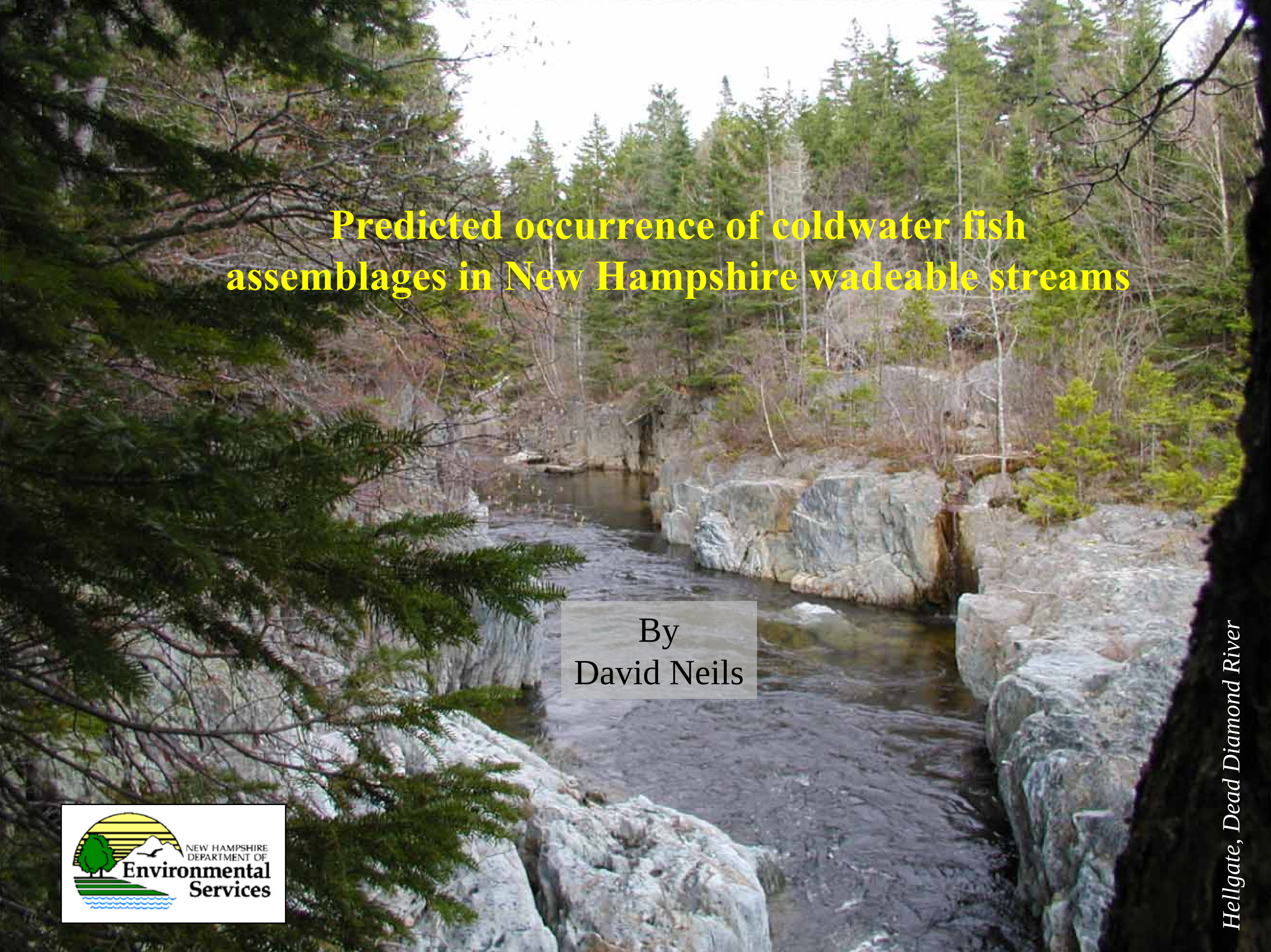
Predicted occurrence of coldwater fish assemblages in New Hampshire wadeable streams

By
David Neils



Hellgate, Dead Diamond River

New Hampshire Department of Environmental Services

Purpose

- DES maintains separate dissolved oxygen criteria for "coldwater" streams from Oct. 1 – May 14 (to June 30 for late spawners)
- Strict coldwater fish assemblages are geographically defined; but doesn't include all streams where more diverse coldwater fish assemblages occur
- Assists in defining where warmwater communities are expected
- Useful for establishing instream water temperature criteria

Objectives

- To determine if a model could be built that predicts where cold water fish communities are expected occur
- Decide what variables are important in determining the presence or absence of cold water fish communities
- Assess the practicality of applying the model’s results statewide

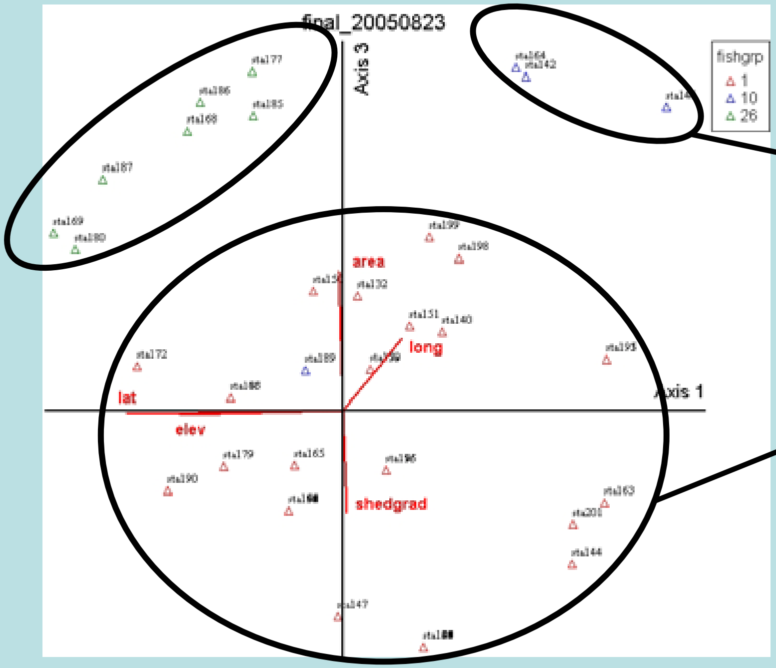
Dataset

- NH DES biomonitoring fish collections 1997 – 2006
- Limited to 1st – 4th order streams sampled from June – August
- 163 stations included in analysis (eliminated sites known to have significant human disturbance
- Broken in calibration (115 sites) and validation (48 sites) datasets
- Analysis based on presence / absence occurrence
- A minimum of 2 individuals collected at site to be considered “present”

Approach

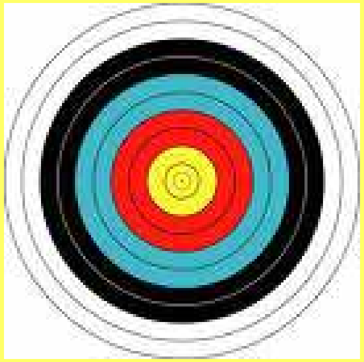
Basic premise: biological assemblages are, in part, structured by the physical and chemical environmental conditions in which they live. If distinct biological assemblages can be identified, then the variables that define them can be determined.

