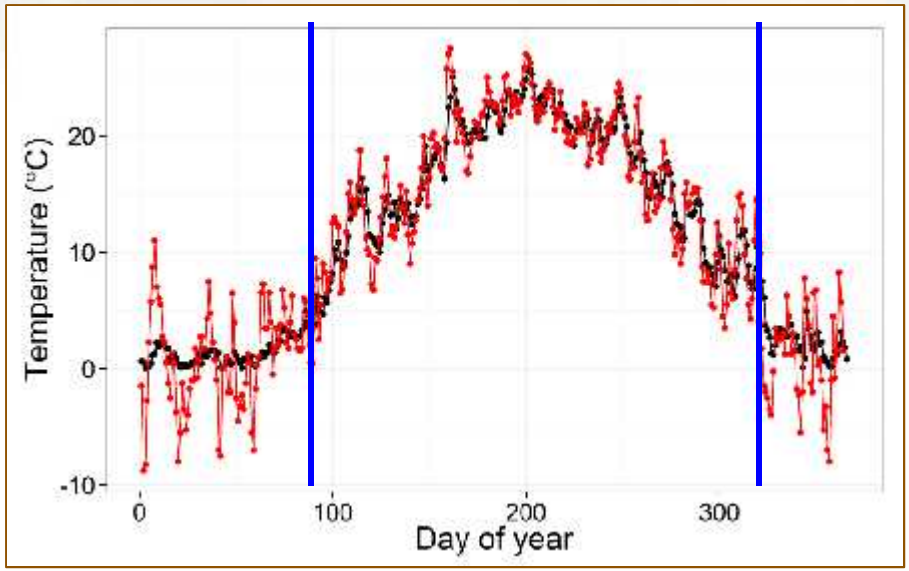



— Water
— Air

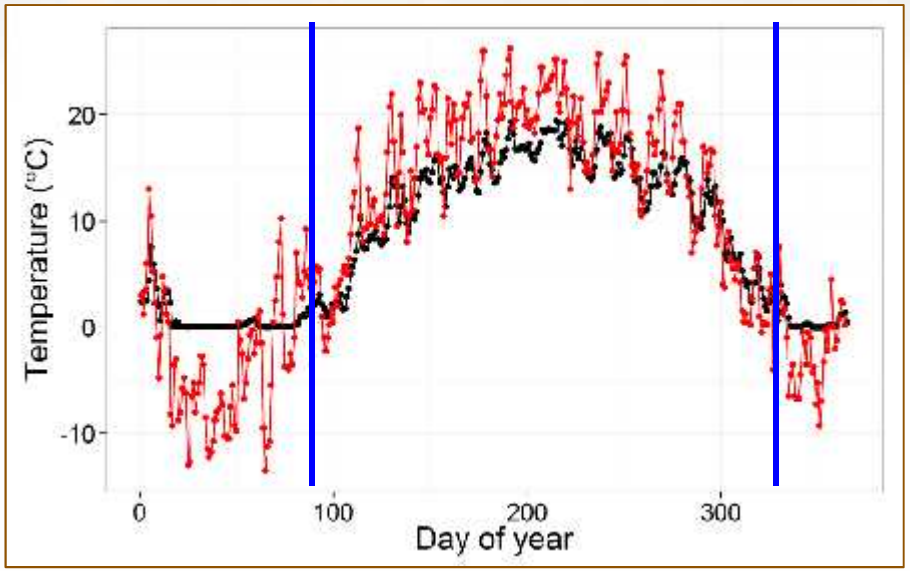


# Stream Temperature

Stream 1




Stream 2




