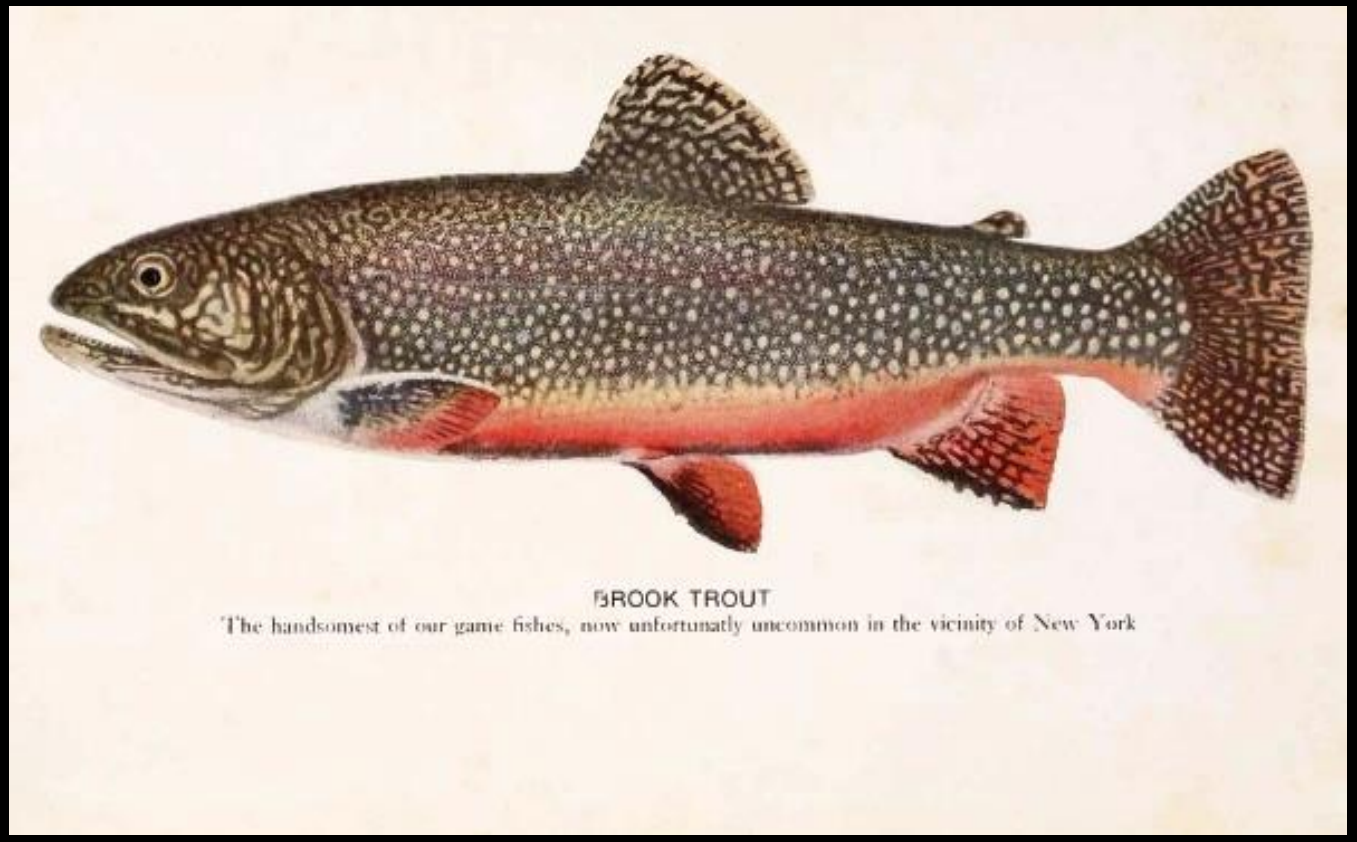
Climate Change and Trout (ᏧhᏀᏠ tsunilodi) on the Qualla Boundary

Andrew Sanders

Art: Derek DeYoung, www.derekdeyoung.com



Brook Trout (*Salvilinus fontinalis*)
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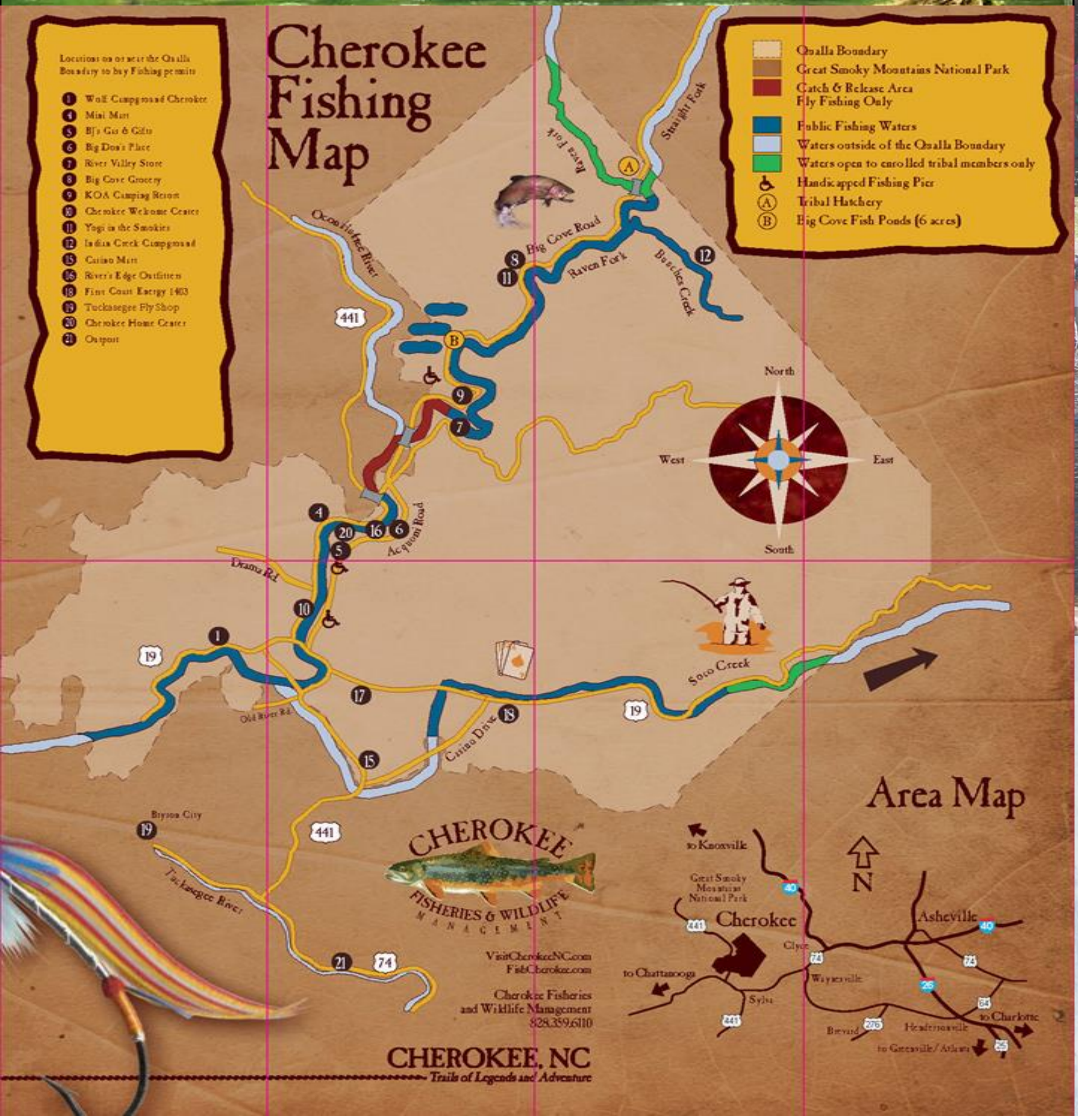
Indian Fish Weir System
Little Tennessee River
Iotla to McCoy Bridge

Fish Weir Location

0.0 0.5 1.0 miles
0.0 0.5 1.0 1.5 km

Surveyed by Lamar Marshall & Brent Martin
Aug 21, 2008 (extremely low water)


Year-round
fishing fun.
Unless you're the fish.


