

Wild Trout XI, October 2, 2013: Brook Trout Research and Management In Their Native Range



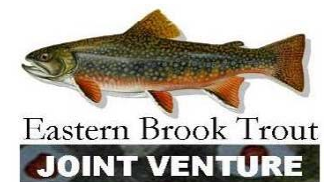
The Importance of Scale In Predicting Brook Trout Presence

Mark Hudy, USGS

Keith Nislow, US Forest Service

Eric Smith, Virginia Tech

Arthur Cooper and Dana Infante
Michigan State



Introduction: Current Status



1. Many recent and historic events have changed the distribution of brook trout.

2. Unbiased assessments of occupancy are critical for the conservation of brook trout



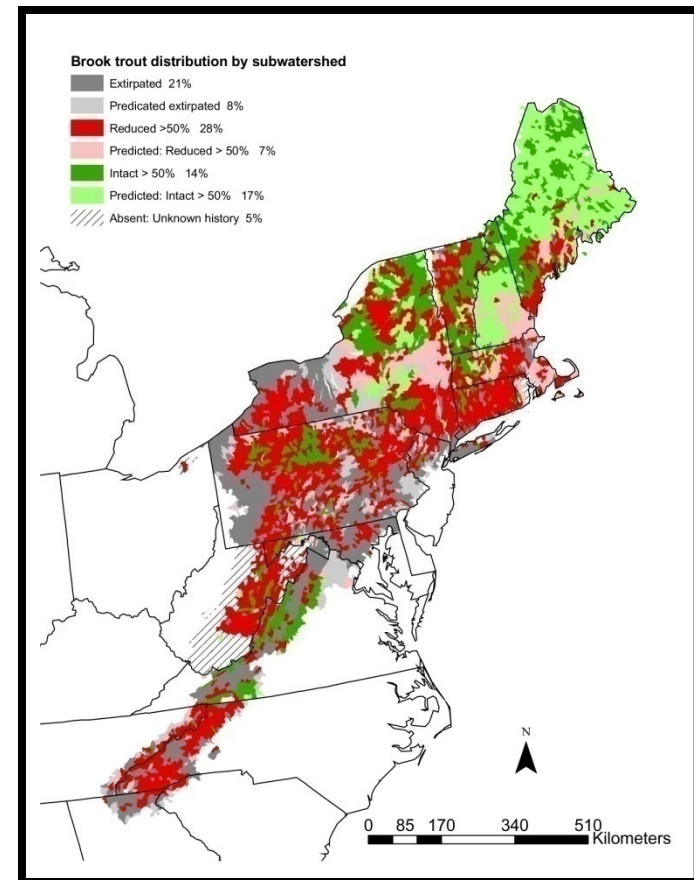
Brook Trout Range (2005)

(Hudy et al. 2008)

- 29 % of brook trout subwatersheds have been extirpated
- Important drivers:
 - % Forest
 - % agriculture
 - Road density
 - S04/N03 deposition



Eastern Brook Trout
JOINT VENTURE



Objectives



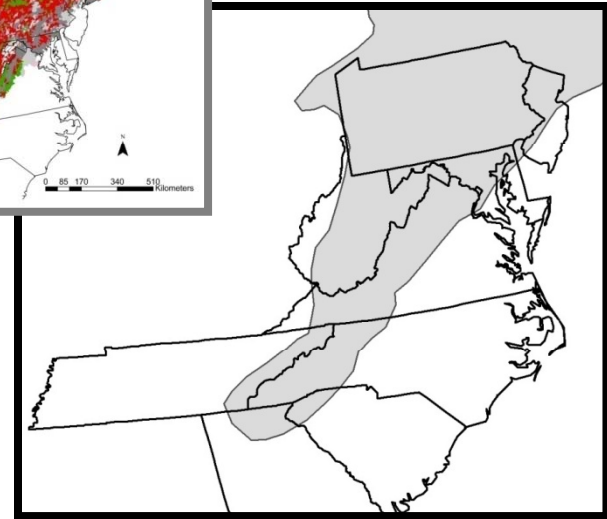
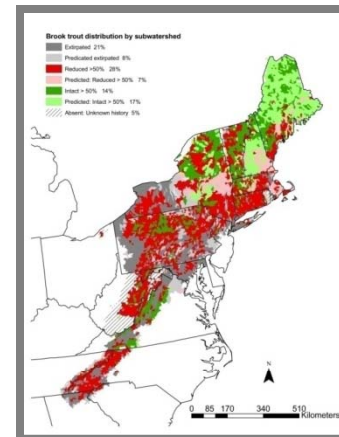
1. Explore relationships among scale and occupancy using an extensive fine scale data set.

2. Develop landscape predictors of occupancy at various scales of interest.

3. Provide EBTJV partners, managers and decision makers scale sensitive tools to answer management questions at various scales of interest.



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Study Area / Assessment Scales

Watersheds (5th HUC;

10 digit)

808 (avg size = 41,201 ha)

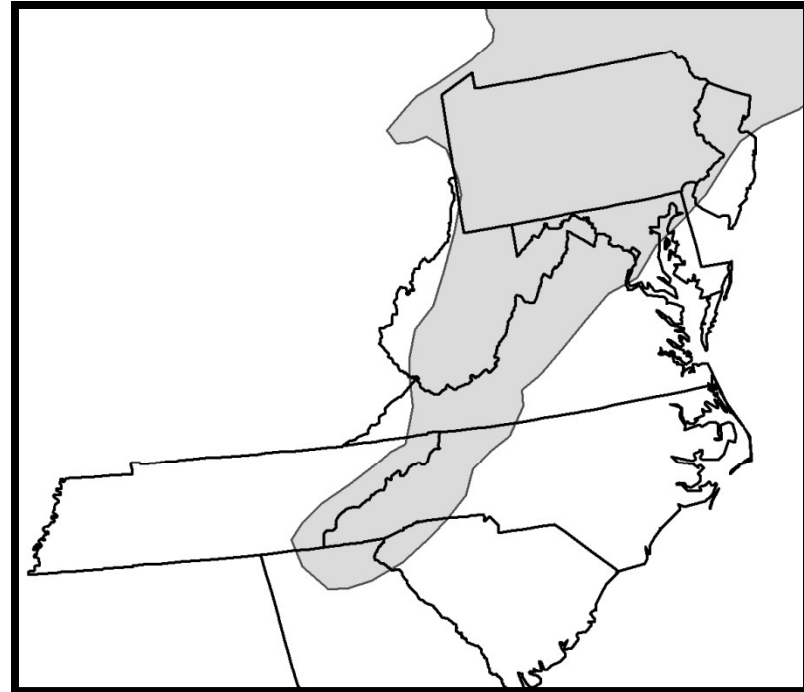
Subwatersheds (6th HUC;

12 digit)

3,804 (avg size = 8,879 ha)

Catchments (14 digit ?)

132,321 (avg size = 237 ha)



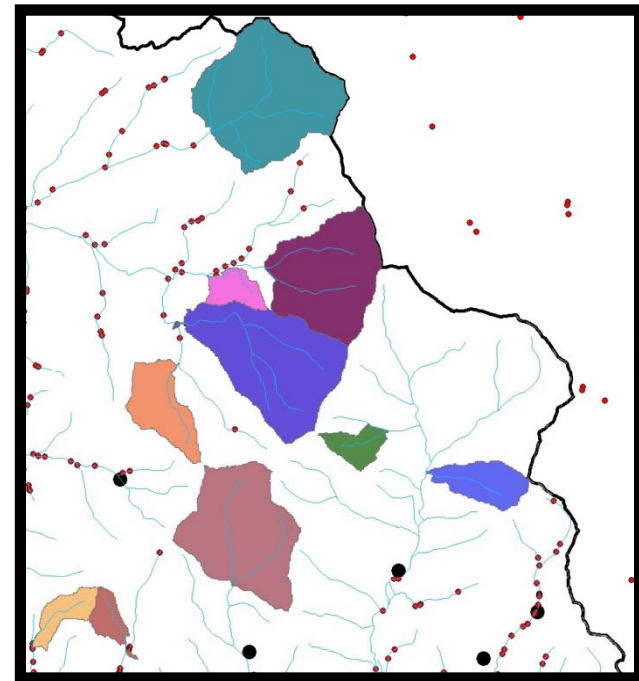
Methods



GIS Data

(National Fish Habitat Assessment: Esselman et al. 2011)

- **Summarized 85 landscape metrics** by 808 watersheds, 3,804 subwatersheds and 132,321 catchments. Each catchment was also summarized by 4 categories
 - 1. LC= local catchment
 - 2. NC = network catchment
 - 3. LB = local catchment buffer
 - 4. NB = network catchment buffer



Fish Sampling Data

- Over 100 years of extensive fine scale sampling records
- Census of downstream extant of reproducing salmonids
- Detection probabilities unknown but using similar gear and methods ranged from 89% to 99% in Pennsylvania (Wagner et al. 2013)
- Classified occupancy by all scales for categories of interest to EBTJV