Identification of assemblage types



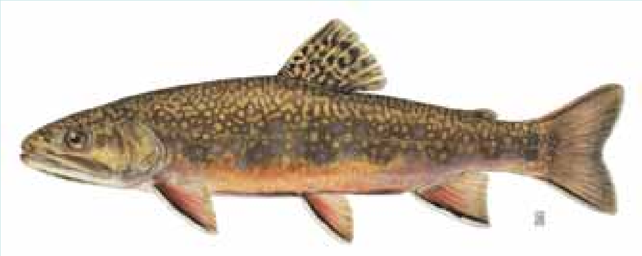
Species composition indicated these are coldwater

Identification of target species

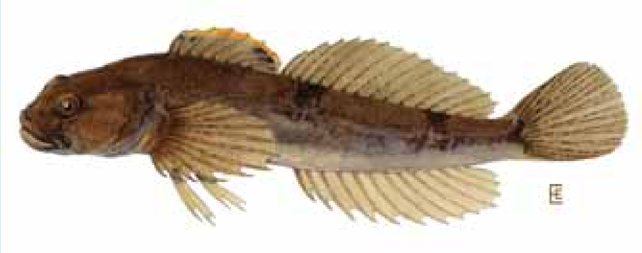


Requirements for target species:

- ✓ Coldwater "specialists"
- ✓ >30 occurrences
- ✓ known to have statewide distribution
- ✓ native to NH



Brook Trout (*Salvalinus fontinalis*)



Slimy Sculpin (*Cottus cognatus*)

Defining the Variables that Structure Coldwater Fish Assemblages

Requirements

- **Permanence** – Variables that resist change

  Good Example: Elevation

  Bad Example: Substrate composition

- **Ease of collection** – Variables that can be obtained quickly, accurately

  Good Example: Latitude

  Bad Example: Flood prone width

- **Natural range of variability** – Variables that are robust

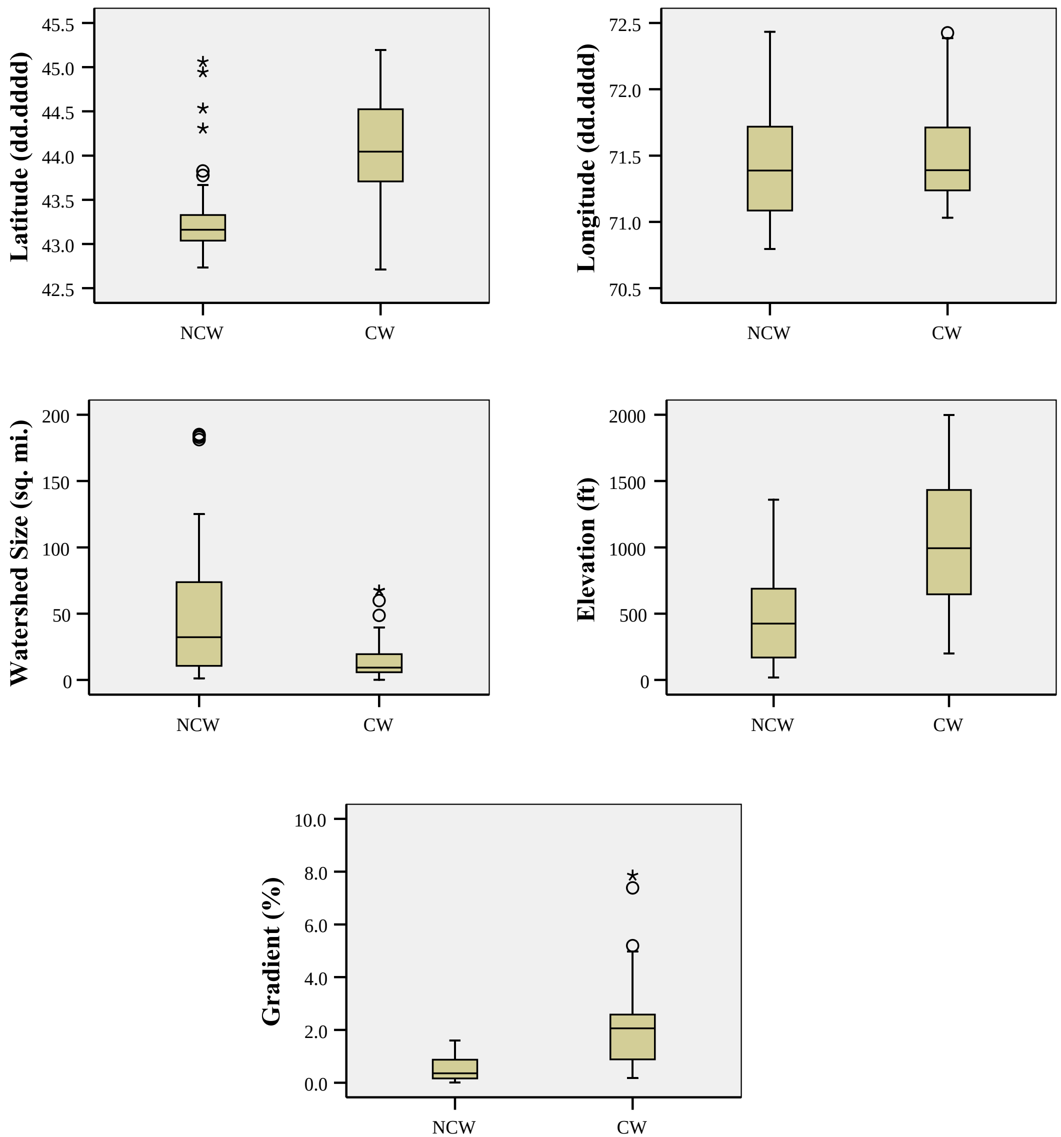
  Good Example: Watershed size

  Bad Example: Stream bank slope

Candidate Variables

- **Latitude** – dd.dddd
- **Longitude** – dd.dddd
- **Elevation** – feet
- **Watershed Area** – square miles
- **Gradient** - % slope
- **Major River Basin** – Merrimack, Piscataqua, Saco, Connecticut, Androscoggin
- **Ecological Drainage Unit (EDU)** – Androscoggin, Upper CT, Lower CT, Merrimack/Coastal