Cherokee Fishing Map
Locations on or near the Qualla Boundary to buy Fishing permits
1 Wolf Campground Cherokee
4 Mini Mart
5 BJ's Gas & Gifts
6 Big Don's Place
7 River Valley Store
8 Big Cove Grocery
9 KOA Camping Resort
10 Cherokee Welcome Center
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Qualla Boundary
Great Smoky Mountains National Park
Catch & Release Area
Fly Fishing Only
Public Fishing Waters
Waters outside of the Qualla Boundary
Waters open to enrolled tribal members only
Handicapped Fishing Pier
A Tribal Hatchery
B Big Cove Fish Ponds (6 acres)
North
South
East
West
Big Cove Road
Raven Fork
Straight Fork
Bunches Creek
Oconaluftee River
Acquoni Road
Soco Creek
Casino Drive
Old River Rd
Tuckasegee River
Bryson City
441
19
74
Area Map
N
to Knoxville
Great Smoky Mountains National Park
Cherokee
Asheville
Clyde
Waynesville
Sylva
Brevard
Hendersonville
to Chattanooga
to Charlotte
to Greenville/Atlanta
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And for fisherman.

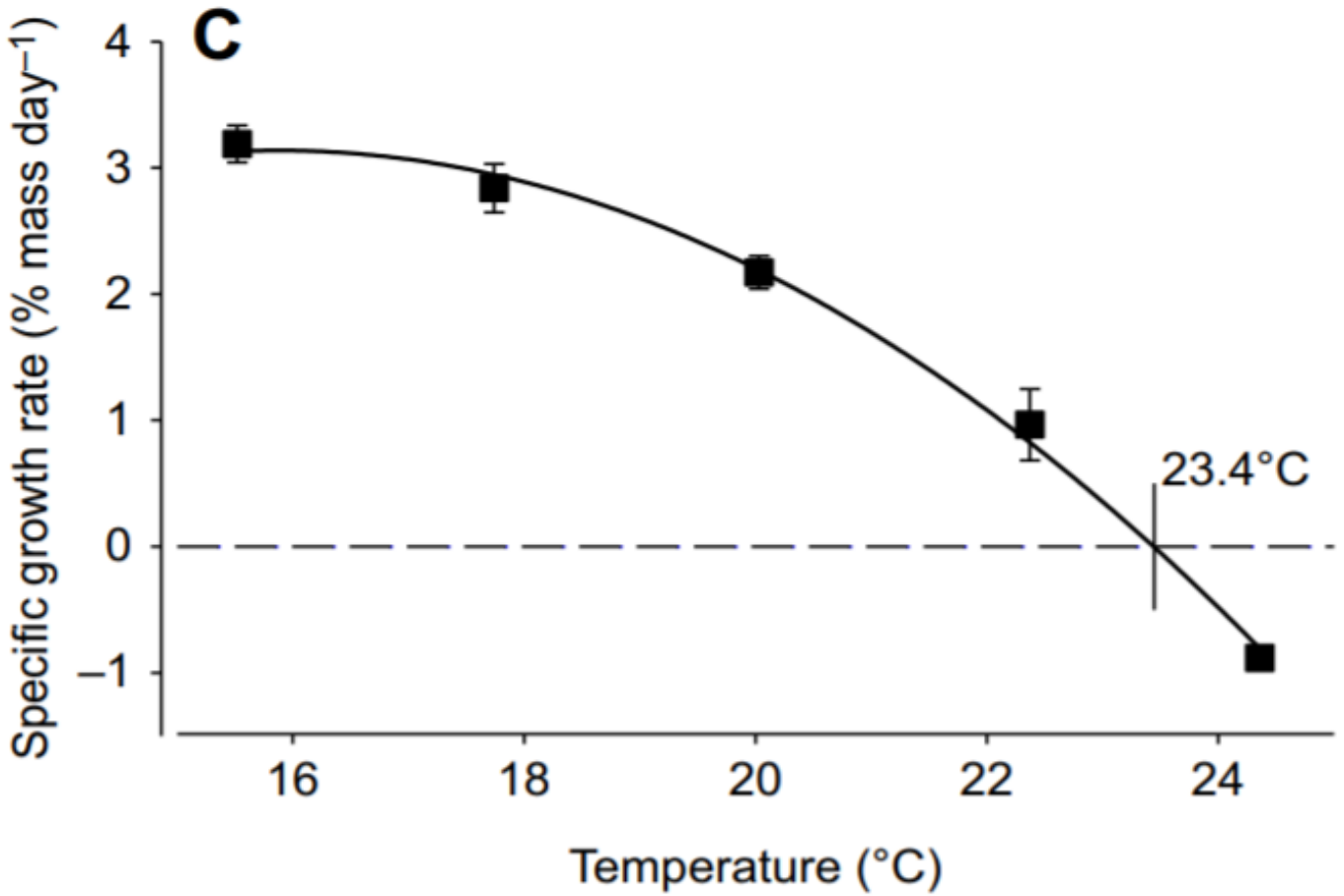
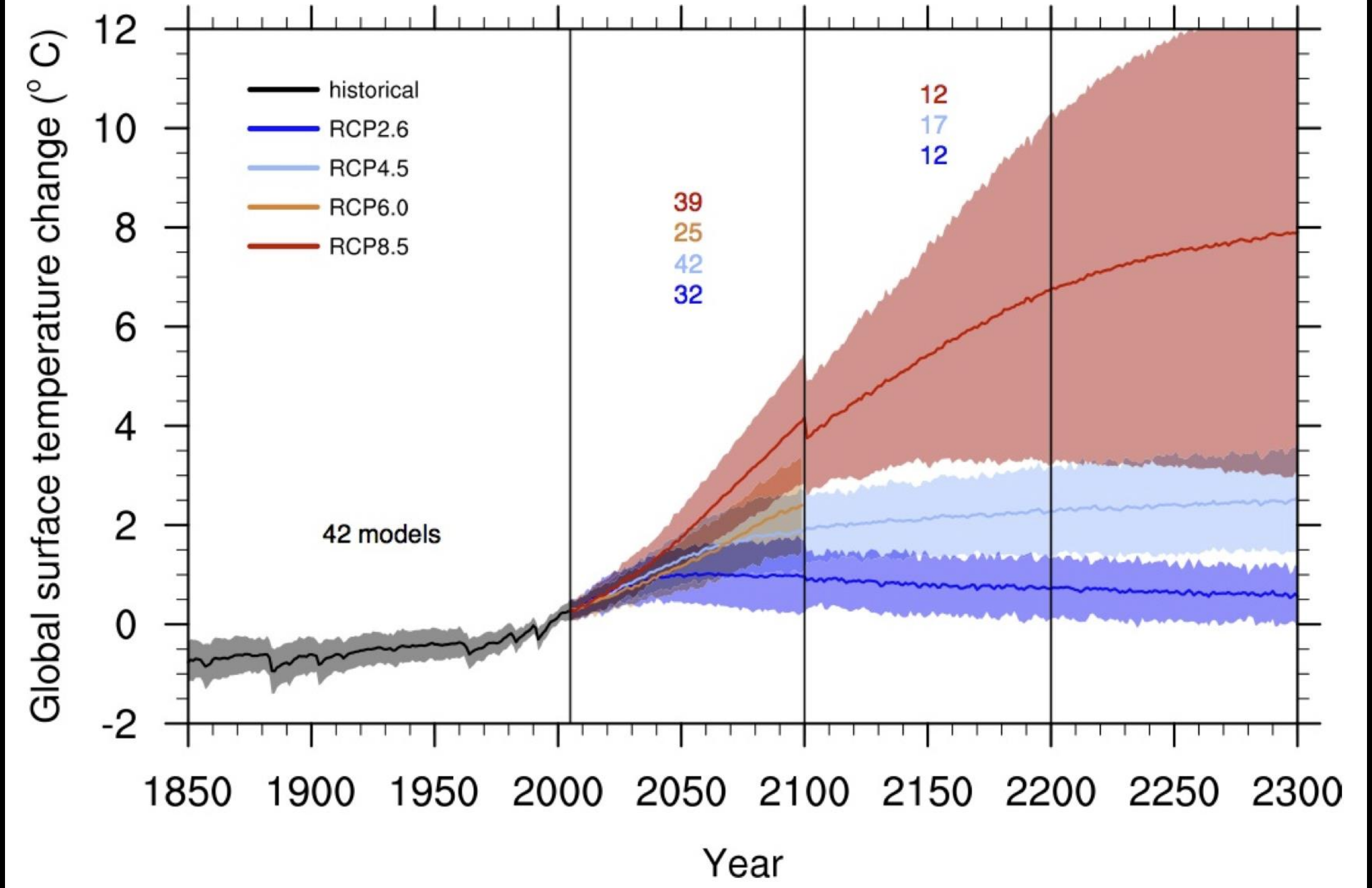
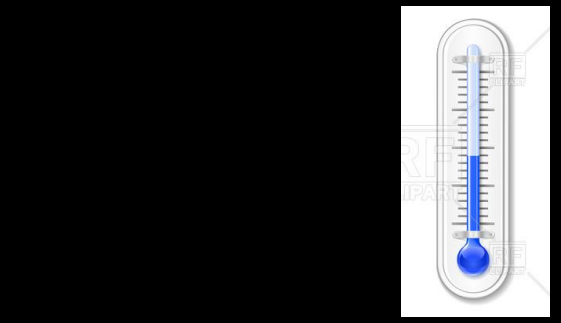