Occupancy Classifications

(8 classifications; 132,321 determinations)

Occupancy	Brook Trout	Rainbow Trout	Brown Trout
Allopatric	1	0	0
Sympatric	1	1	0
Sympatric	1	0	1
Sympatric	1	1	1
Non-native	0	0	1
Non-native	0	1	0
Non-native	0	1	1
No trout	0	0	0

Models Case 1: Brook Trout; No Brook Trout

Occupancy	Brook Trout	Rainbow Trout	Brown Trout
Allopatric	1	0	0
Sympatric	1	1	0
Sympatric	1	0	1
Sympatric	1	1	1
Non-native	0	0	1
Non-native	0	1	0
Non-native	0	1	1
No trout	0	0	0

Models Case 2: Brook Trout; Non-native Trout;
No Brook Trout

Occupancy	Brook Trout	Rainbow Trout	Brown Trout
Allopatric	1	0	0
Sympatric	1	1	0
Sympatric	1	0	1
Sympatric	1	1	1
Non-native	0	0	1
Non-native	0	1	0
Non-native	0	1	1
No trout	0	0	0

Models Case 3: Allopatric Brook Trout; Sympatric Brook Trout; Non-native Trout; No Brook Trout

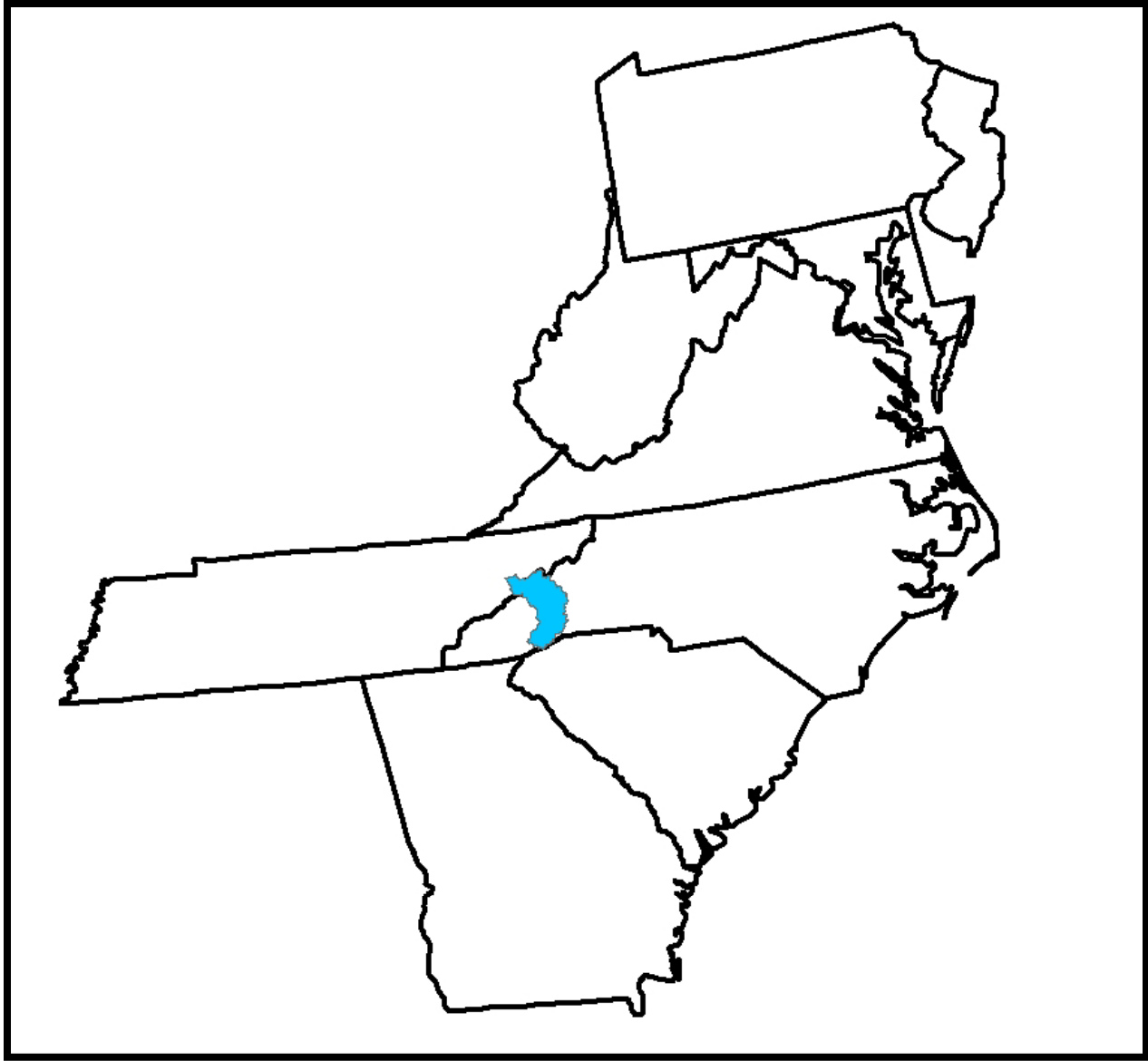
Occupancy	Brook Trout	Rainbow Trout	Brown Trout
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Sympatric	1	1	0
Sympatric	1	0	1
Sympatric	1	1	1
Non-native	0	0	1
Non-native	0	1	0
Non-native	0	1	1
No trout	0	0	0

Model Development

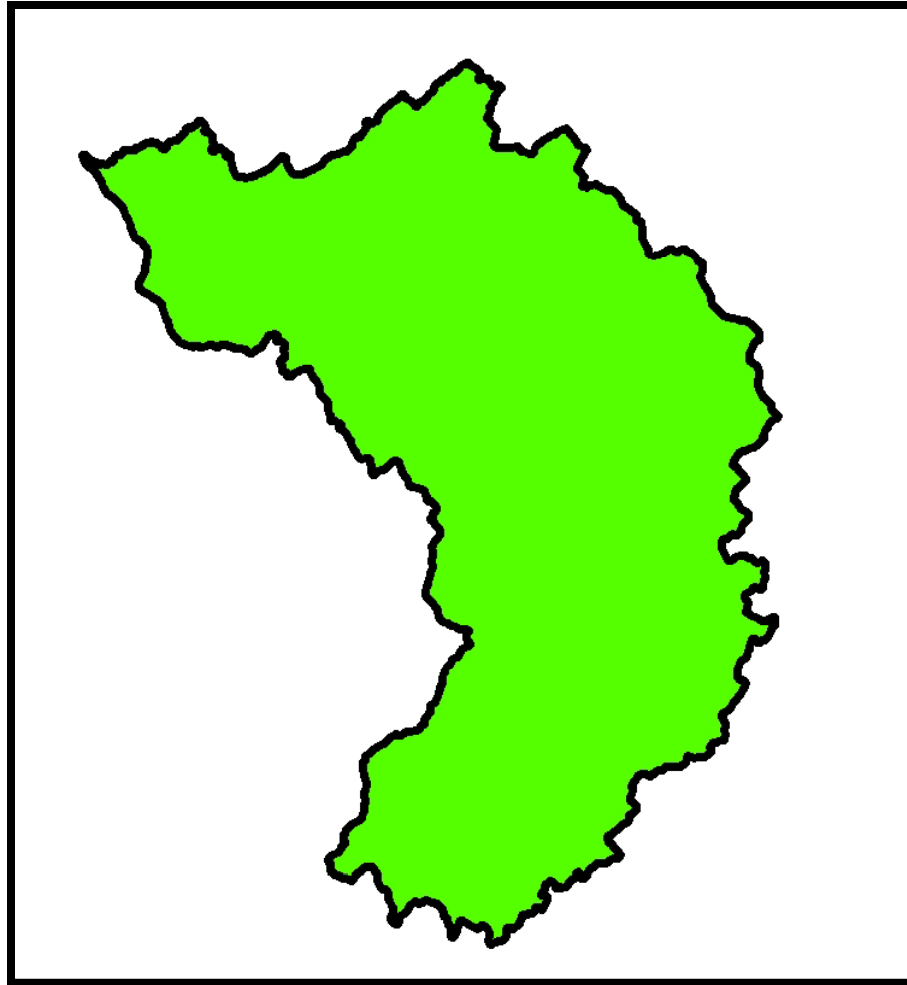
- Data analyzed with classification and regression trees (CART)
- 9 total models (3 cases X 3 scales)
- Tenfold cross validation method