— Water
— Air

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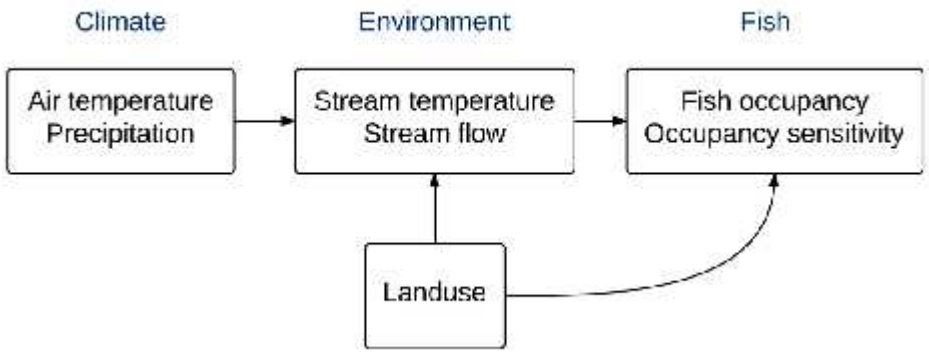
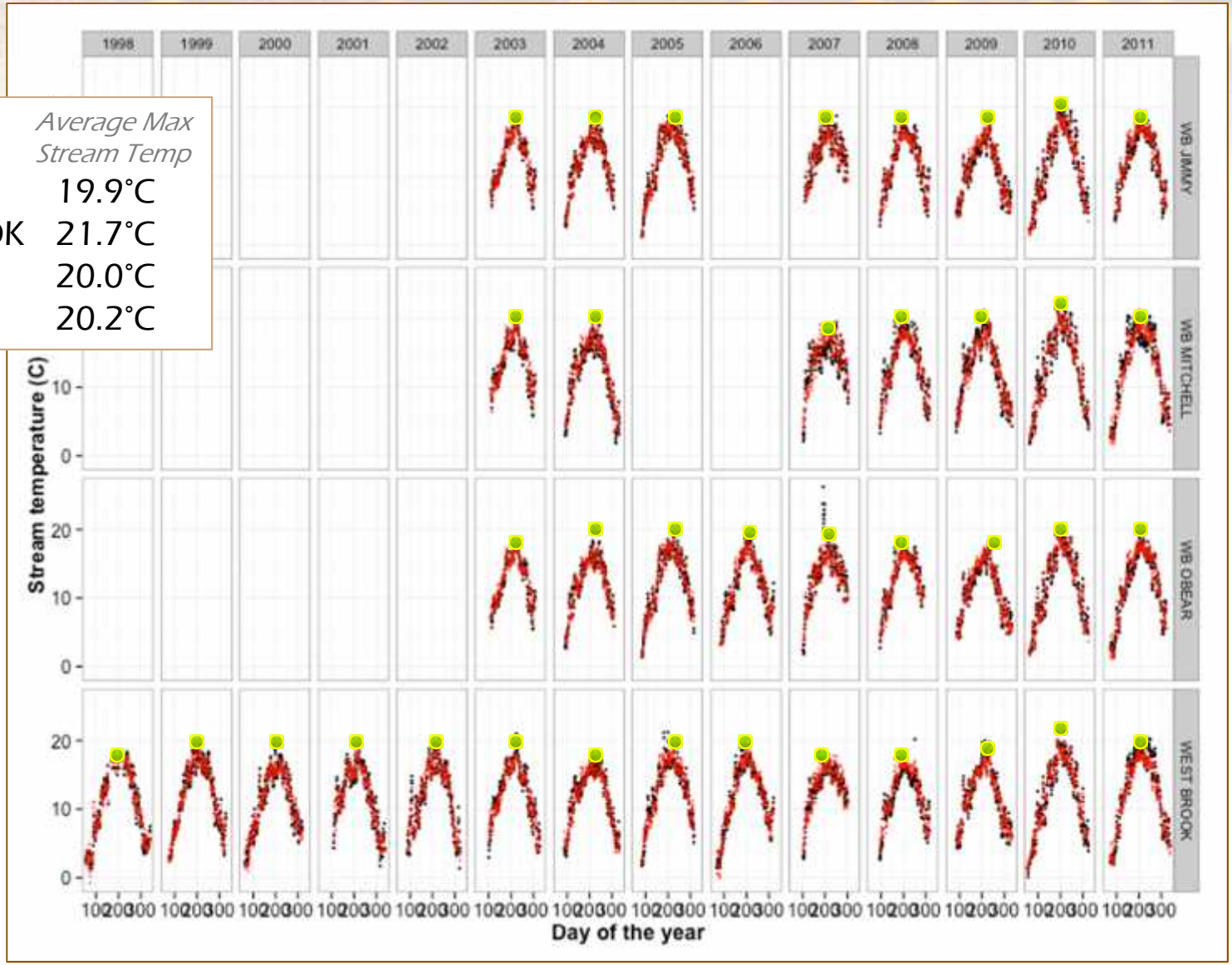