Independent Consideration of Variables

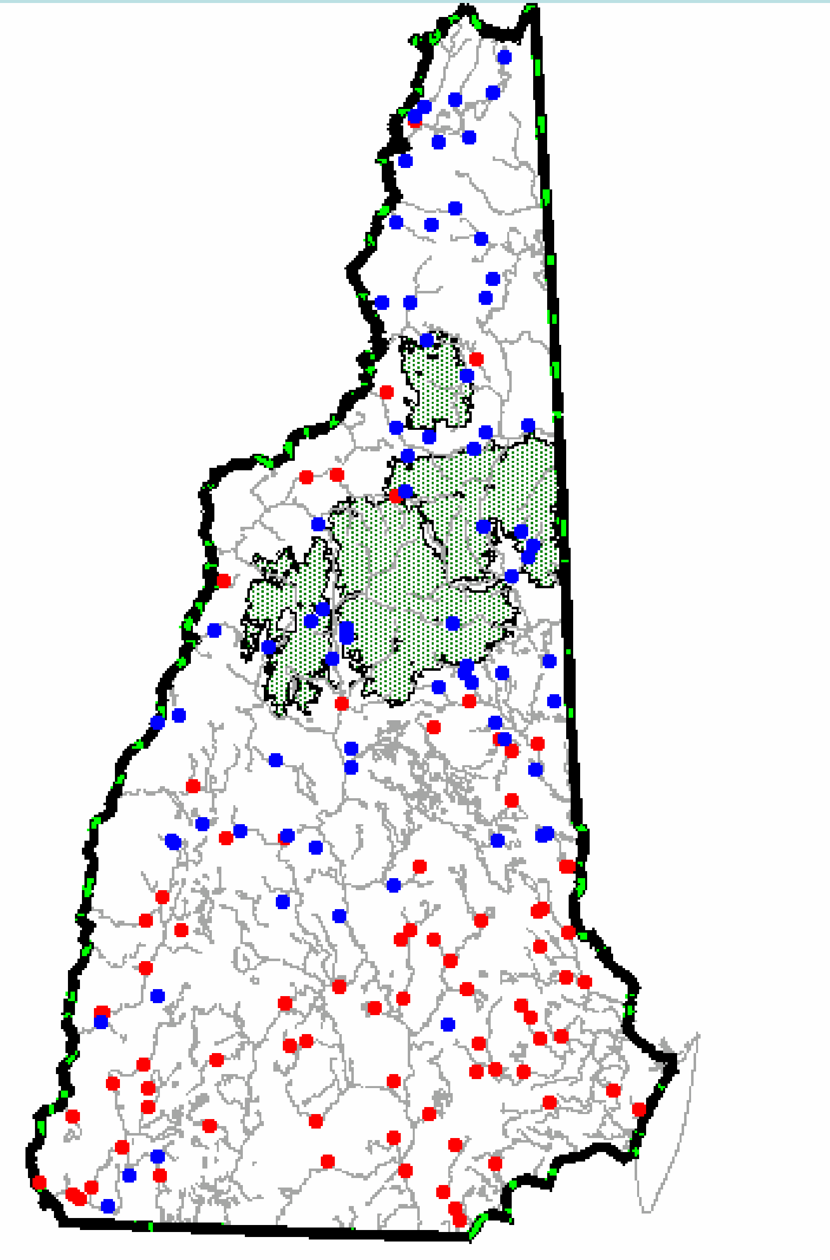


Results

Variable	Significance
Continuous	
Latitude	<0.001
Longitude	0.396
Drainage Area	<0.001
Elevation	<0.001
Gradient	<0.001
Categorical	
River Basin	<0.005
EDU	<0.005

Distribution of calibration dataset cold and non-cold water fish assemblages sampled by NH DES biomonitoring unit 1997 – 2006.

- CW community present
- CW community absent
- WMNF Boundaries



- More frequent in north
- More frequent in smaller watersheds
- Less frequent in Merrimack and Coastal areas
- More frequent in steeper gradients
- More frequent at higher elevations

Simultaneous Variable Consideration

OK – So 5 of 6 variables show differences b/t cold and non-cold water fish communities, but how do the variables inter-relate?

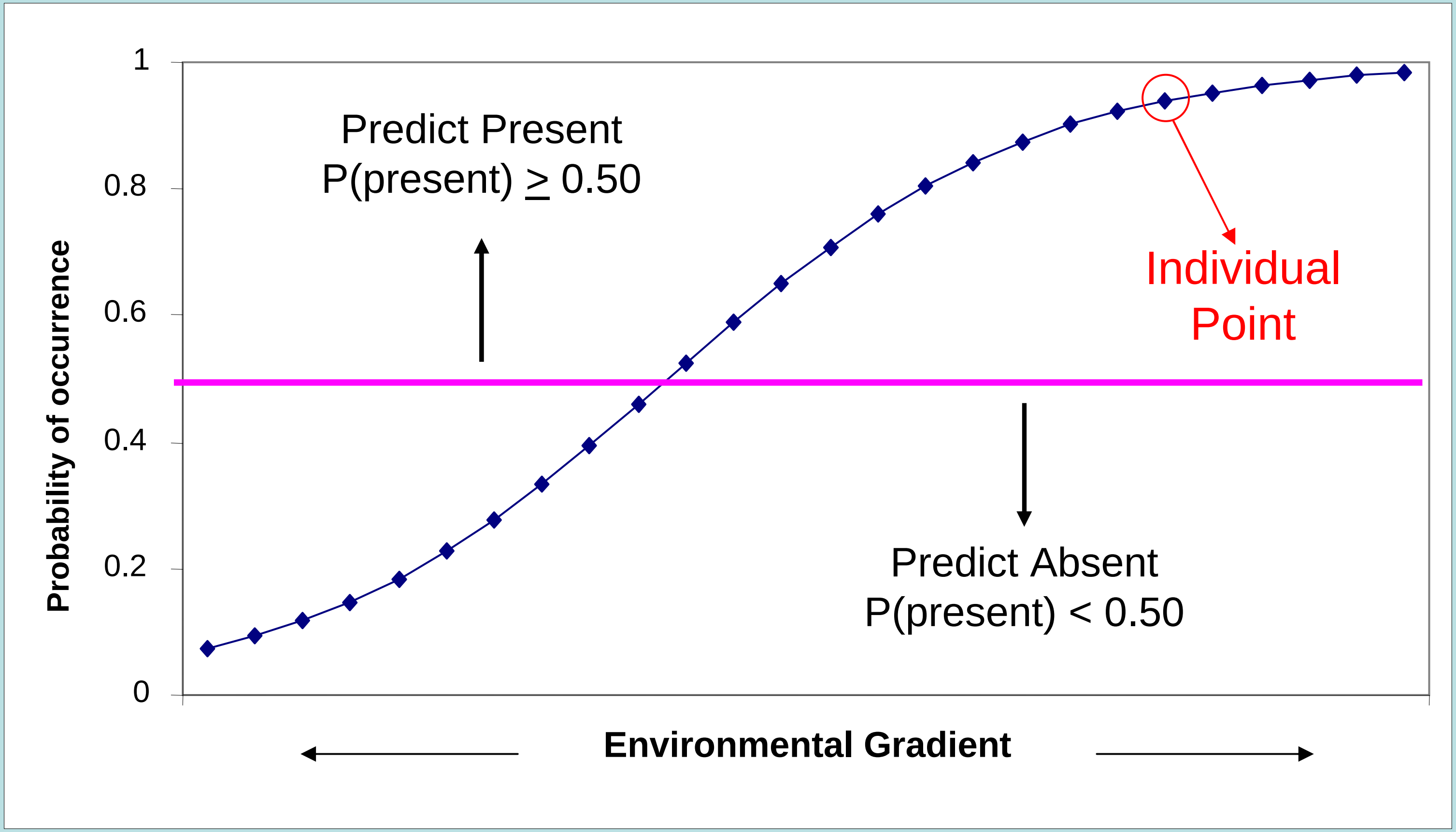
We need another analysis tool…

Logistic Regression: yes, I'll spare you the details

What you need to know:

- **Each variable is examined for its relative importance (similar to step-wise linear regression)**
- **Regression equation assigns each site a probability (0 – 1) of being a cold (1) or non-cold (0) water fish community based on important variables**
- **Predictive accuracy (i.e. # correct predictions) of model as measure of success**

Logistic Regression Overview

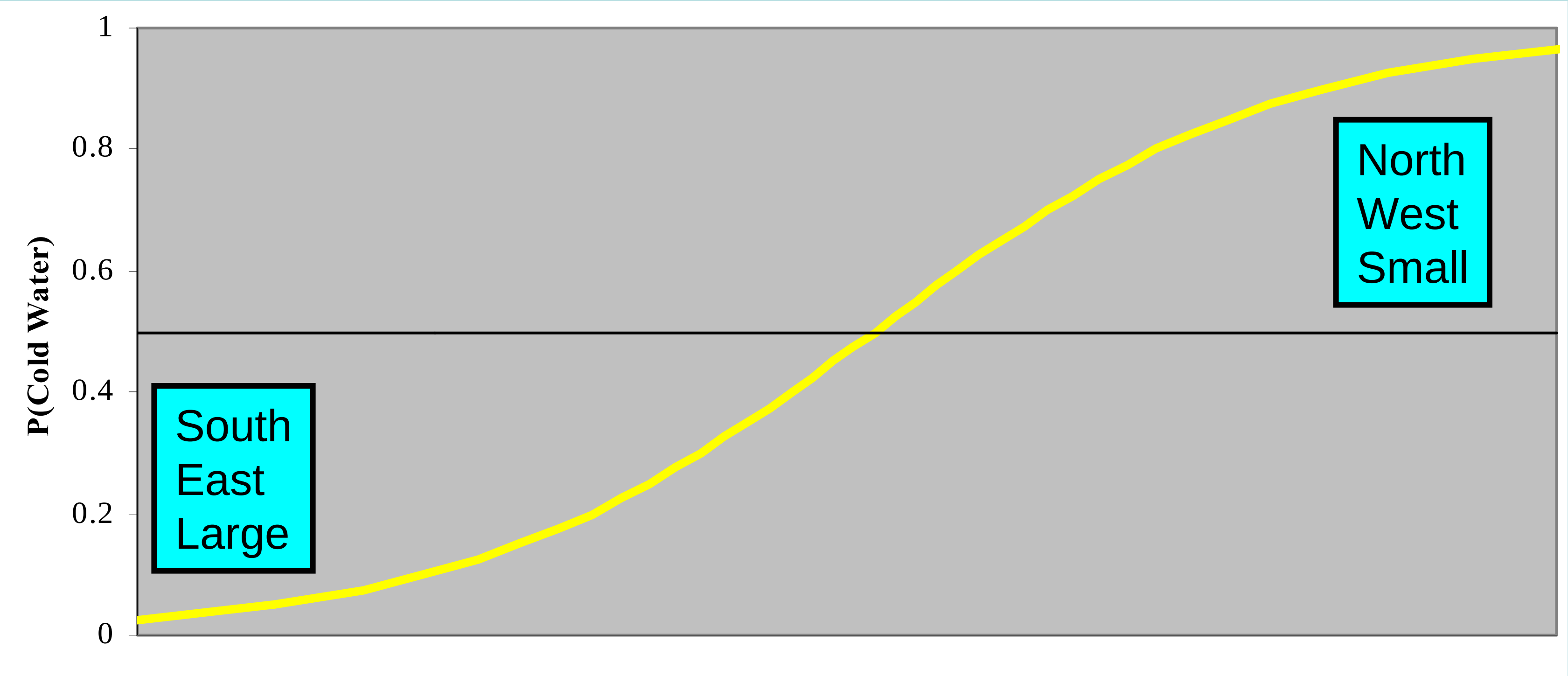


$$\textbf{P(present)} = \frac{1}{1 + \exp(-\alpha - \beta_1 X_1 - .. \beta_i X_i)}$$

Model Results

Model #	Variables	Overall Predictive Accuracy
1	Elevation	75.7%
2	Elevation, Drainage Area	82.6%
3	Elevation, Drainage Area, Latitude	83.5%
4	Elevation, Drainage Area, Latitude, Longitude	84.3%
5	Latitude[1], Drainage Area[2], Longitude[3]	89.9% (92% present; 86% absent)