Results

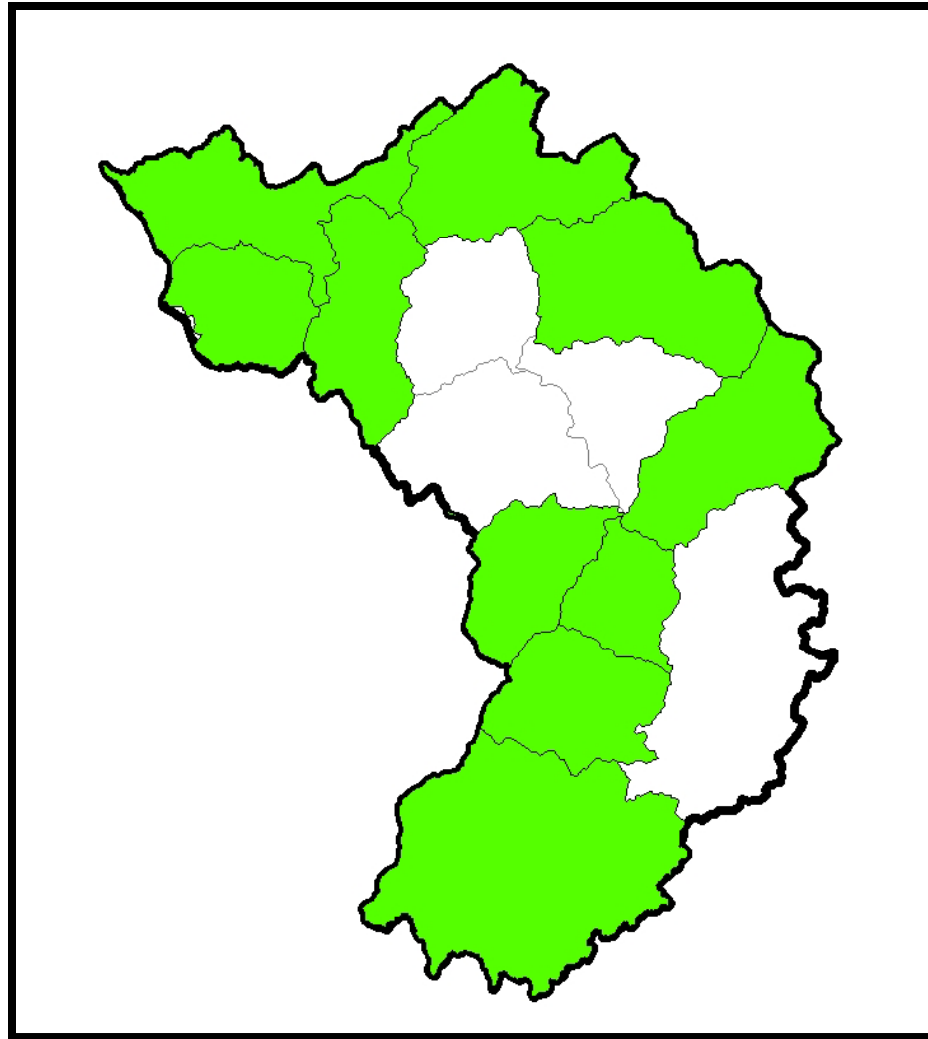




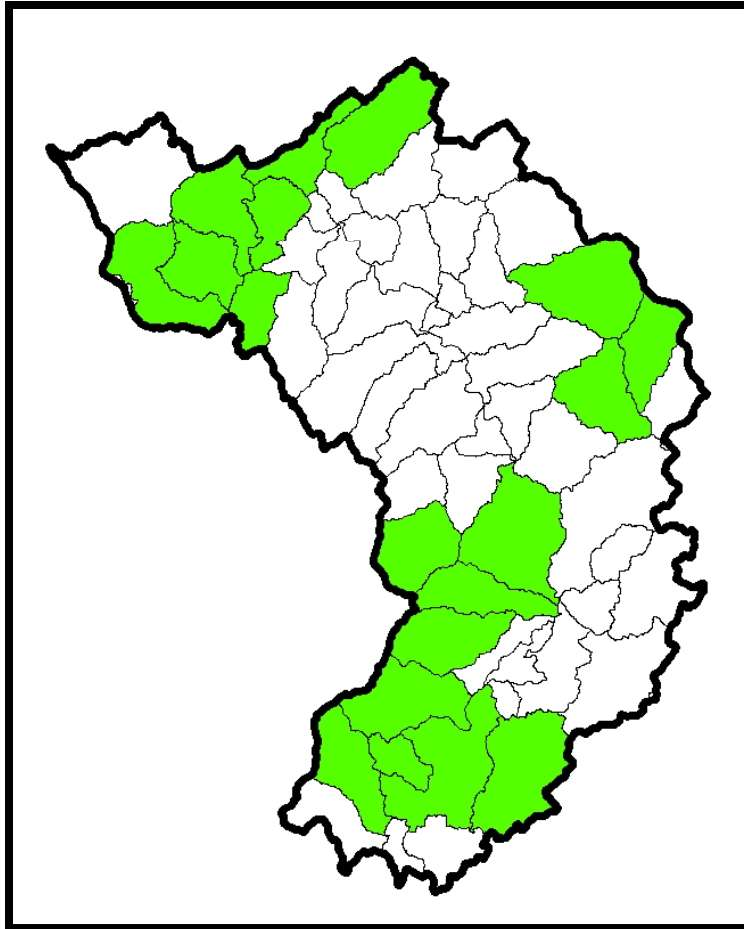
Sub-basins (4th HUC)



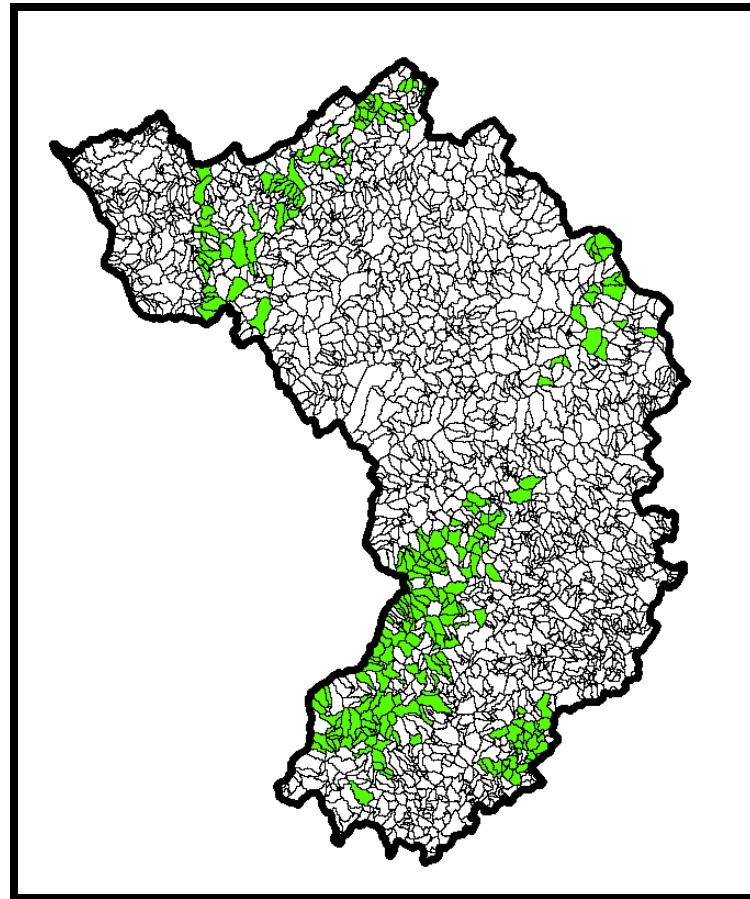
Watersheds (5th HUC)



Subwatersheds (6th HUC)



Catchments



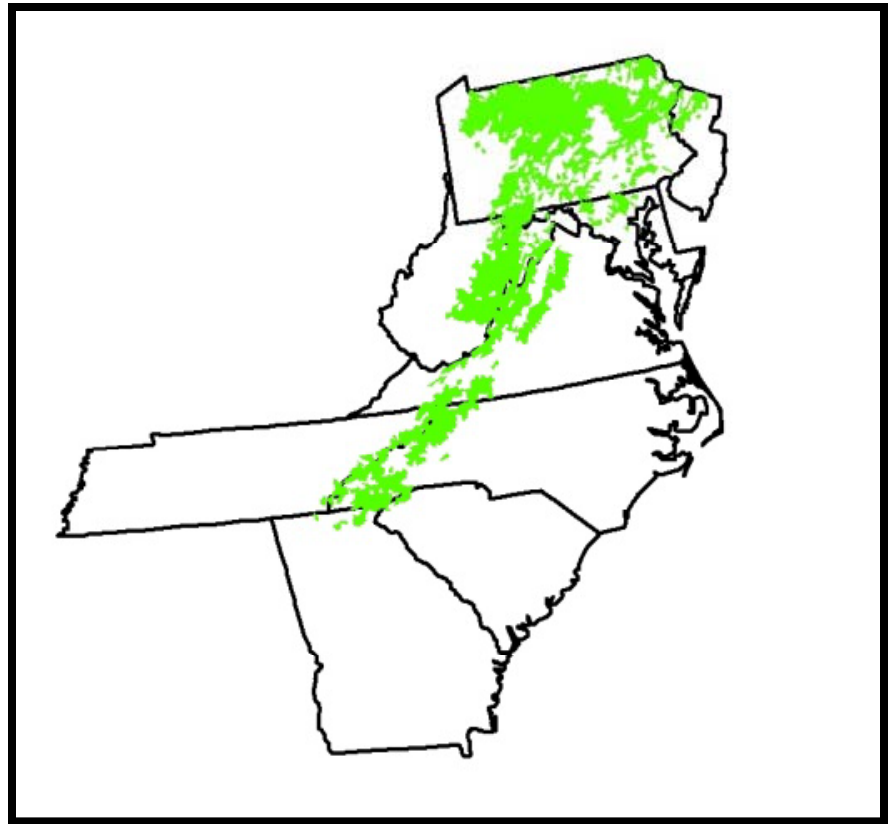


Brook Trout Occupancy: Watershed (5th HUC)

52% of 808

8% allopatric

“There have been some losses of brook trout but they are still found in approximately 50% of their range”.