# Stream temperature interpreted metrics
## Average Maximum

| *Stream Name* | *Average Max Stream Temp* |
|---|---|
| JIMMY BROOK | 19.9°C |
| MITCHELL BROOK | 21.7°C |
| OBEAR BROOK | 20.0°C |
| WEST BROOK | 20.2°C |

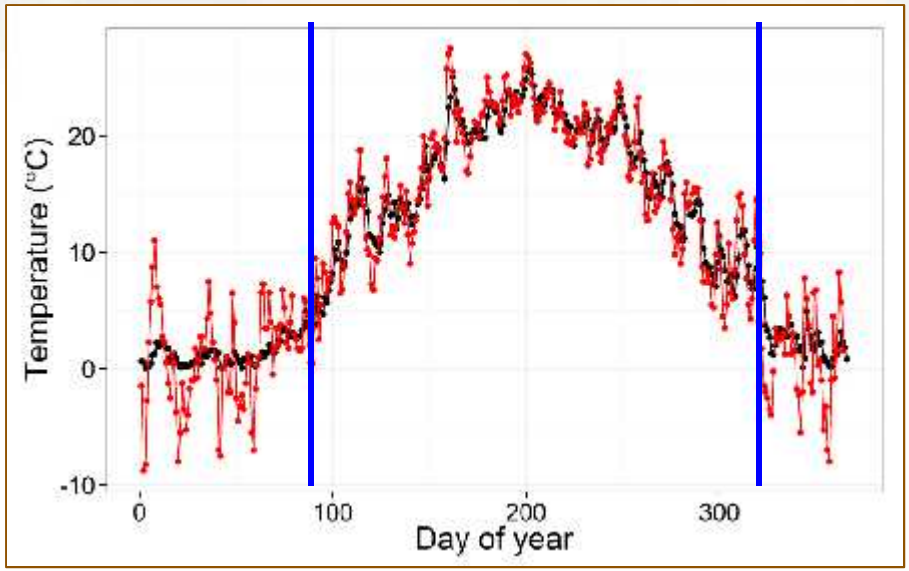



— Air
— Water
● Tmax water

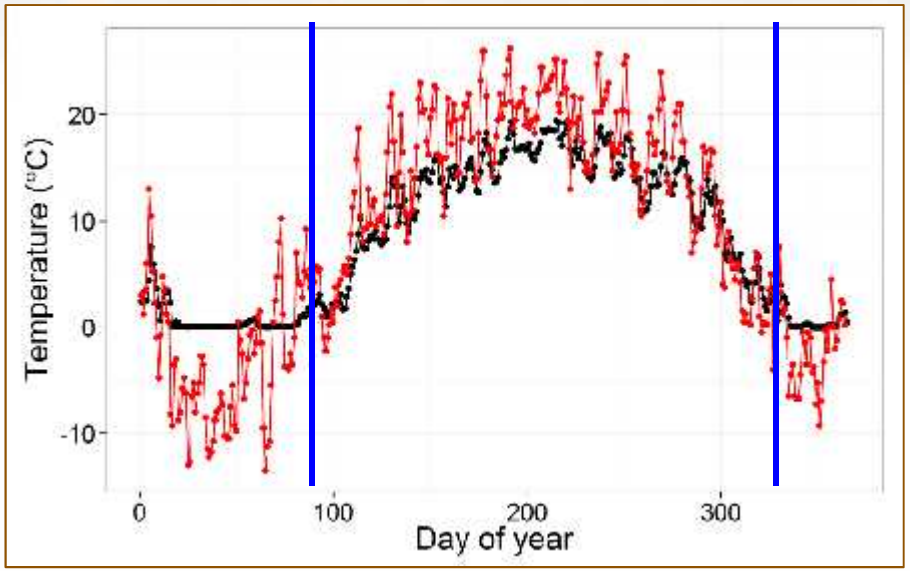
# Stream temperature interpreted metrics
## Number of days over 18 °C