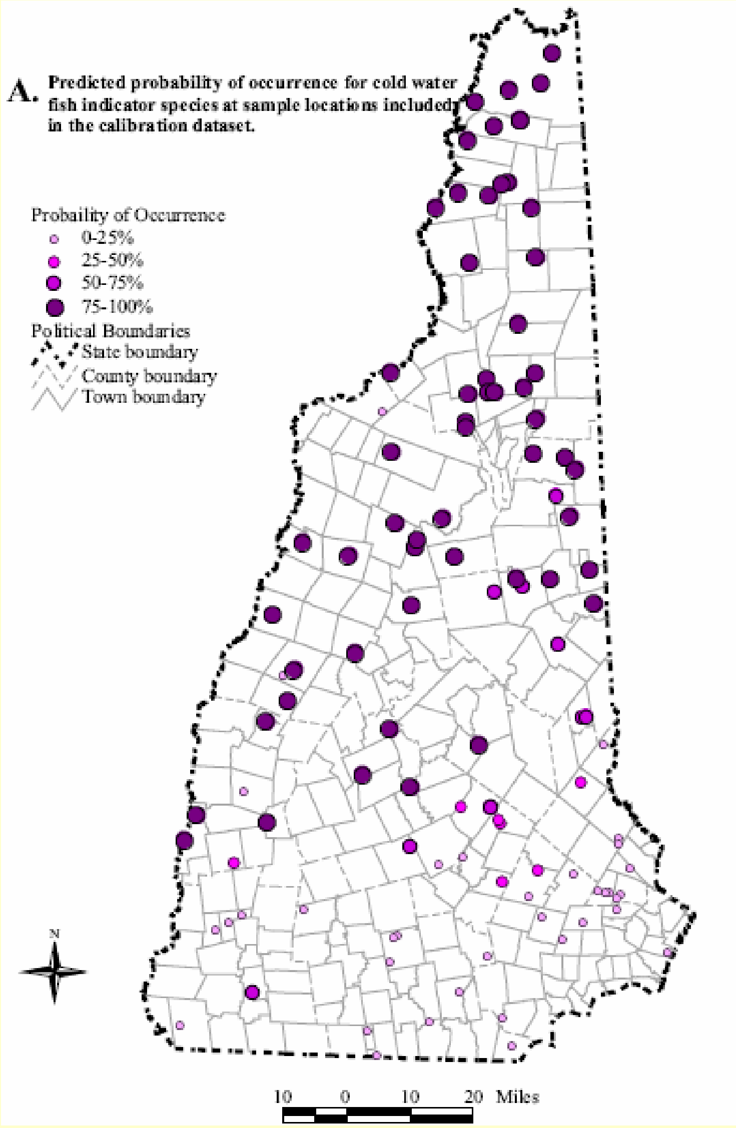
Environmental Gradient



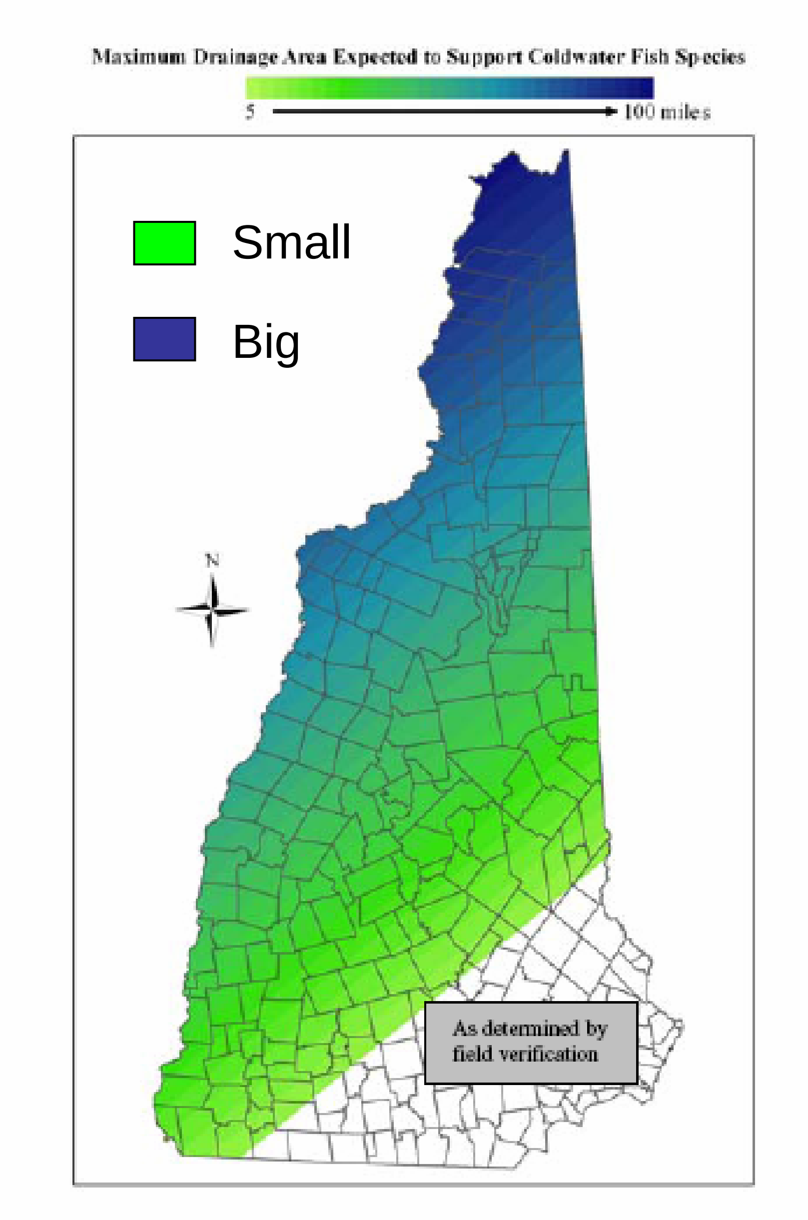
South	←	Latitude	→	North
East	←	Longitude	→	West
Large	←	Watershed Size	→	Small

Increasing probability of occurrence as move from SE to NW and decreasing drainage area

Calibration Sample Locations

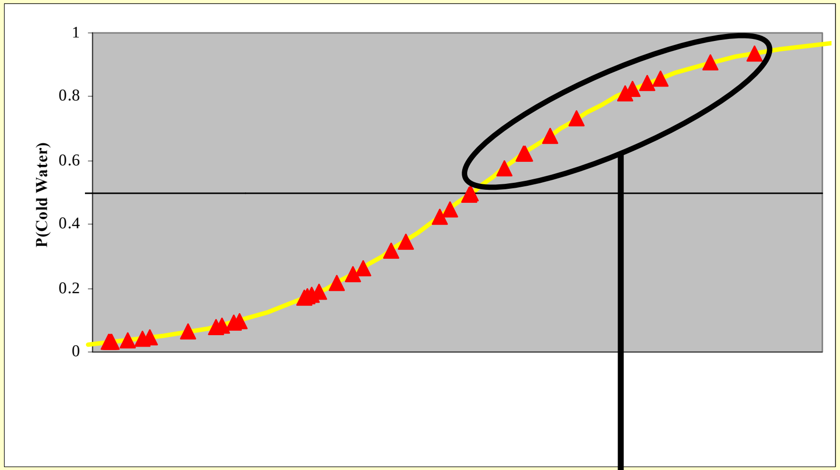


Statewide Application of Model

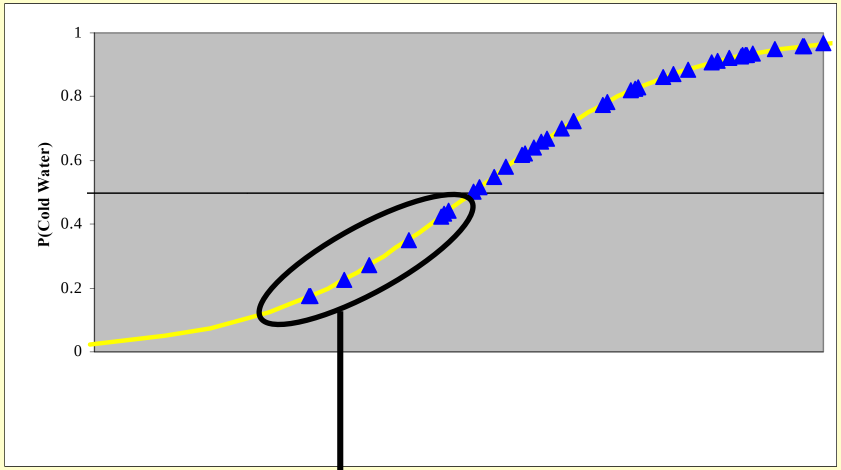


Exploring Predictive Errors (No Model is Perfect!)