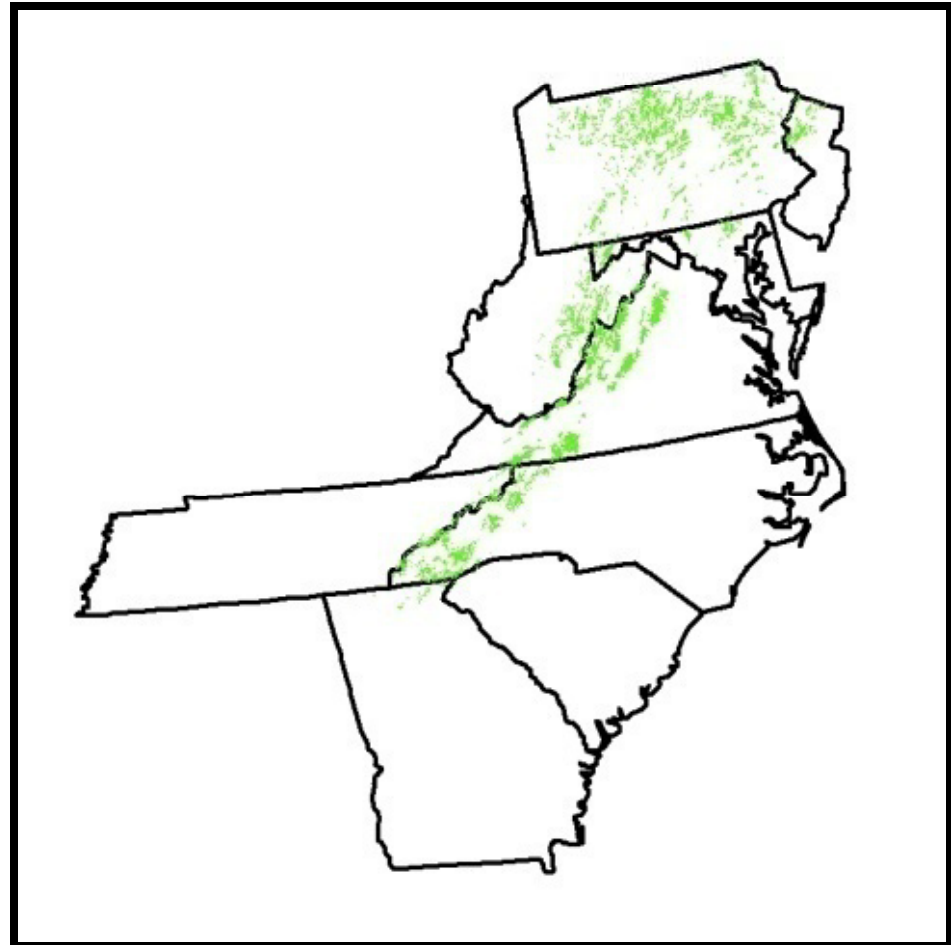


Brook Trout Occupancy: Subwatershed (6th HUC)

32% of 3,804

10% allopatric

“Brook trout have been extirpated from over 65% of their historic subwatersheds”.