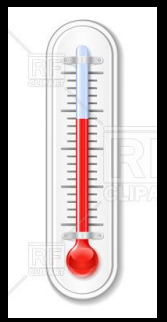
Fig. 1. Influence of temperature on growth rate of brook trout. Water temperature recorded every 20 min in each of the five temperature treatments (A) and their impact on linear (B) and specific growth rate in mass (C) in brook trout. Values are means±s.e.m. of 7–8 fish per treatment. Regression lines for B and C were R^2=0.82 and R^2=0.81, respectively (P<0.00001).

Chadwick, J.G. & McCormick, S.D. (2017). Upper thermal limits of growth in brook trout and their relationship to stress physiology. *J. Exp. Biol.*, 220, 3976-3987.


Global surface temperature change (° C)
12
10
8
6
4
2
0
-2
historical
RCP2.6
RCP4.5
RCP6.0
RCP8.5
42 models
39
25
42
32
12
17
12
1850
1900
1950
2000
2050
2100
2150
2200
2250
2300
Year

Elevational range shifts and mountain top extinction





Methods:
Brook Trout habitat
over the next 100 years

- Temperature estimates pulled from NOAA GFDL-CM3 surface air temperature model using DataThief III

- Future temperatures plugged into the following models to determine the lower elevational limit (LEL) of brook trout habitat and the mean was used:
  1. Future LEL = current LEL + ($188*\Delta_t$) Meisner 1990
  2. Future LEL = ($6813.6+\Delta_t*188$) – ($178.6*lat$) Flebbe 1993
  3. Future LEL = $398 + (188*\Delta_t)$ Flebbe 2006
     - Current LEL estimated at 500m from Meisner 1990
     - Latitude of Cherokee, NC = 35.5°N

Methods:
Brook Trout habitat
over the next 100 years

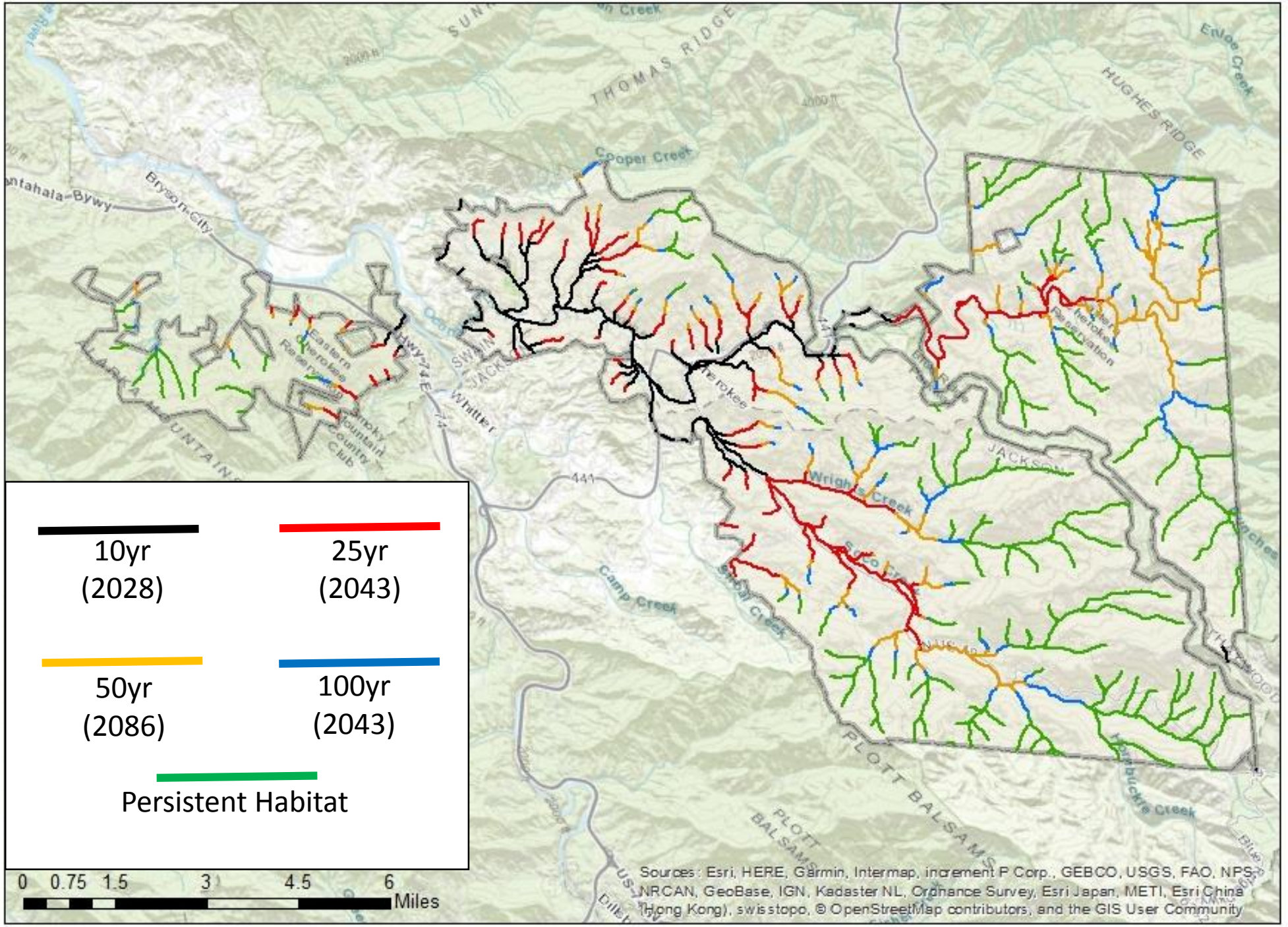
- Maps prepared in ArcMap using
  - US Census data to define the area of the Qualla Boundary
  - State of NC QL2 LIDAR elevation data
  - USGS National Hydrography Dataset flowlines for the Tuckasegee watershed
- NHD flowlines clipped at future LEL predictions

Meisner, J.D. (1990). EFFECT OF CLIMATIC WARMING ON THE SOUTHERN MARGINS OF THE NATIVE RANGE OF BROOK TROUT, SALVELINUS-FONTINALIS. *Canadian Journal of Fisheries and Aquatic Sciences*, 47, 1065-1070.

Flebbe, P.A. (1993). MEISNER (1990) - EFFECT OF CLIMATIC WARMING ON THE SOUTHERN MARGINS OF THE NATIVE RANGE OF BROOK TROUT, SALVELINUS-FONTINALIS - COMMENT. *Canadian Journal of Fisheries and Aquatic Sciences*, 50, 883-884.