Obear Brook 2010:
26 days

Stream 1




Stream 2




— Water
— Air

Streams differ in their
resistance to air temperature peaks

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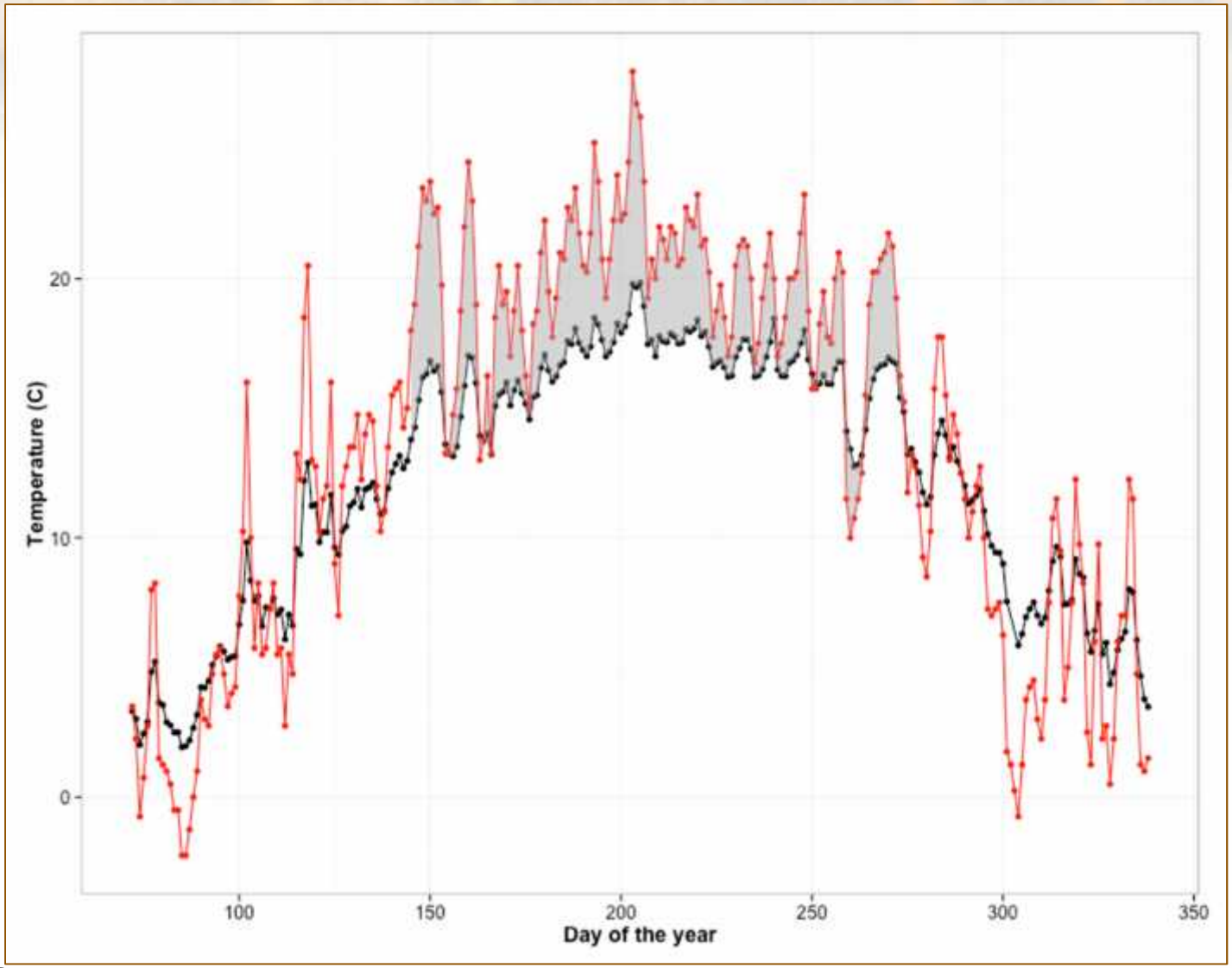
# Stream temperature interpreted metrics
# Resistance to peak air temperature