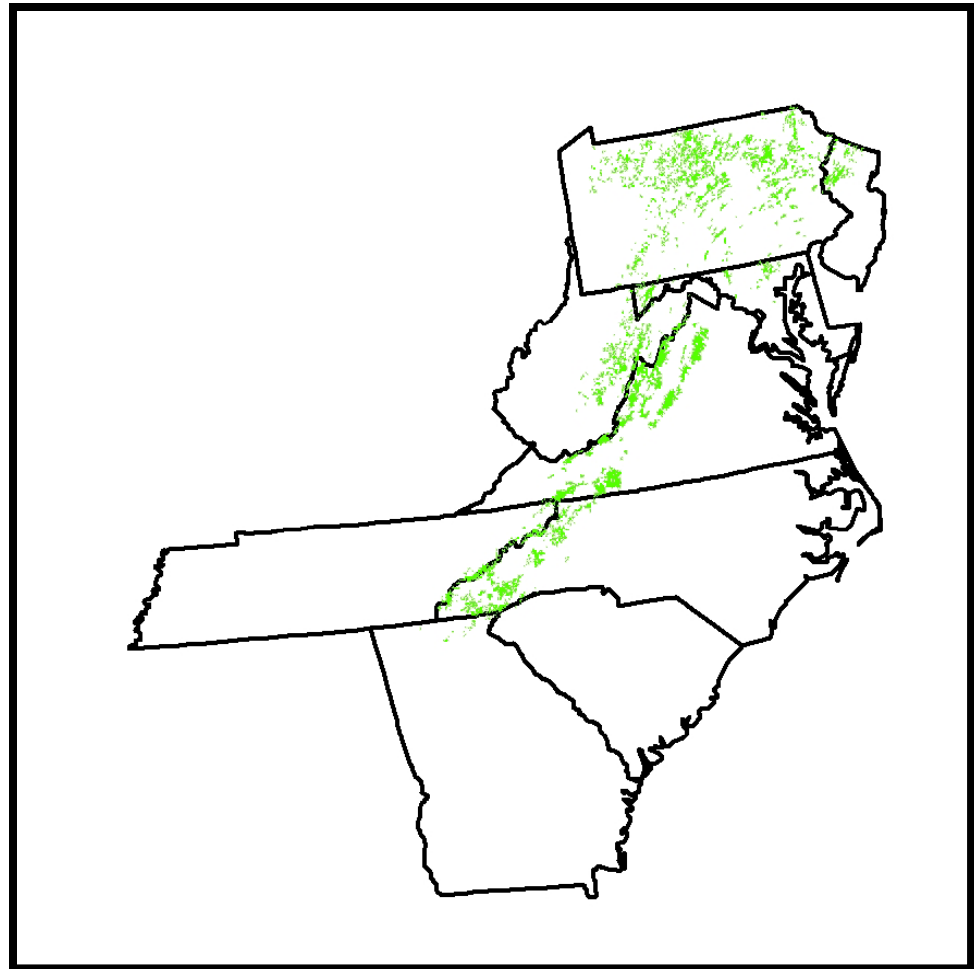


Brook Trout Distribution: Catchments

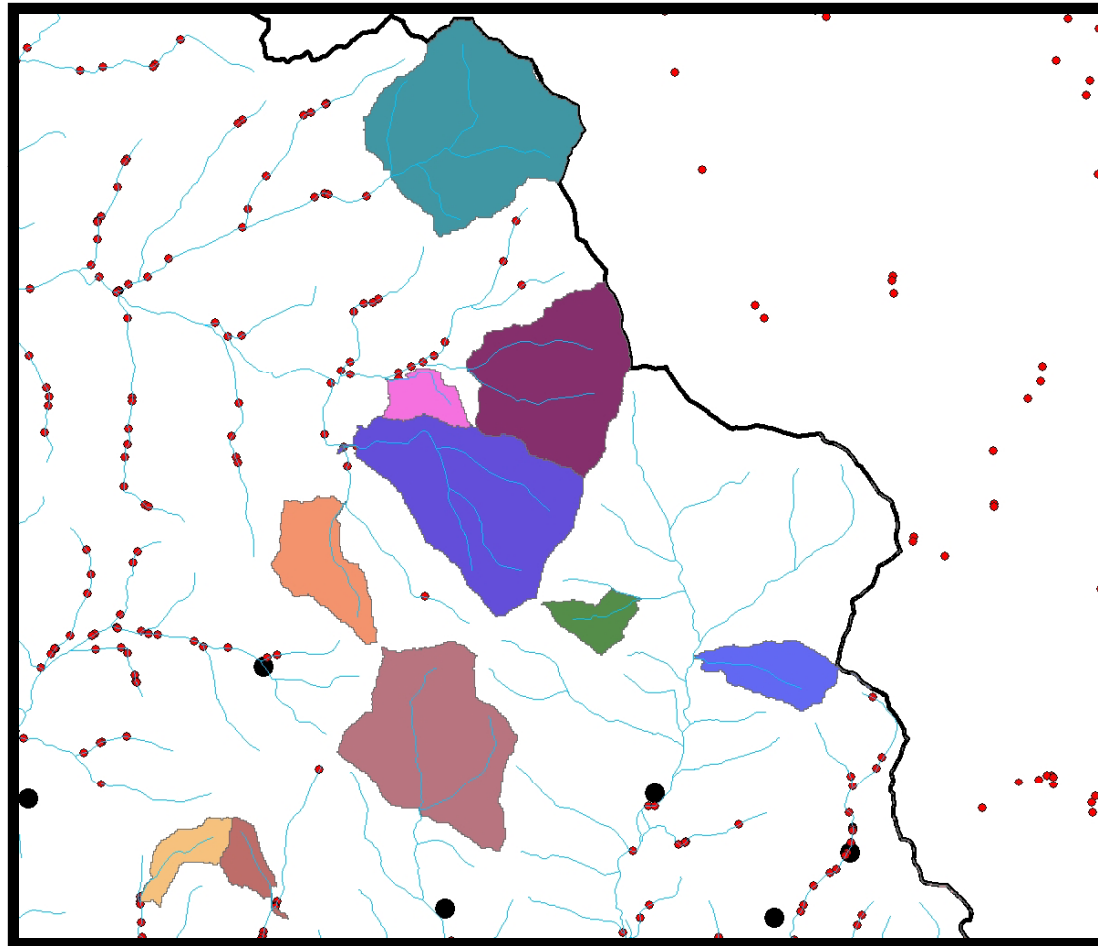
14 % of 132,321

9% allopatric

“Brook trout do not occupy 85 % of catchments within the historic range”.



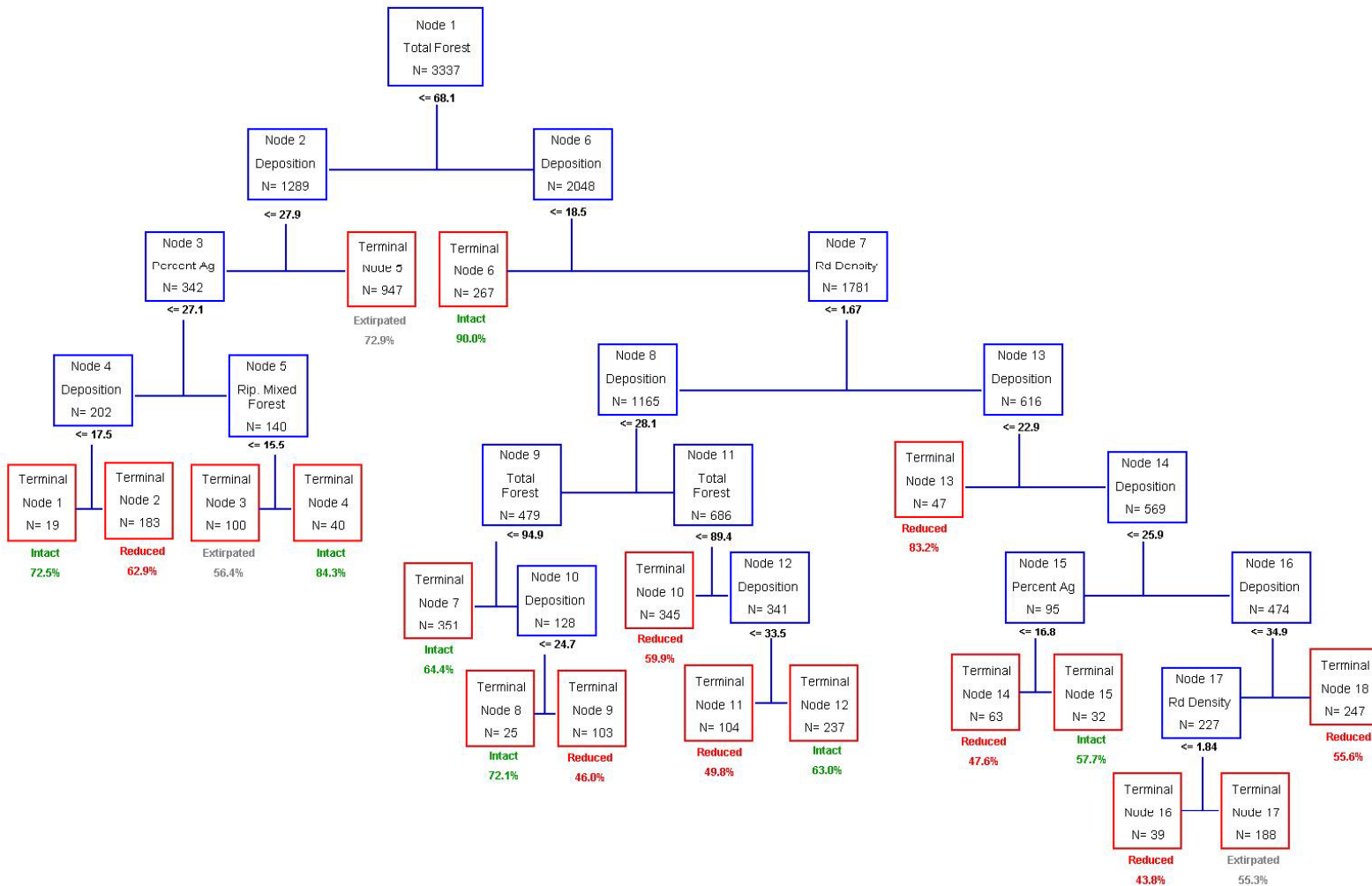
Today's brook trout occupy isolated fragmented patches of habitat with poor connectivity



A close-up photograph of a fisherman's hands holding a wooden-handled net containing a rainbow trout. The fisherman is wearing a green and grey life vest and a dark jacket. The background shows dark water. The text "Predictions using CART models" is overlaid in large yellow font.

Predictions using CART models

CART (splitting nodes; terminal nodes; predictions & probabilities)



Watershed Case 1 (80% correct)

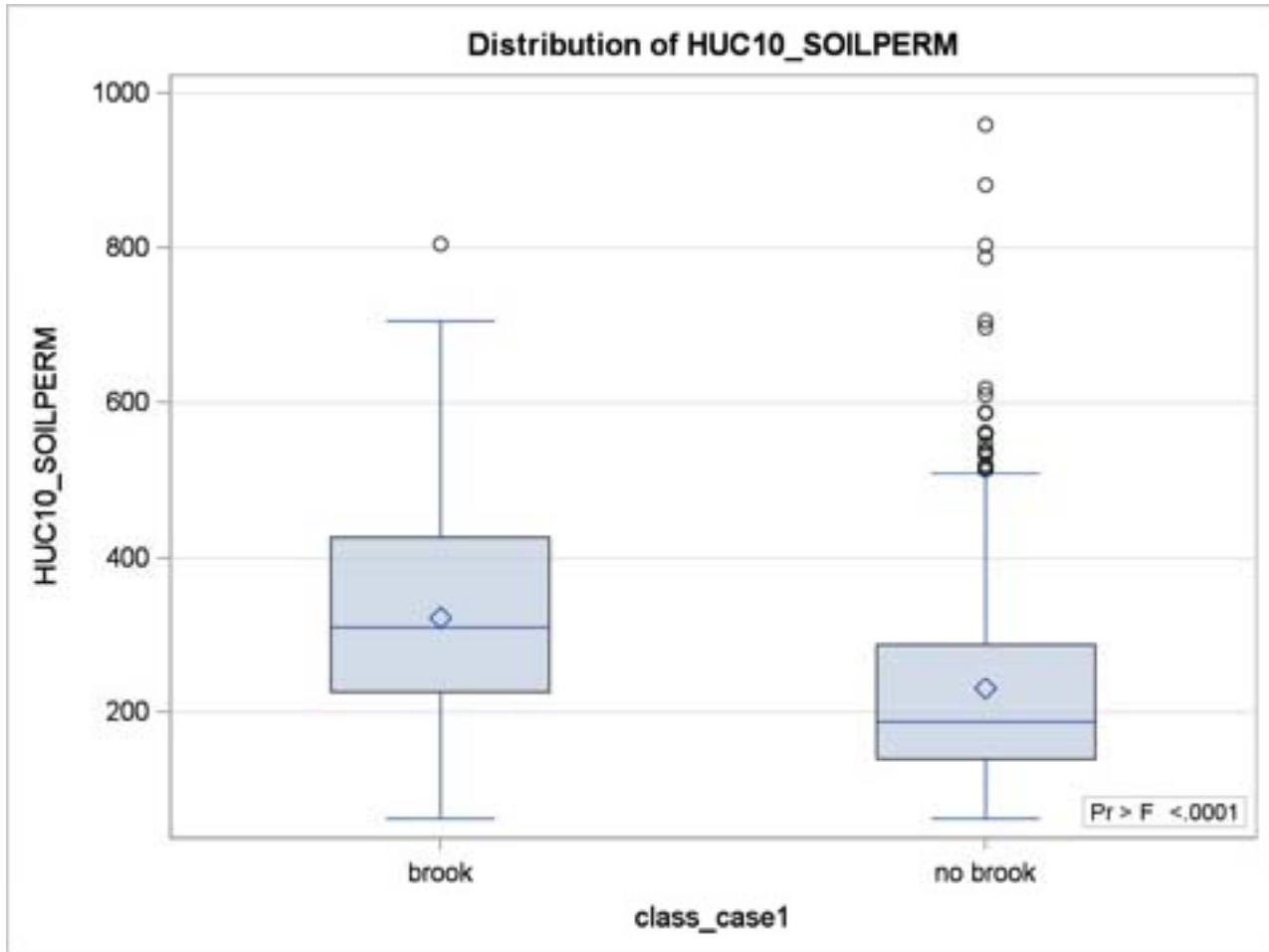
(n = 808)