Observed Absent



Observed Present



P(occur) > 0.50; Predict Present

ERRORS

P(occur) < 0.50; Predict Absent

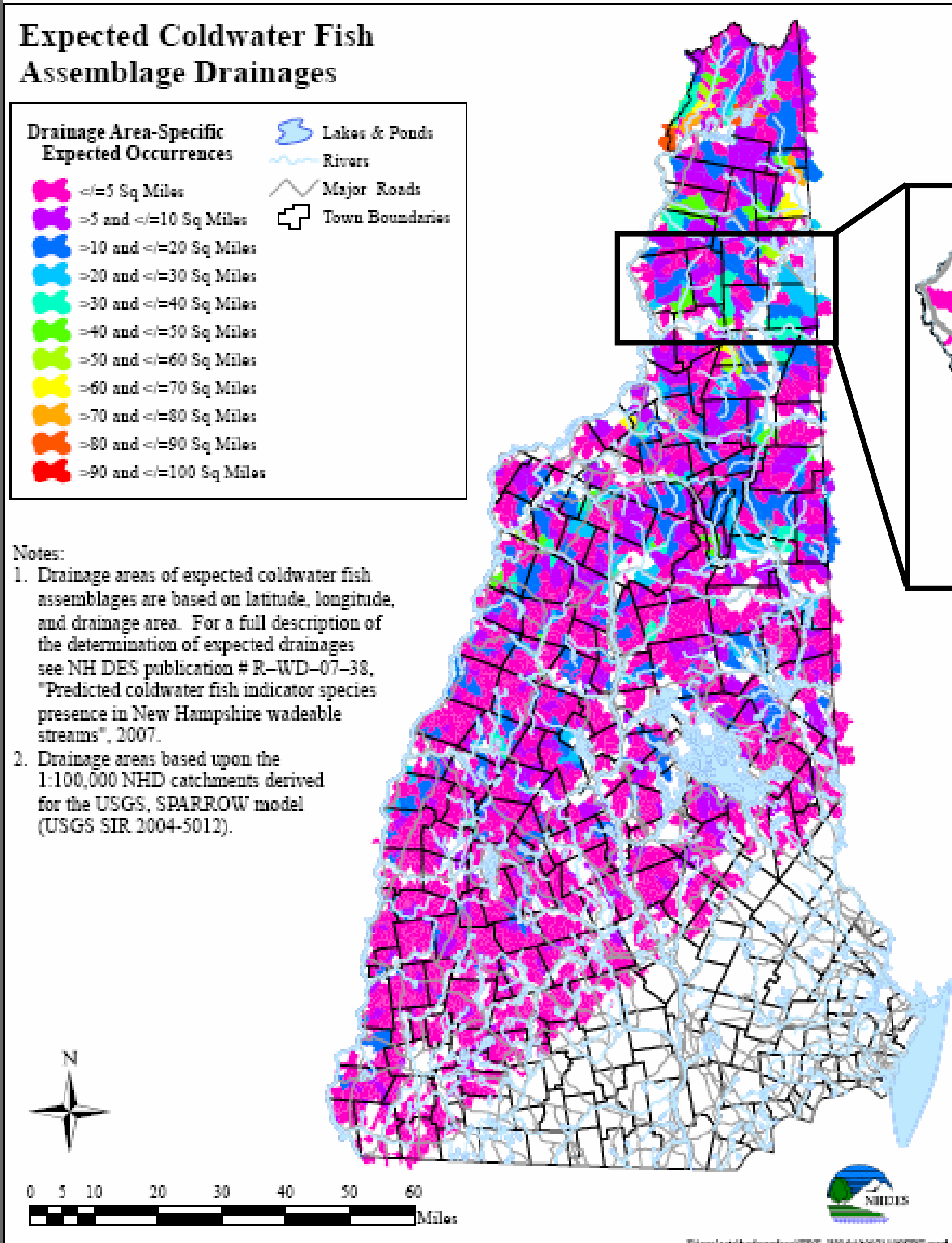
Type I – Reject null hypothesis when it is true

For model – predicting CW present when observed absent (6%-cal; 10%-val)

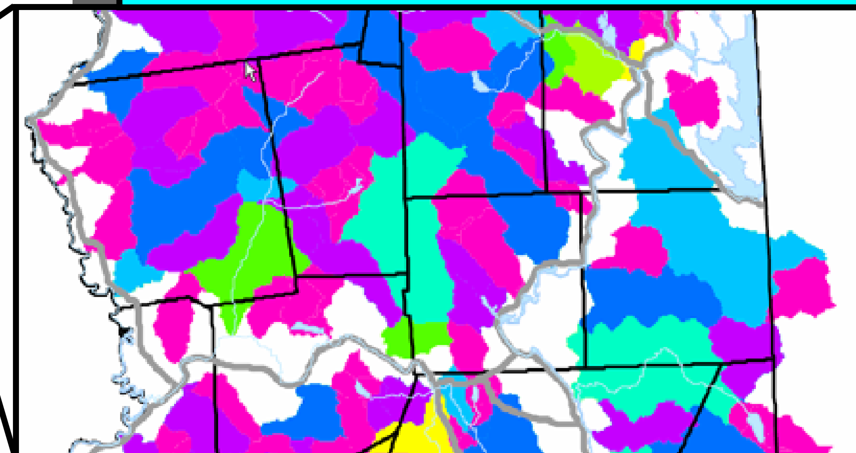
50% Prob. Is a balanced approach

Type II - Do not reject null hypothesis when false

For model – predicting CW absent when observed present (5%-cal;6%-val)