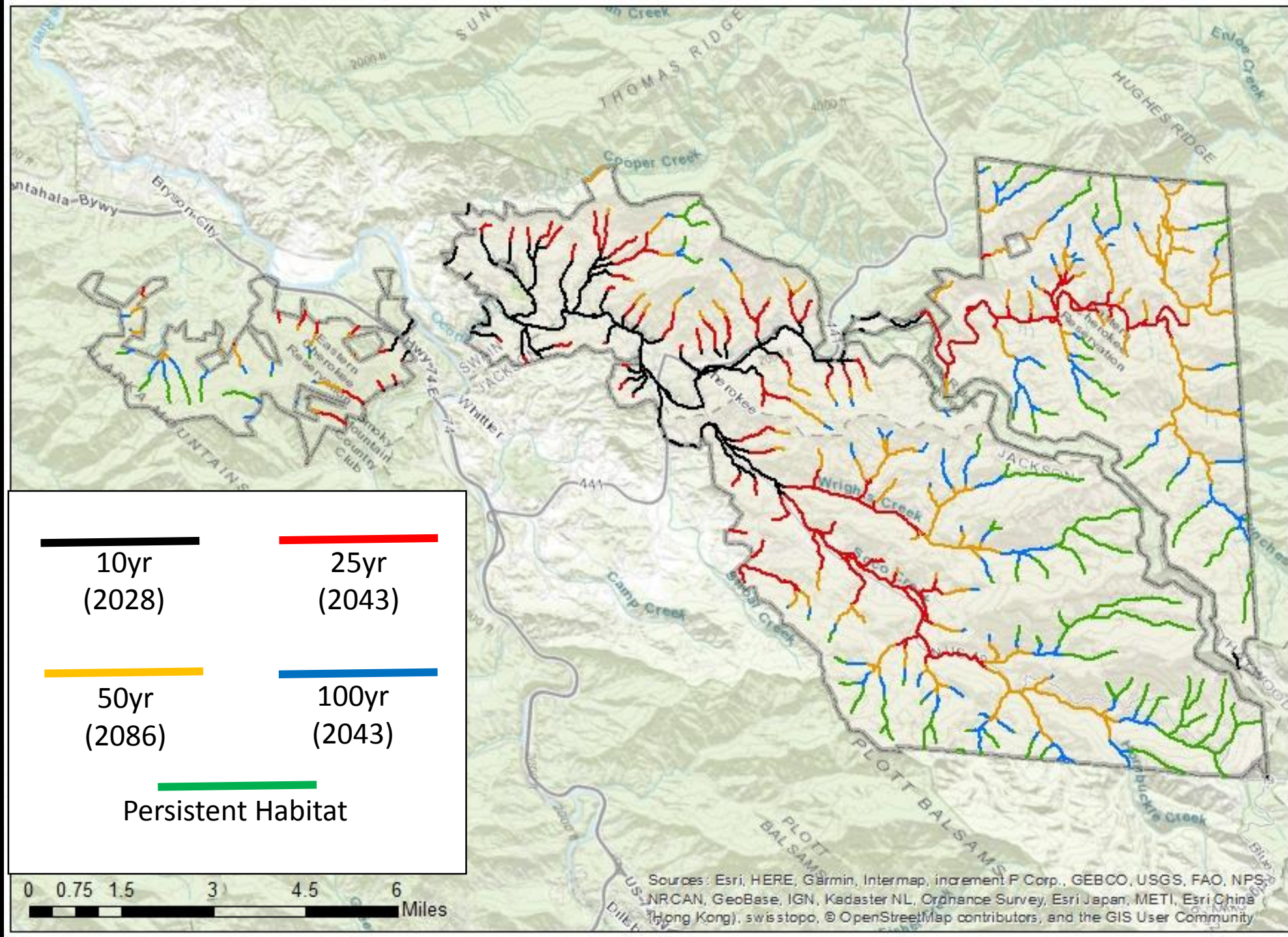
Flebbe, P.A., Roghair, L.D. & Bruggink, J.L. (2006). Spatial Modeling to project southern Appalachian trout distribution in a warmer climate. *Transactions of the American Fisheries Society*, 135, 1371-1382.

Results:
Brook Trout
Countdown to local extinction



RCP2.6
+2°C by 2100
Best case scenario

Results:
Brook Trout
Countdown to local extinction



RCP4.5
+2.7°C by 2100

Results:
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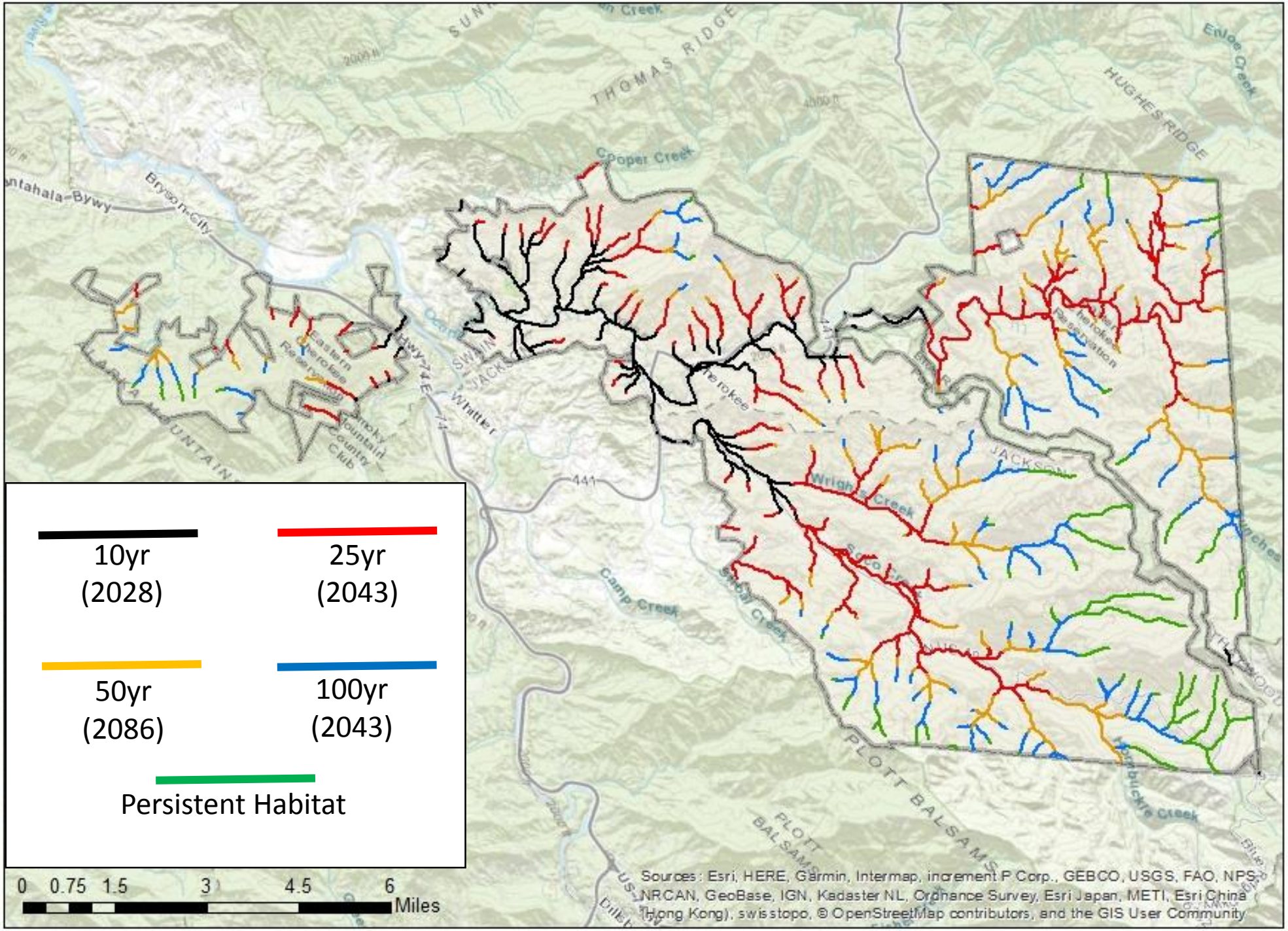
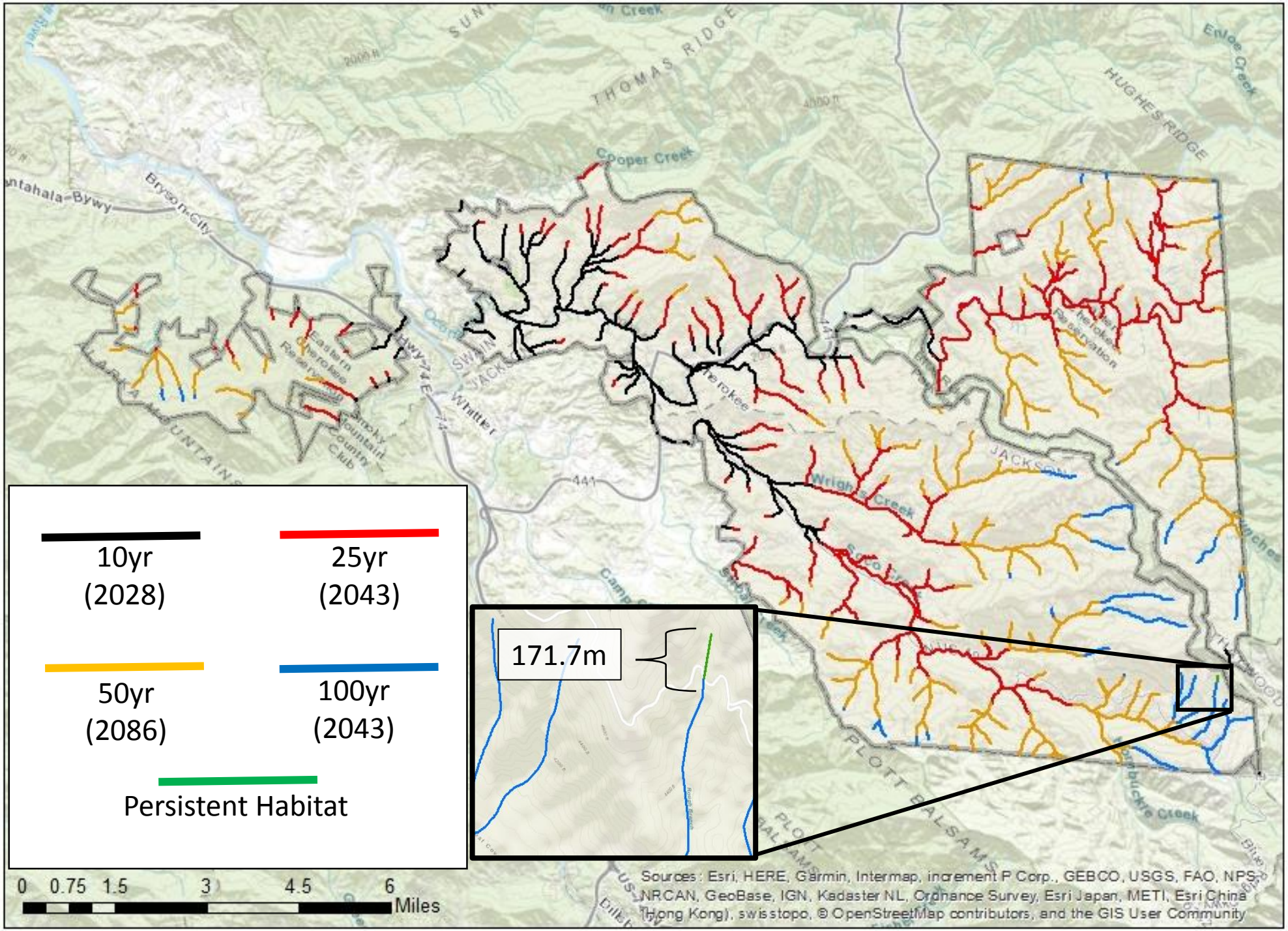
Countdown to local extinction