- 11 splitting nodes
- 13 terminal nodes
- 10 variables (variable importance)
 - Soil permeability (100)
 - Grasslands (43)
 - Mean elevation (41)
 - N03 max (20)
 - Watershed area (19)
 - Road Xing density (14)
 - Mean Air temperature (11)
 - Maximum elevation (7)
 - Non-carbonate soils (6)

Occupancy	Brook Trout	Rainbow Trout	Brown Trout
Allopatric	1	0	0
Sympatric	1	1	0
Sympatric	1	0	1
Sympatric	1	1	1
Non-native	0	0	1
Non-native	0	1	0
Non-native	0	1	1
No trout	0	0	0

Terminal Node	Number of Watersheds	Splitting Criteria	Brook	No Brook
1	211	SP<238; N<1468	0.162	0.838
2	30	SP<238; N>1468; G<0.003; SP<195; EMx < 673; L3<0.52	0.254	0.746
3	8	SP<238; N>1468; G<0.003; SP<195; EMx < 673; L3>0.52	0.868	0.132
4	19	SP<238; N>1468; G<0.003; SP<195; EMx < 673	0.833	0.167
5	19	SP<238; N>1468; G<0.003; SP>195	1.00	0.00
6	83	SP<238; N>1468; G>0.003	0.264	0.736
7	49	SP>238; EMe <179	0.174	0.826
8	27	SP>238; EMe >178; G<0.02; A< 252; AM>9.31	0.843	0.157
9	36	SP>238; EMe >178; G<0.02; A< 252; AM>9.31; S<0.03	0.238	0.762
10	8	SP>238; EMe >178; G<0.02; A< 252; AM>9.31; S>0.03	0.868	0.132
11	278	SP>238; EMe >178; G<0.02; A> 252	0.886	0.114
12	14	SP>238; EMe >178; G>0.02 ;RD < 1.4	0.775	0.225
13	26	SP>238; EMe >178; G>0.02; RD > 1.4	0.036	0.964

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Case 1: Predictions/ Drivers

- Watershed: 80% (74%)
 - Soil permeability
 - Grasslands/ herbaceous
 - Mean elevation
- Subwatershed: 85% (80%)
 - Soil permeability
 - N03_max
 - Maximum elevation
- Catchment: 71% (70%)
 - N03_max NB
 - S04_max
 - Base flow Index LB

Occupancy	Brook Trout	Rainbow Trout	Brown Trout
Allopatric	1	0	0
Sympatric	1	1	0
Sympatric	1	0	1
Sympatric	1	1	1
Non-native	0	0	1
Non-native	0	1	0
Non-native	0	1	1
No trout	0	0	0

Case 2: Predictions/ Drivers

- **Watershed: 69% (62%)**
 - Soil permeability
 - Deposition (N03 + S04)
 - N03_max
- **Subwatershed: 69% (64%)**
 - Soil permeability
 - Mean elevation
 - Minimum air temperature
- **Catchment: 57% (54%)**
 - N03_maxall LC
 - Mean elevation LB
 - Minimum air temperature LB

Occupancy	Brook Trout	Rainbow Trout	Brown Trout
Allopatric	1	0	0
Sympatric	1	1	0
Sympatric	1	0	1
Sympatric	1	1	1
Non-native	0	0	1
Non-native	0	1	0
Non-native	0	1	1
No trout	0	0	0

Case 3: Predictions/ Drivers

- **Watershed: 59% (46%)**
 - Soil permeability
 - Deposition (N03 + S04)
 - N03_maxall
- **Subwatershed: 60% (56%)**
 - Soil permeability
 - Canopy Cover %
 - Base Flow Index %
- **Catchment: 48% (45%)**
 - N03_maxall LB
 - Minimum air temperature LB
 - grasslands/herbaceous NC

Occupancy	Brook Trout	Rainbow Trout	Brown Trout
Allopatric	1	0	0
Sympatric	1	1	0
Sympatric	1	0	1
Sympatric	1	1	1
Non-native	0	0	1
Non-native	0	1	0
Non-native	0	1	1
No trout	0	0	0

Summary



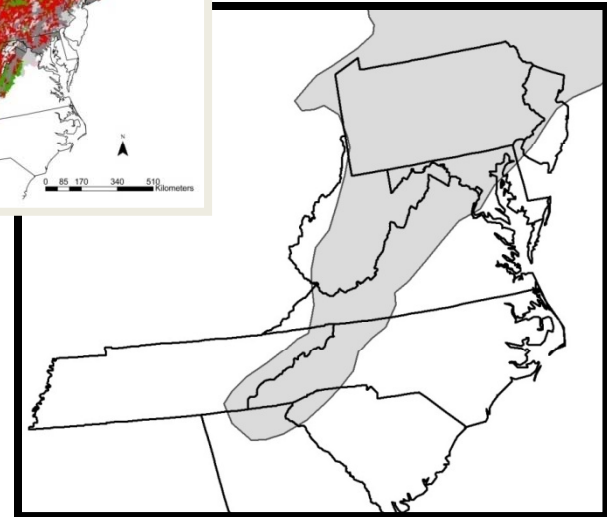
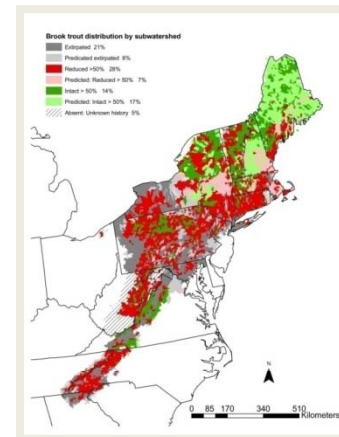
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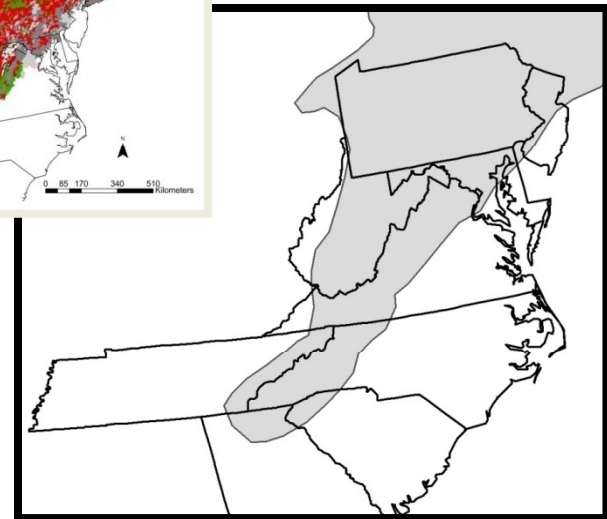
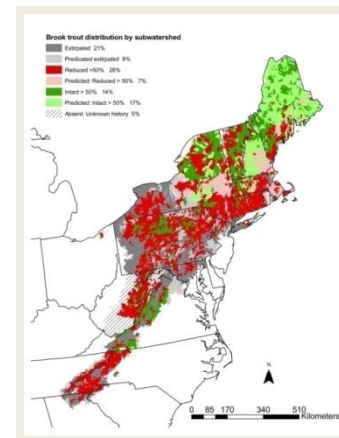
Eastern Brook Trout
JOINT VENTURE