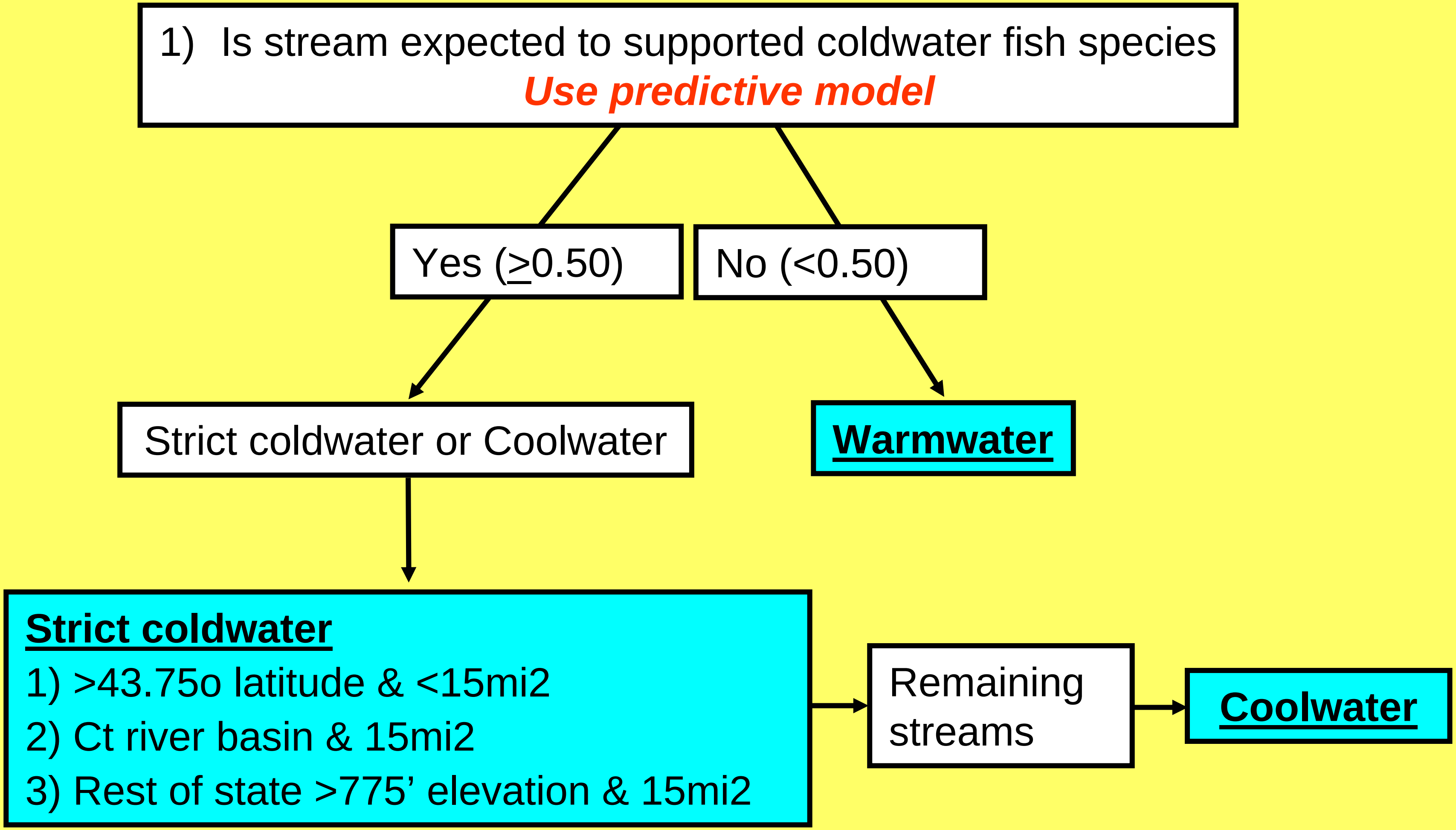
Expected Drainages Supporting Coldwater Fish Species

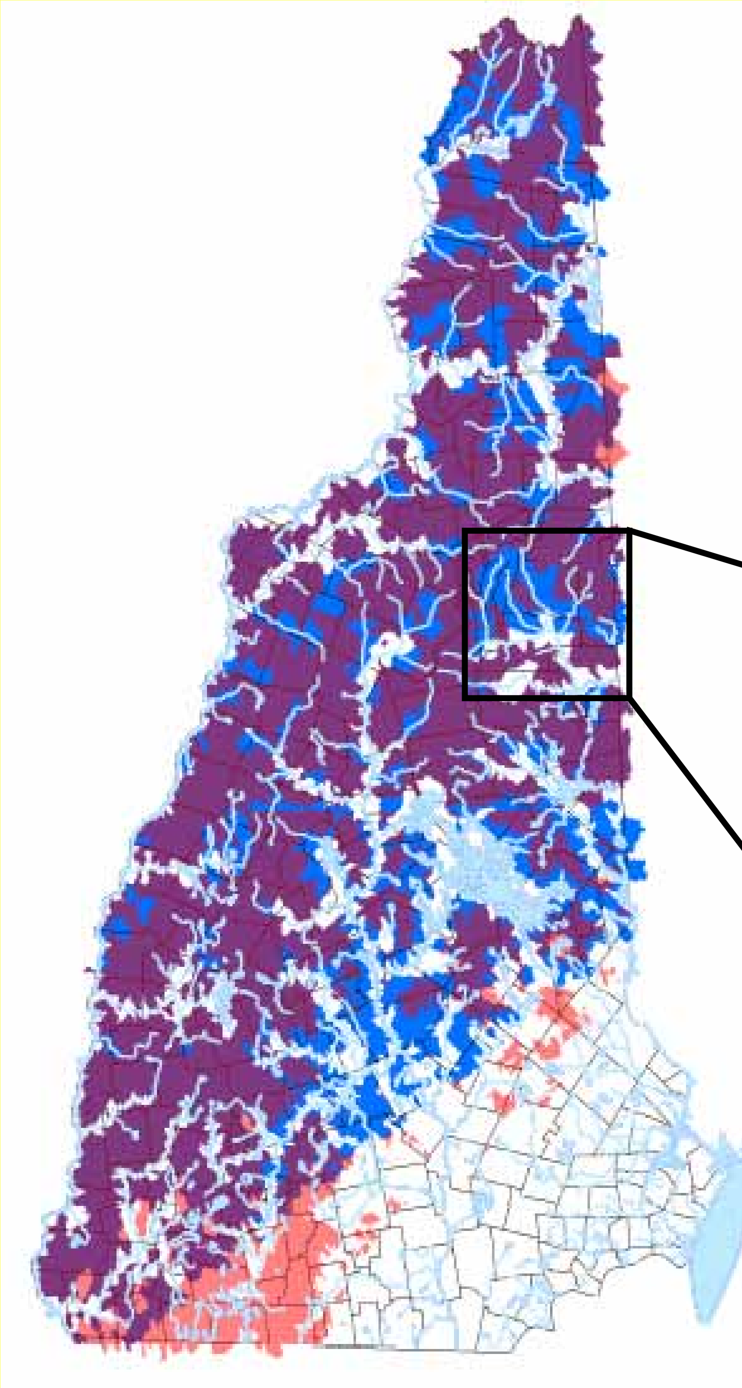


- Small drainages most dominant
- Larger drainages in north
- Warmwater streams in white
- Provides definition of streams where coldwater dissolved oxygen criteria should be applied

Use in Defining Fish Assemblage Types

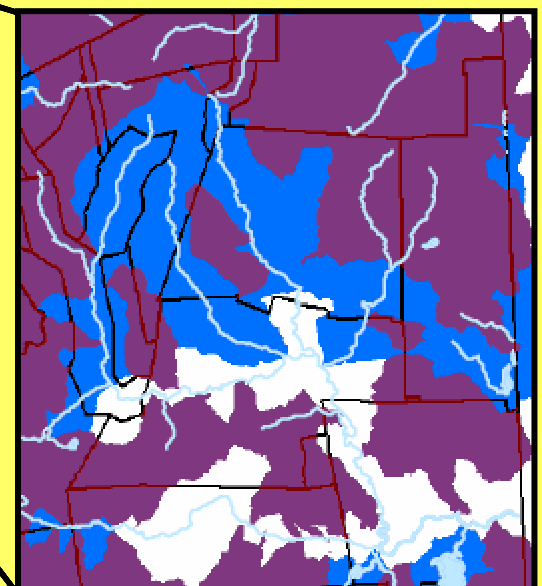
DES has defined 3 fish assemblage types: Strict Coldwater, Coolwater, Warmwater