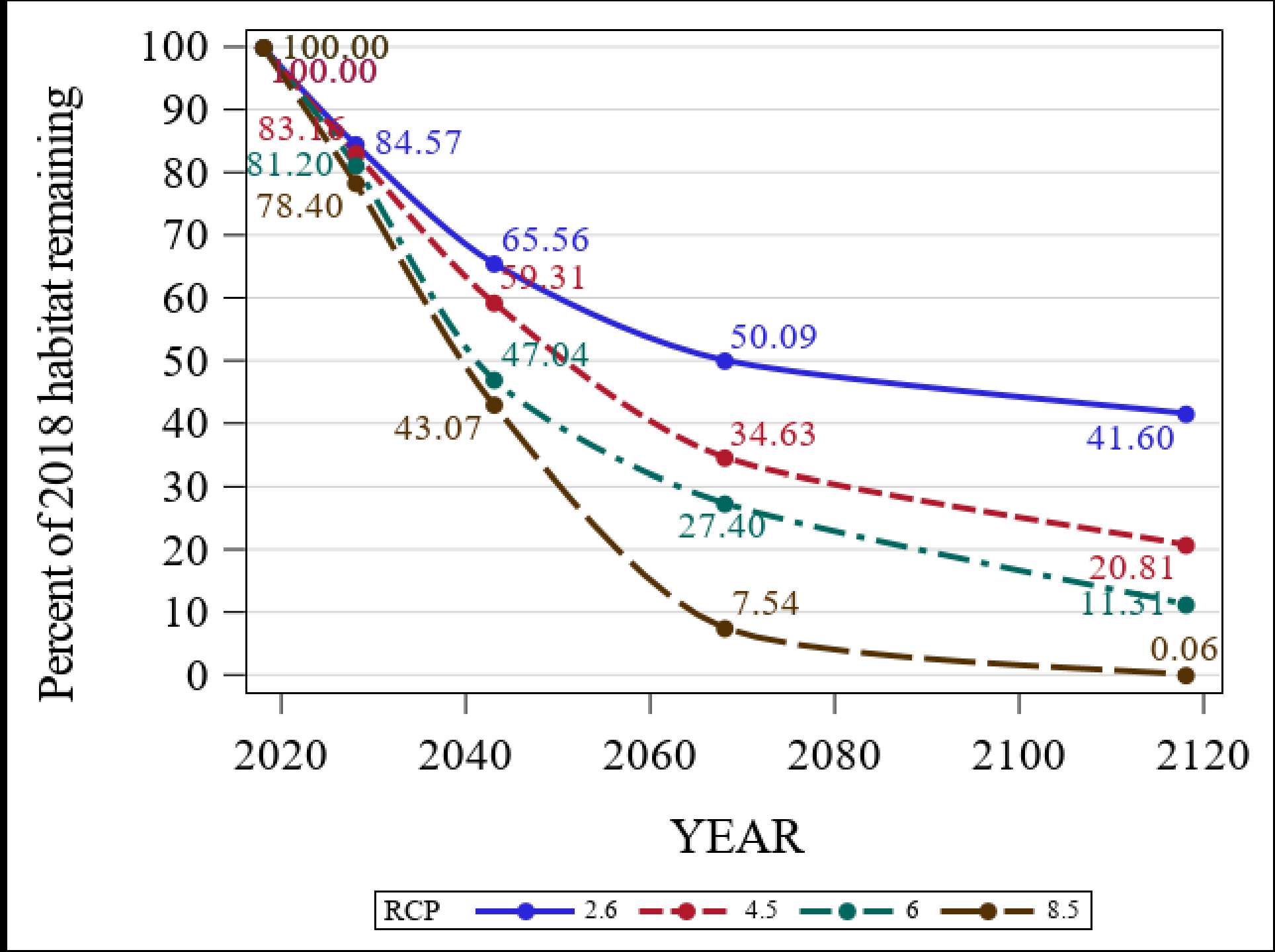
RCP6
+3.3°C by 2100

Results:
Brook Trout
Countdown to local extinction

RCP8.5
+5.1°C by 2100
May overestimate availability of fossil fuels

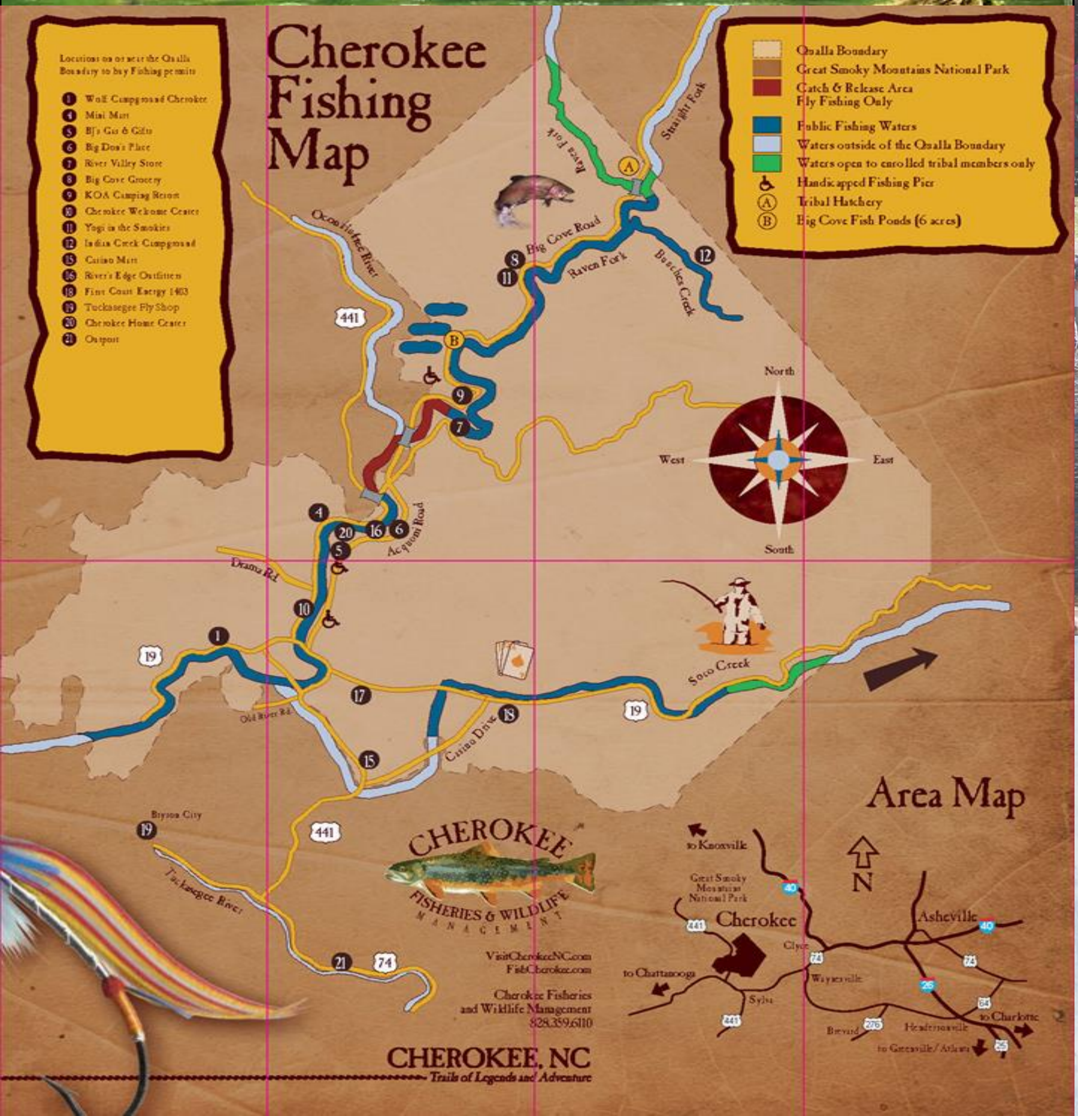


Results:
Brook Trout habitat over the next 100 years



Rainbow Trout (*Oncorhynchus mykiss*)