West Brook 2011:
417 air-water °C-days

— Water
— Air
■ Resistance to air temp peaks

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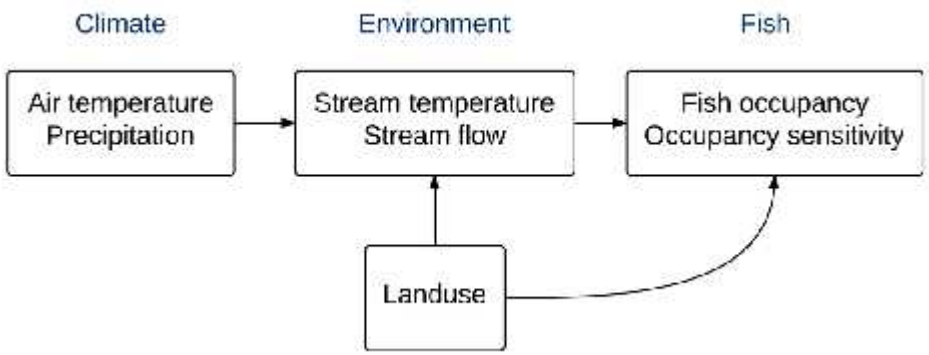

# Suggested Objectives modeled after EBTJV

| EBTJV Conservation Priorities | Category | Ranking (within each category) | Objective (within each category) |
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| **Protect the "best of the best" habitat that supports existing, healthy wild brook trout populations;** | All streams | Identify x km streams w/ highest probability of occupancy<br>or<br>Identify all streams above 80% probability of occupancy<br>or<br>Identify top 10% of streams w/ highest ˚C of warming tolerated | Set target of x km streams with ≥ 50% probability of occupancy |
| **Focus on critical wild brook trout spawning and early life history habitat in sub-watersheds classified as Intact;**<br><br>**Conserve unique wild brook trout life history strategies (i.e. lacustrine populations, large river populations, and coastal populations)** | Classify stream reaches by stream size, to distinguish *stream-resident* and *fluvial populations* | | |
| **Preserve genetic diversity and strains of wild brook trout populations** | Classify stream reaches by air temperature, to ensure inclusion of populations with genetic *adaptations to warming* | | |
| **Other conservation Priorities** | | | |
| **Protect habitat where brook trout are expected to persist under climate warming** | Identify stream reaches that are more resistant to high peaks in air temperature | Identify x km streams w/ lowest maximum stream temperature<br>or<br>Identify x km of streams w/ fewest days exceeding 18˚C<br>or<br>Identify top 10% of streams with highest resistance to air temperature peaks | Set target of x km streams with maximum stream temperature ≤20°C<br>or<br>Set target of x km **protected** streams with resistance to air temperature peaks ≥ 300 air-water degree-days |

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