1. Explore relationships among scale and occupancy using an extensive fine scale data set.

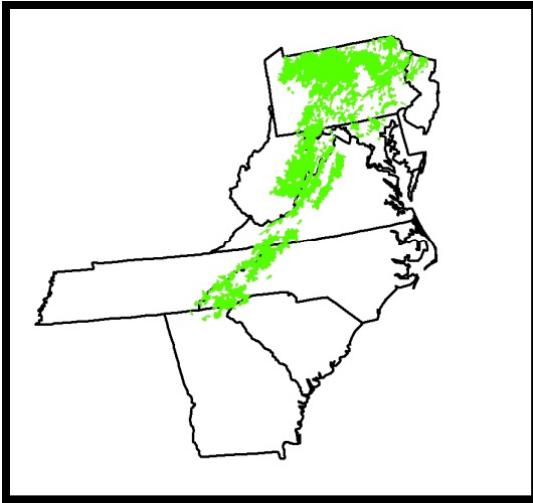


Eastern Brook Trout
JOINT VENTURE

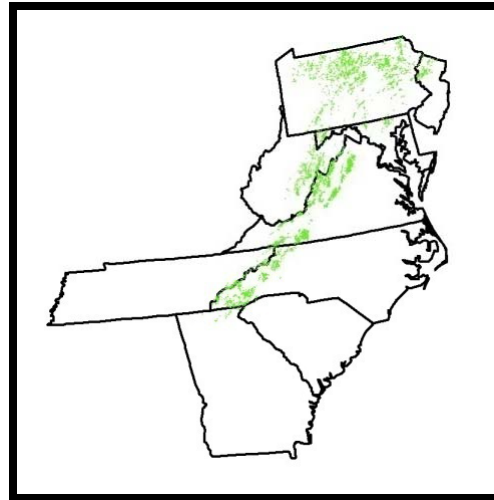


1. The scale at which occupancy is reported can bias impressions of the true distribution

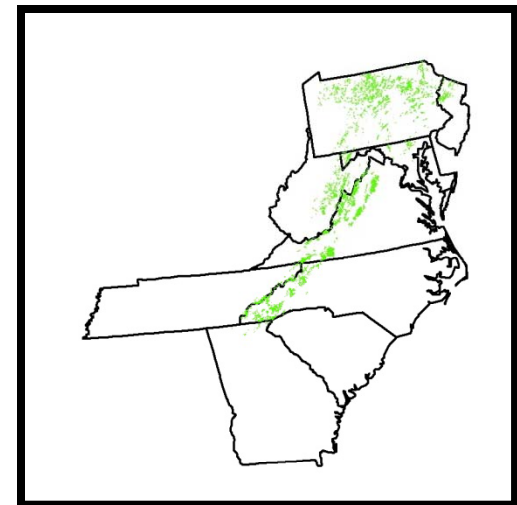
"The Good
52%"



"The Bad
32%"

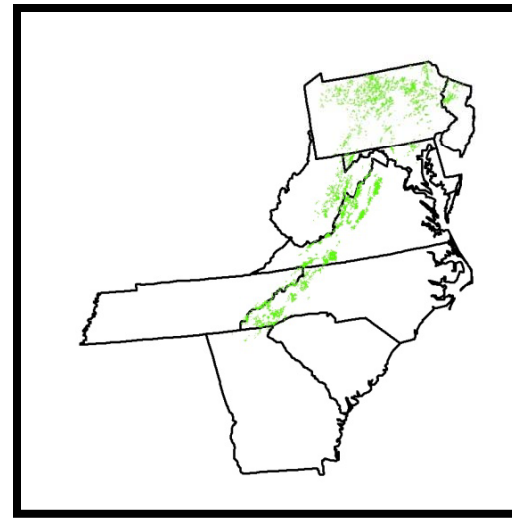
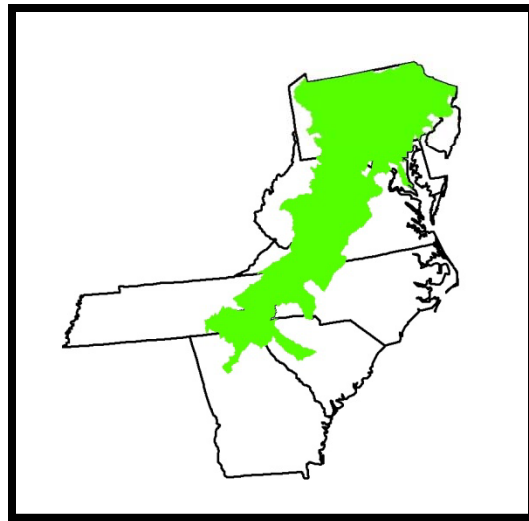


"And the
Ugly 14%"



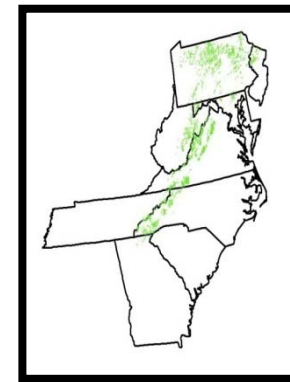
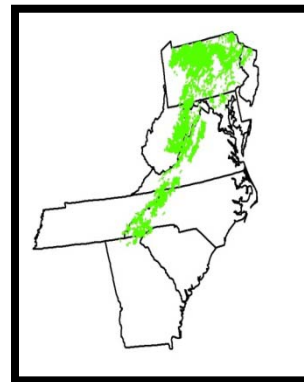
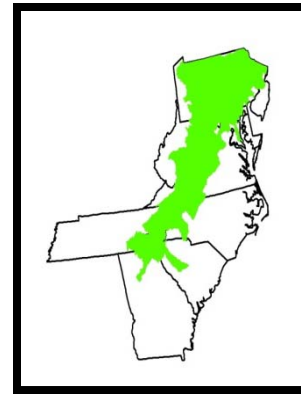
1. The scale at which occupancy is reported can bias impressions of the true distribution (52% to 14%)

Corollary lesson: “The same database will be used to support opposite opinions”!



Very Few Allopatric Populations regardless of reporting scale.

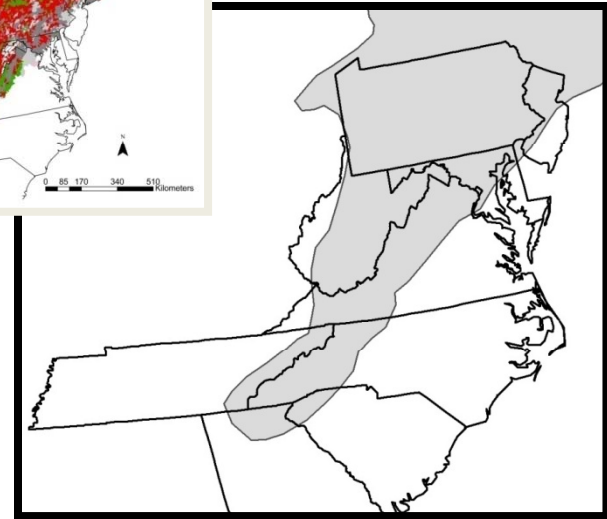
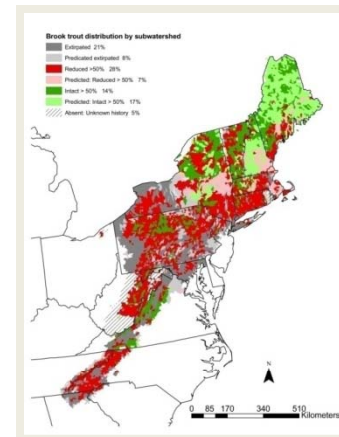
- Watershed 8%
- Subwatershed 10%
- Catchment 9%



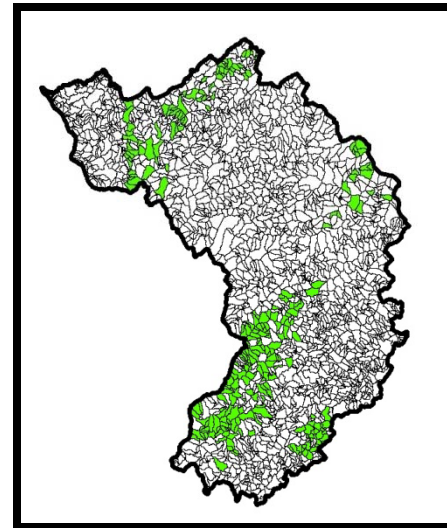
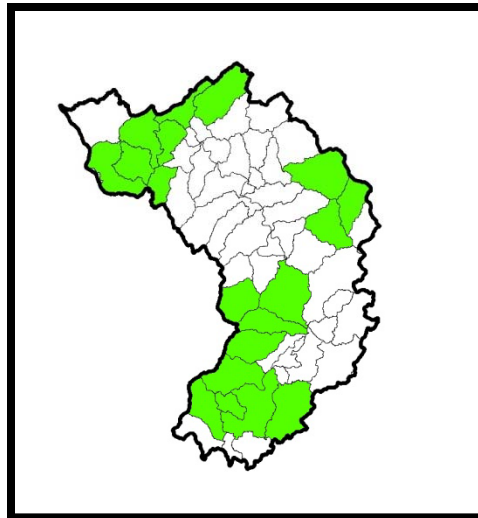
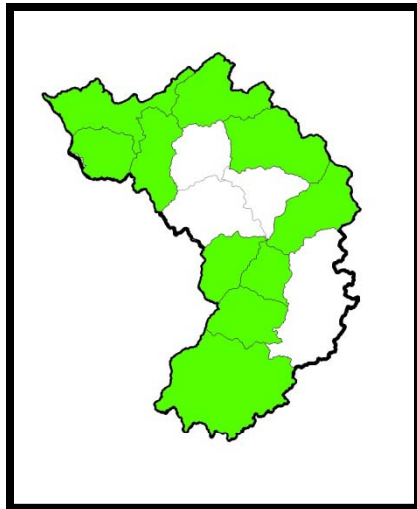
2. Develop landscape predictors of occupancy at various scales of interest.