ᏧᎦᏁᏗᏧᎯ Tsulolvdi atsadi


Year-round
fishing fun.
Unless you're the fish.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N
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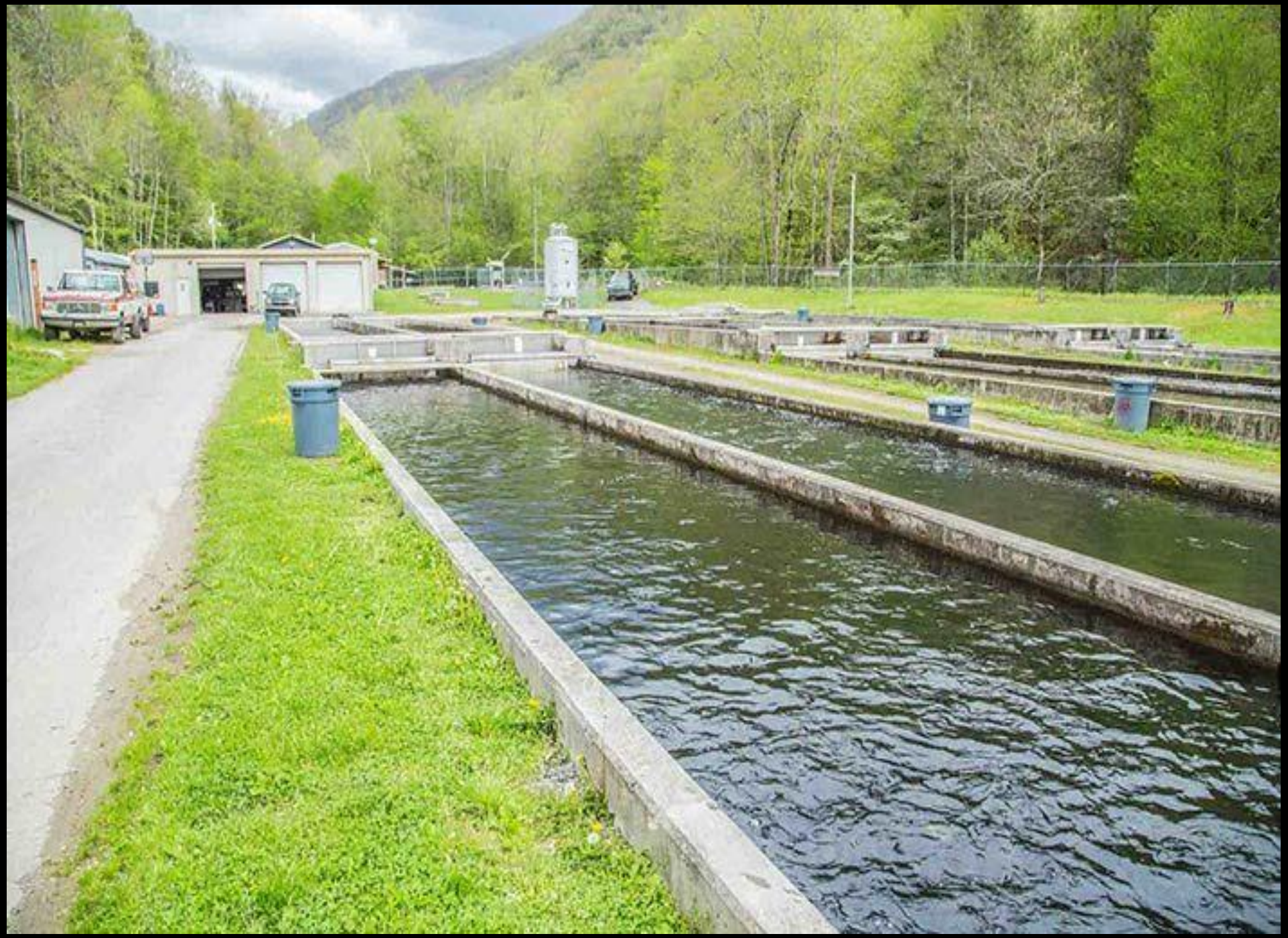
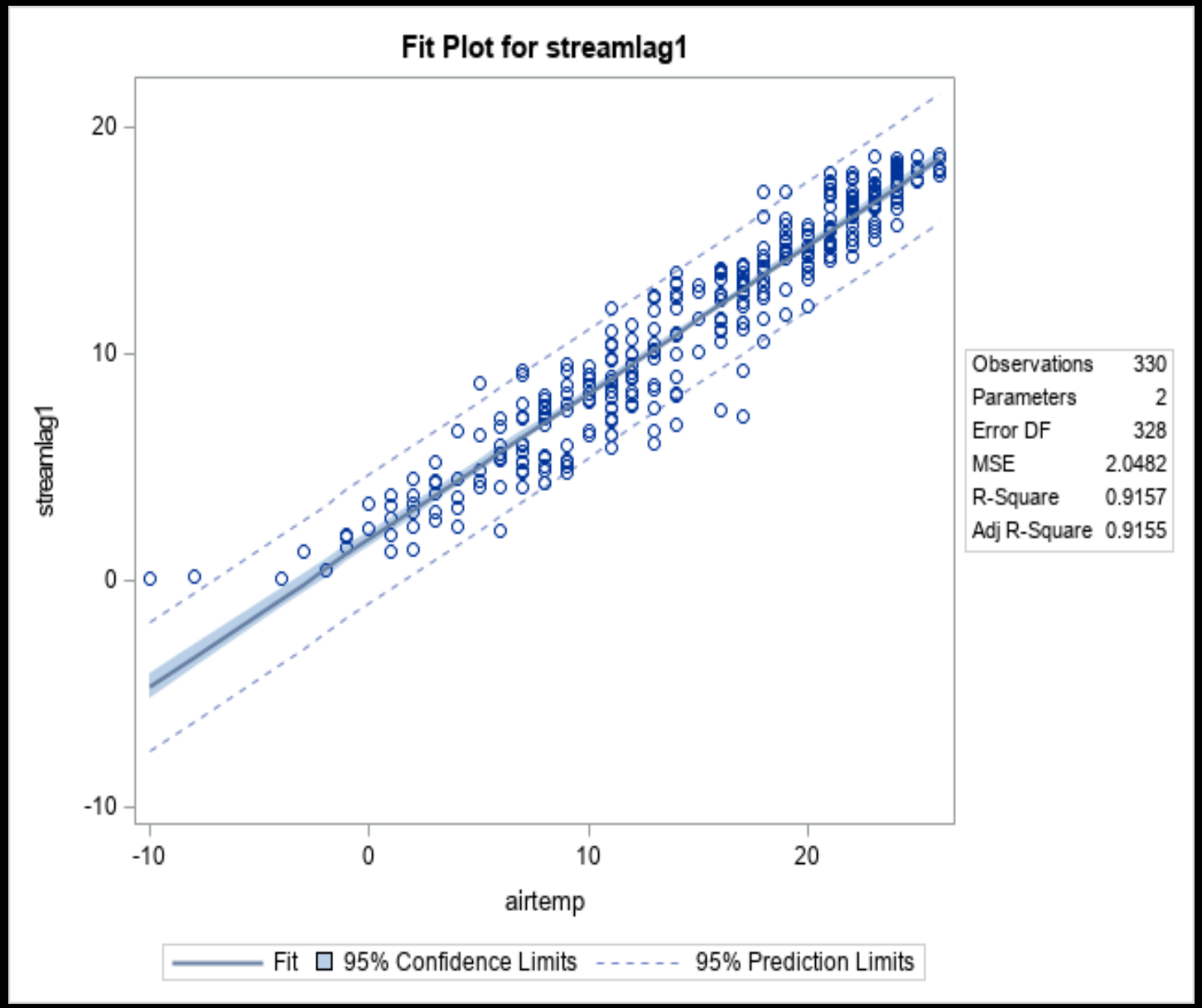
Hatchery operation over the next 25 years