Expected Fish Assemblage Types by Drainage

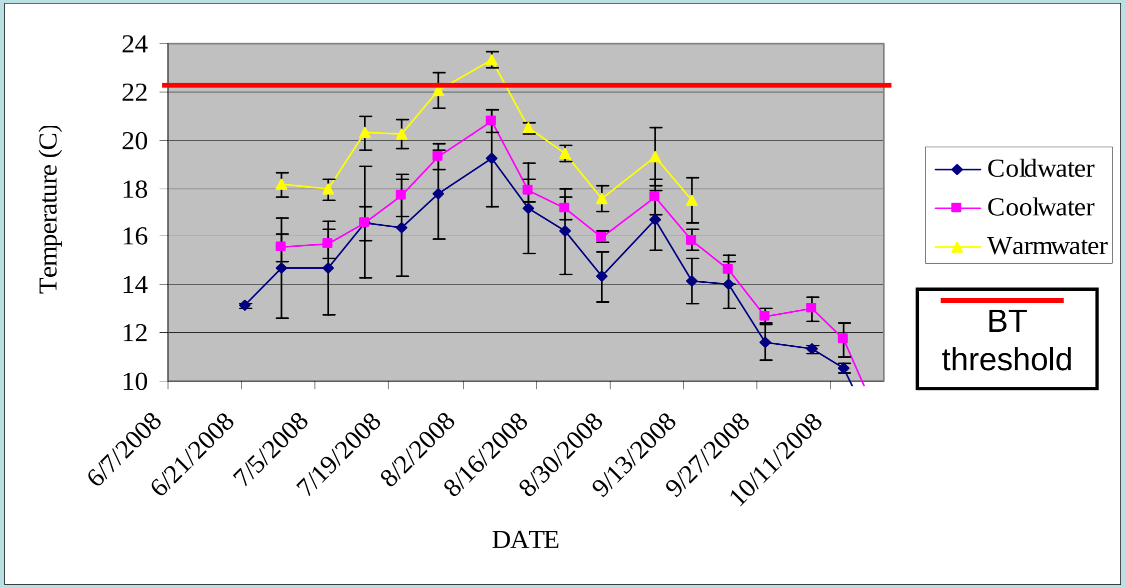
- Strict Coldwater ($P \geq 0.50$)
- Strict Coldwater ($P < 0.50$)
- Coolwater ($P \geq 0.50$)
- Warmwater ($P < 0.50$)



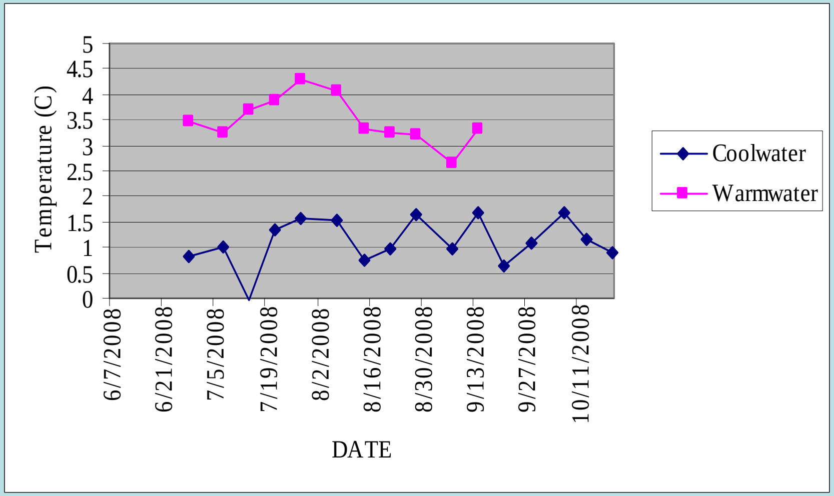
Correspondence With Water Temperature

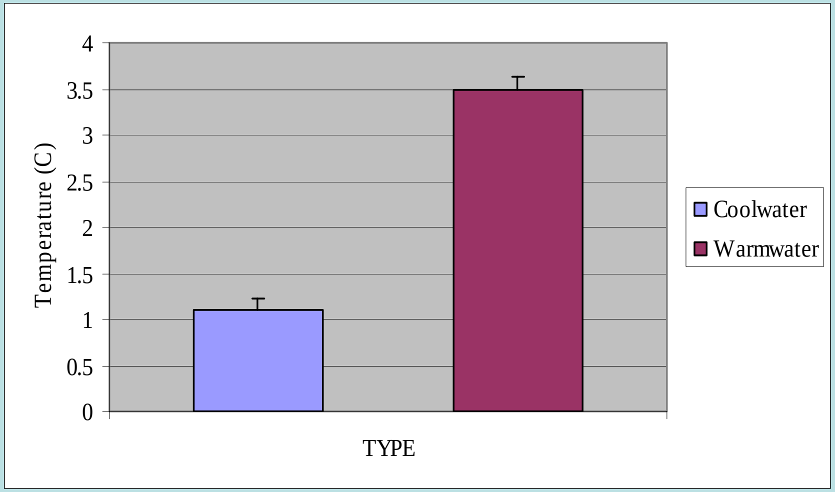
(Lets not forget what we're talking about)

<u>2006/07 Data</u>



- Weekly mean
- Clear separation throughout summer
- Cold and cool below thermal thresholds (BT - 22.3°C, Eaton 1995)
- Coolwater ~1° warmer
- Warmwater ~3° warmer





2007 Field Data Verification

2007 field data: 18 sites sampled; 15 sites followed modeled predictions (83%) for fish community type

Why not perfection? Model predictions are based on undisturbed sites (lack of predicted fish community type may indicate "impact")

<u>Summary</u>

- Model provides a-priori “tool” for determining ability to support coldwater fish assemblage (~85% accuracy)
- Latitude, drainage area, and longitude most effective unchanging environmental variables for predicting ability to support coldwater fish assemblages; latitude strongest predictor
- Model establishes southeast to northwest gradient for expected presence; tempered by drainage area
- 50% probability of occurrence minimizes predictive errors; balances Type I and Type II (model is neither too conservative nor liberal)
- Identification of drainages where coldwater DO criteria should be implemented
- Model allows for identification of expected fish assemblage types for development / application of appropriate of biological indices
- Recent water temperature data and fish sampling results provide confirmation of model predictions
- Future work should include continued model verification and determination of the utility of additional predictive variables (i.e. groundwater)

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