Eastern Brook Trout
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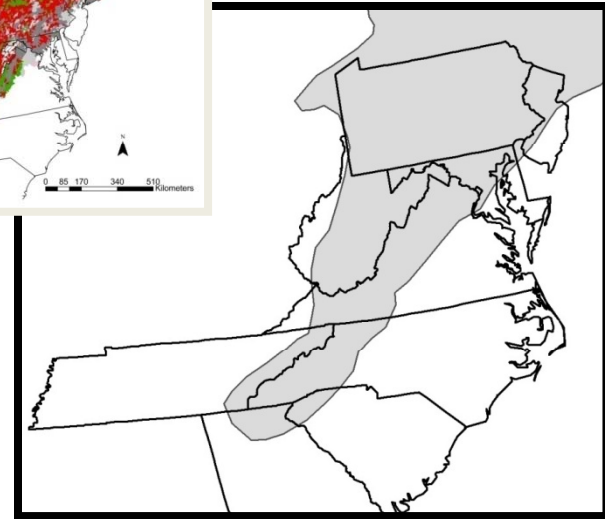
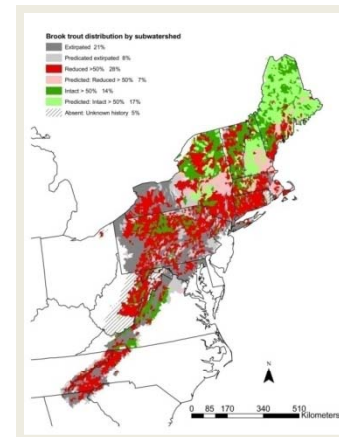
Prediction rates, landscape metric predictors and landscape metric splitting thresholds vary by scale and question (occupancy case).



3. Provide EBTJV partners, managers and decision makers scale sensitive tools to answer management questions at various scales of interest.



Eastern Brook Trout
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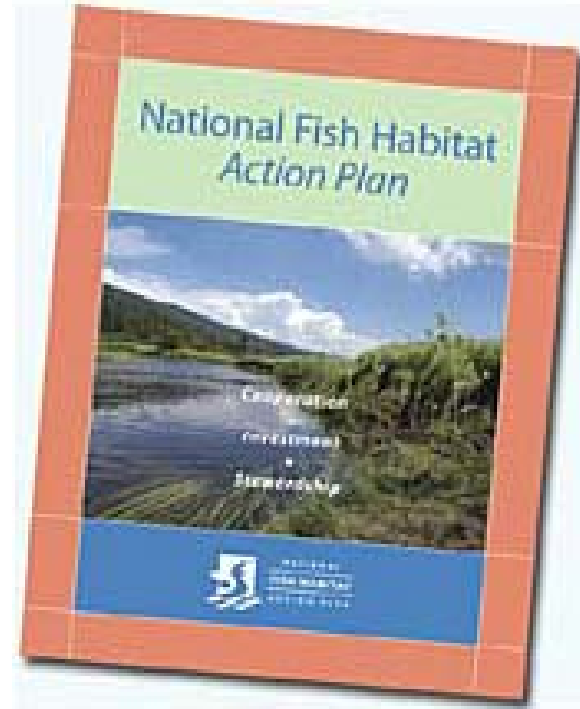
Tools for EBJTV; Managers and Decision Makers

- Extensive fine scale occupancy database
- Extensive GIS database of 85 metrics summarized by 3 scales
- CART models for 3 occupancy classes of interest for 3 different scales

Thanks to the EBTJV Partners!



Eastern Brook Trout
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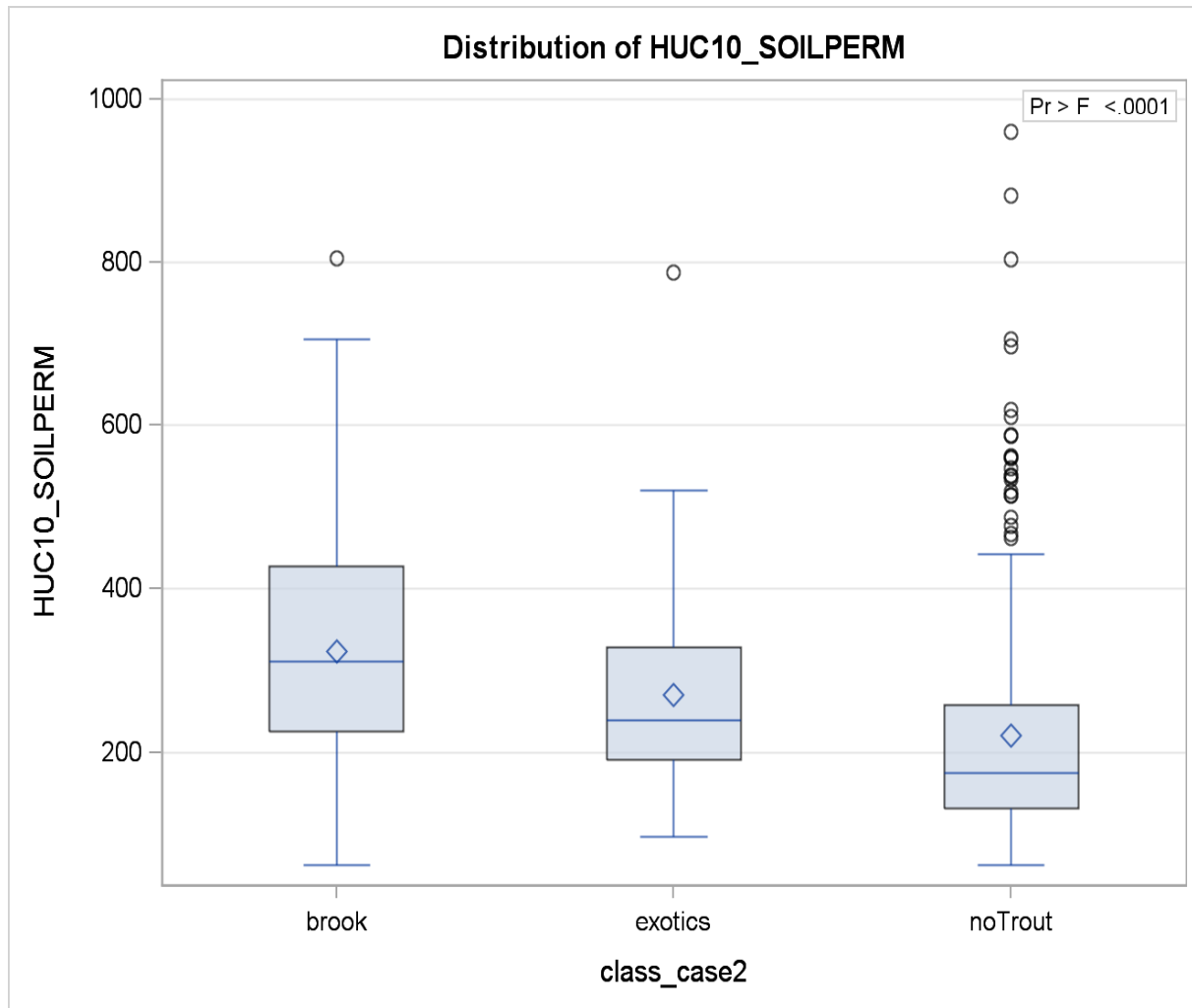
WHENEVER YOU TALK,
I THINK ABOUT MY
FISHING LURES UNTIL
THE NOISE STOPS.



Watershed Case 2 (69% correct) (n = 808)

- 8 splitting nodes
- 9 terminal nodes
- 8 variables (variable importance)
 - Soil permeability (100)
 - Deposition (86)
 - NO3 max (66)
 - Maximum elevation (53)
 - Mixed forest (45)
 - Mean elevation (43)
 - Canopy cover (37)
 - Average annual precip. (33)

Occupancy	Brook Trout	Rainbow Trout	Brown Trout
Allopatric	1	0	0
Sympatric	1	1	0
Sympatric	1	0	1
Sympatric	1	1	1
Non-native	0	0	1
Non-native	0	1	0
Non-native	0	1	1
No trout	0	0	0



Watershed Case 3 (59% correct)

(n = 808)

- 20 splitting nodes
- 21 terminal nodes
- 14 variables (variable importance)
 - Soil permeability (100)
 - Deposition (79)
 - Mean elevation (77)
 - Mixed forest (74)
 - N03 max (63)
 - N03 maxall (45)
 - Stream network length (42)
 - Grasslands (41)
 - N03 mean (37)
 - Maximum elevation (31)
 - Deciduous forest (28)
 - Canopy cover (27)
 - Developed open space (20)

Occupancy	Brook Trout	Rainbow Trout	Brown Trout
Allopatric	1	0	0
Sympatric	1	1	0
Sympatric	1	0	1
Sympatric	1	1	1
Non-native	0	0	1
Non-native	0	1	0
Non-native	0	1	1
No trout	0	0	0