Methods:

Hatchery operation over the next 25 years

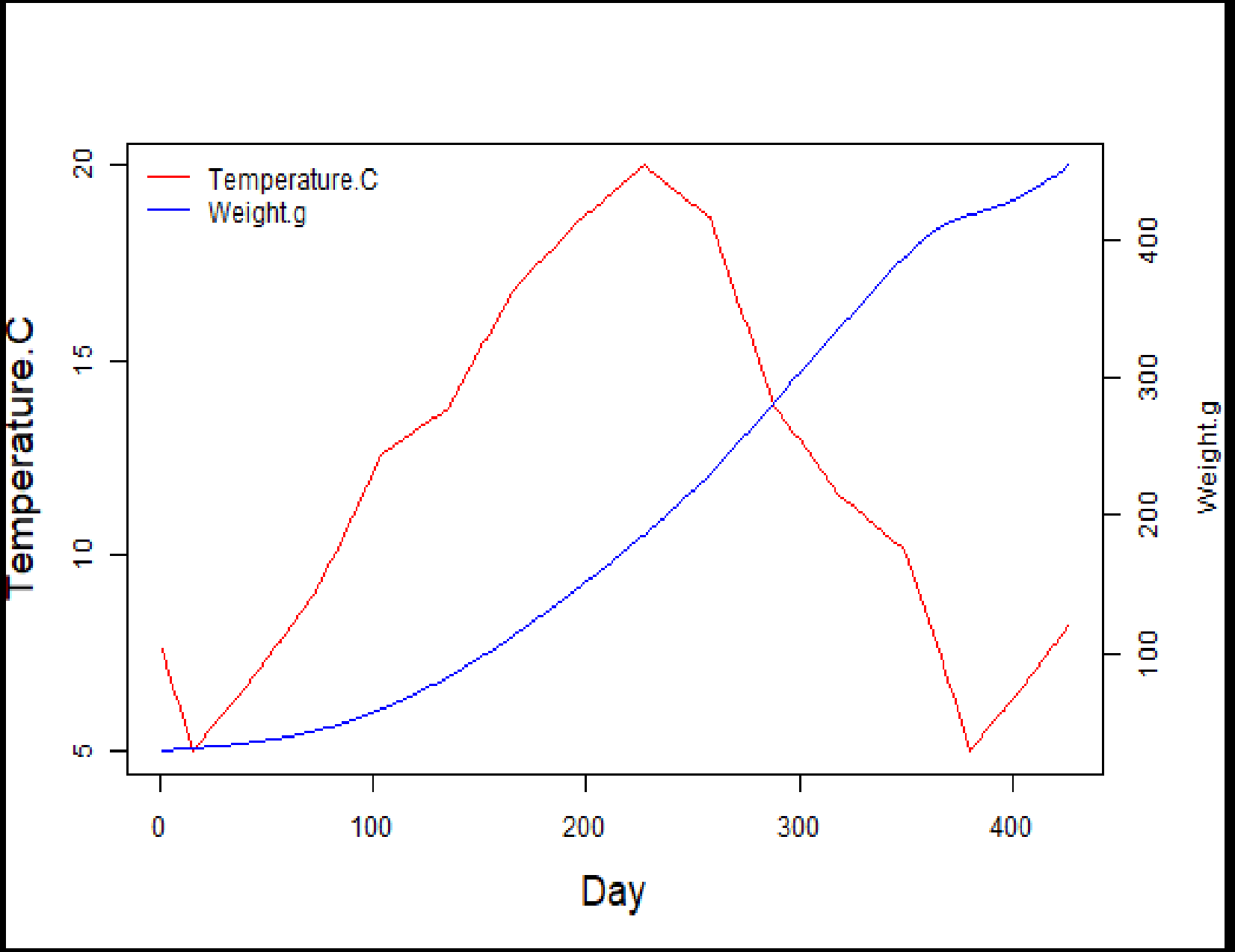
- Relationship between air and stream temp determined by lag effect correlation, using Pearson correlation coefficient and r^2
- Temperature data for LEC from Cataloochie Creek and Asheville Airport



Methods:

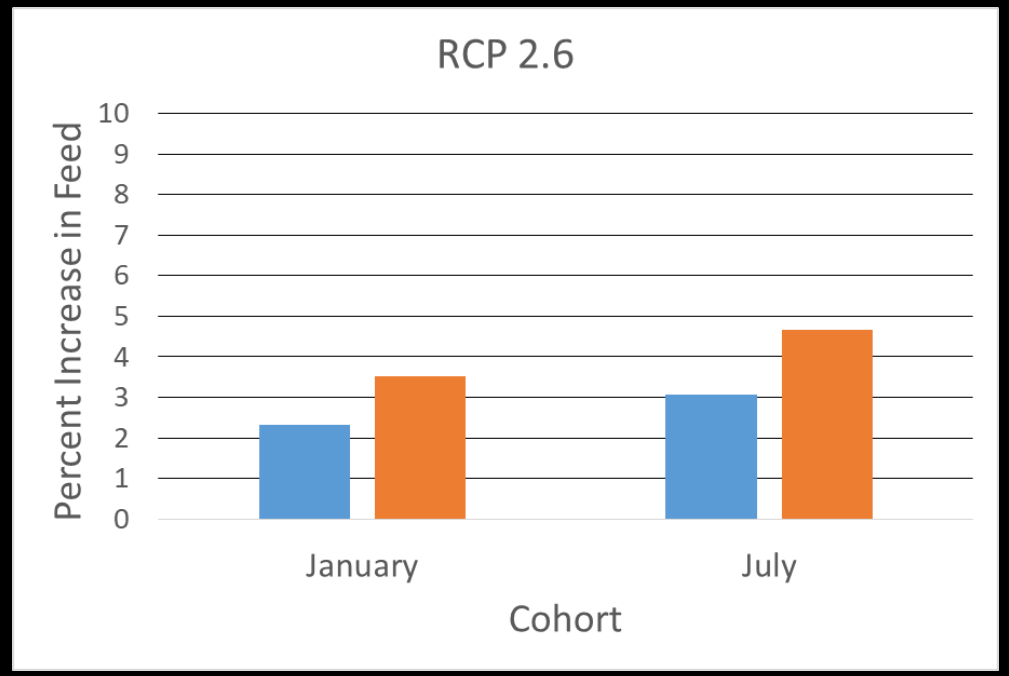
Hatchery operation over the next 25 years

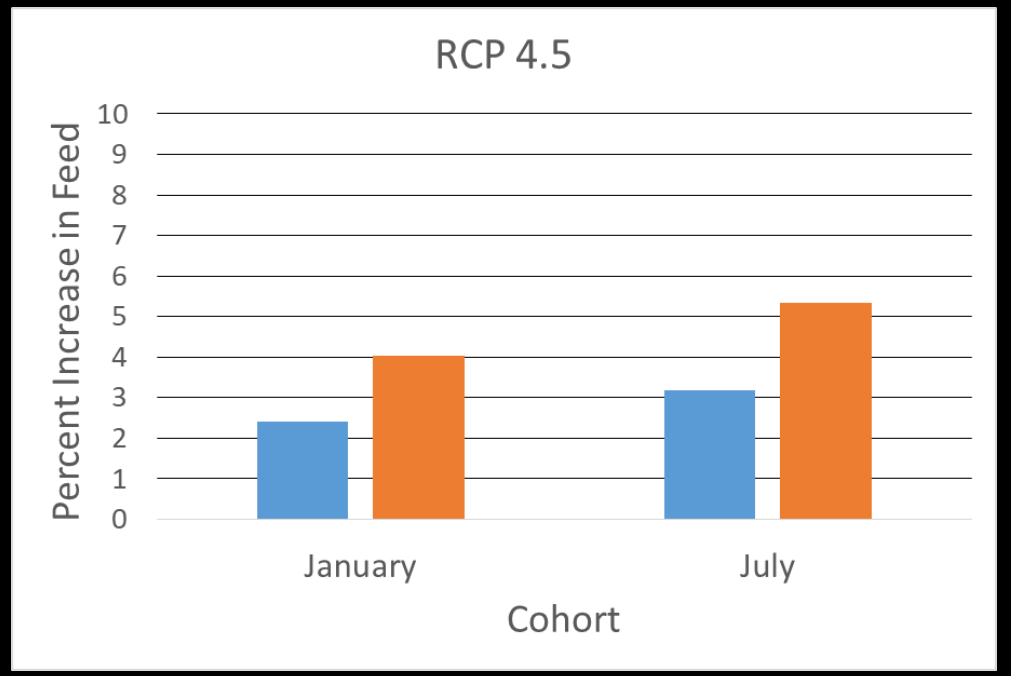
- "Wisconsin" bioenergetics model and Fish Bioenergetics 4 R package
- Model parameters from Railsback & Rose 1999, and unpublished data provided by EBCI fish & wildlife

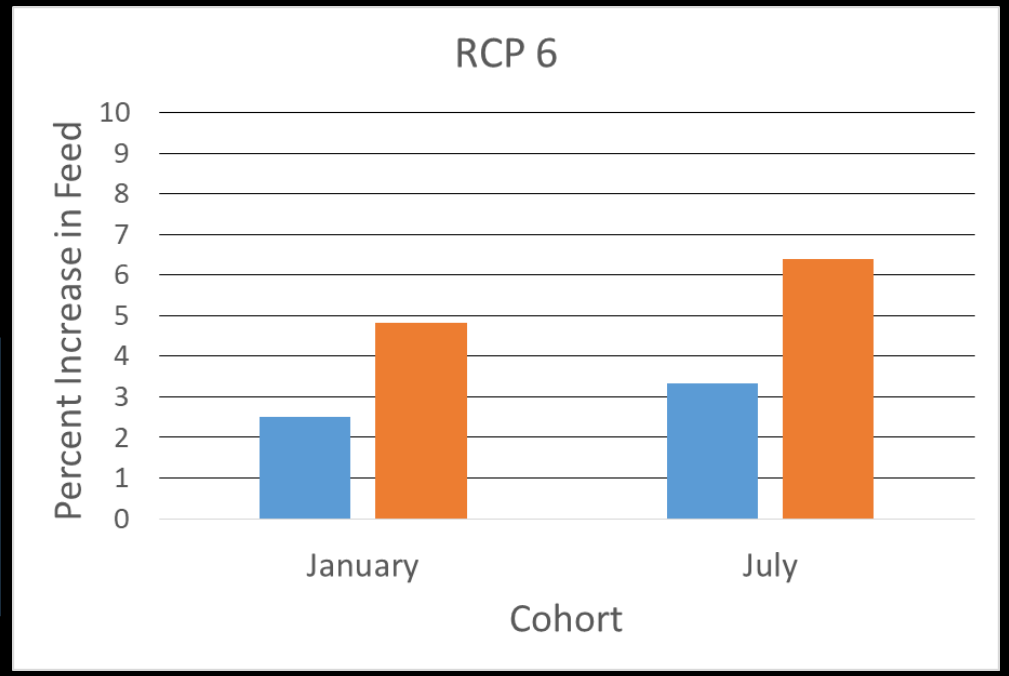


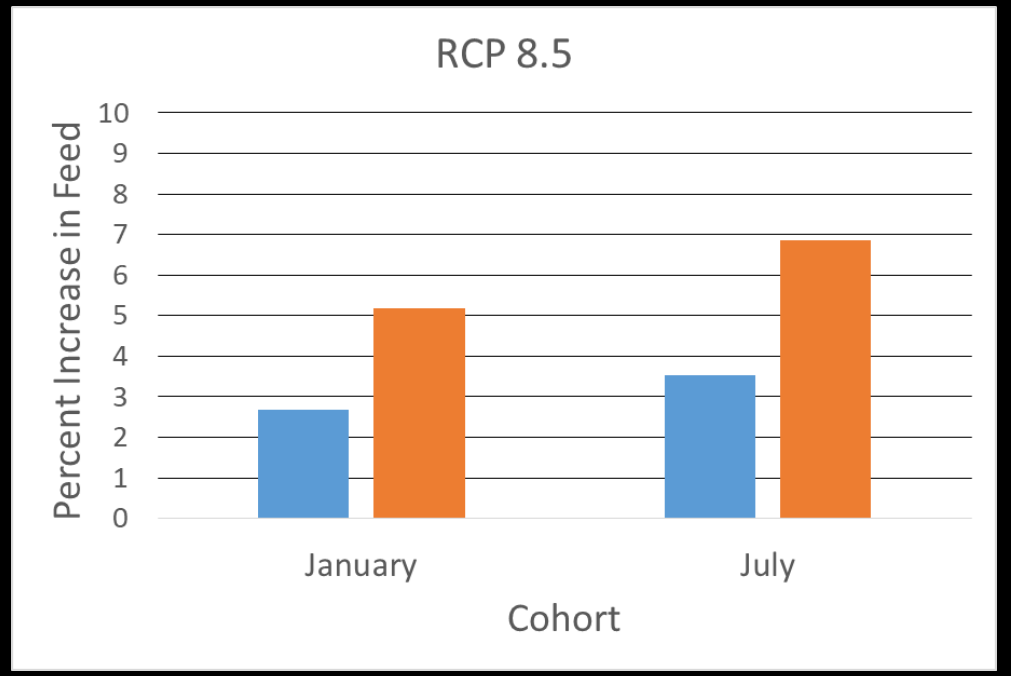
Railsback, S.F. & Rose, K.A. (1999). Bioenergetics modeling of stream trout growth: Temperature and food consumption effects. *Transactions of the American Fisheries Society*, 128, 241-256.

Results:
Hatchery operation over the next 25 years









10 years

25 years

Conclusions

- Native brook trout habitat severely threatened by climate warming
  - **50 to 98 percent loss in 50 years**

- Hatchery production may not be severely impacted by rising temperatures
  - **2.3 to 6.8 increase in feed requirements**

Conclusions

- Habitat models do not account for loss of tree canopy (e.g. Hemlock woolly adelgid)
- Habitat models do not account for changes in precipitation
- Growth models do not account for oxygen limitation or impacts of drought or flood on hatchery operation
- RCP 8.5 “worst case” may actually be optimistic

Future directions

- Re-run models with LOCA statistically downscaled composite temperature predictions
- Investigate predicted changes in precipitation
- Translate abstract into ᏣᎳᎩ (Cherokee)

Special thanks to:
the NSF GRFP, NCSU, EBCI Fisheries and Wildlife Management, USFWS, fishbioenergetics.org, Mark Cantrell, Ryan Emanuel, Jeff Essic, Mike LaVoie, Jim Rice, & David Rowland ᏀᏙ/ᏫᎾᎩ! (thank you!)

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