Forest Restoration and Water Resources: Using the mountains as an example

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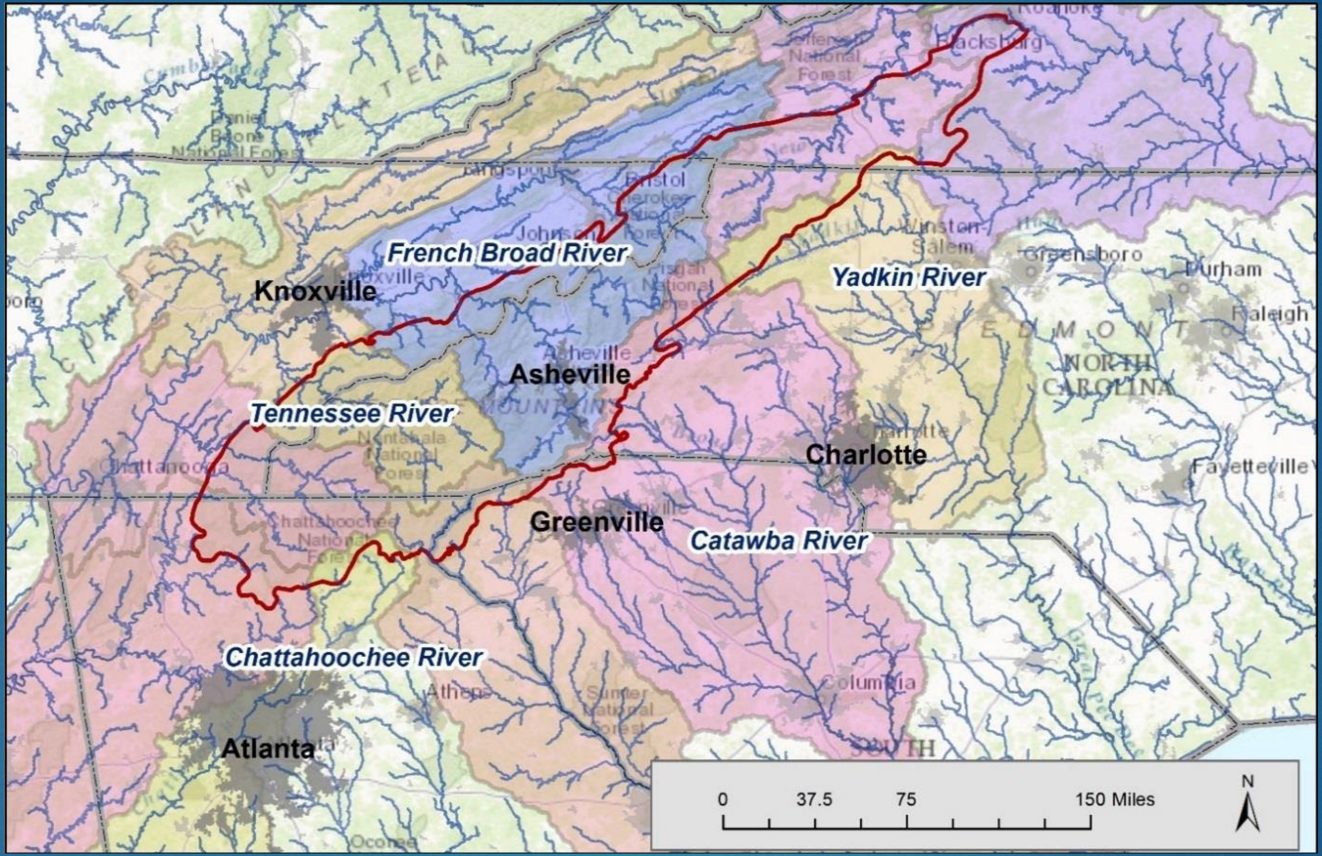
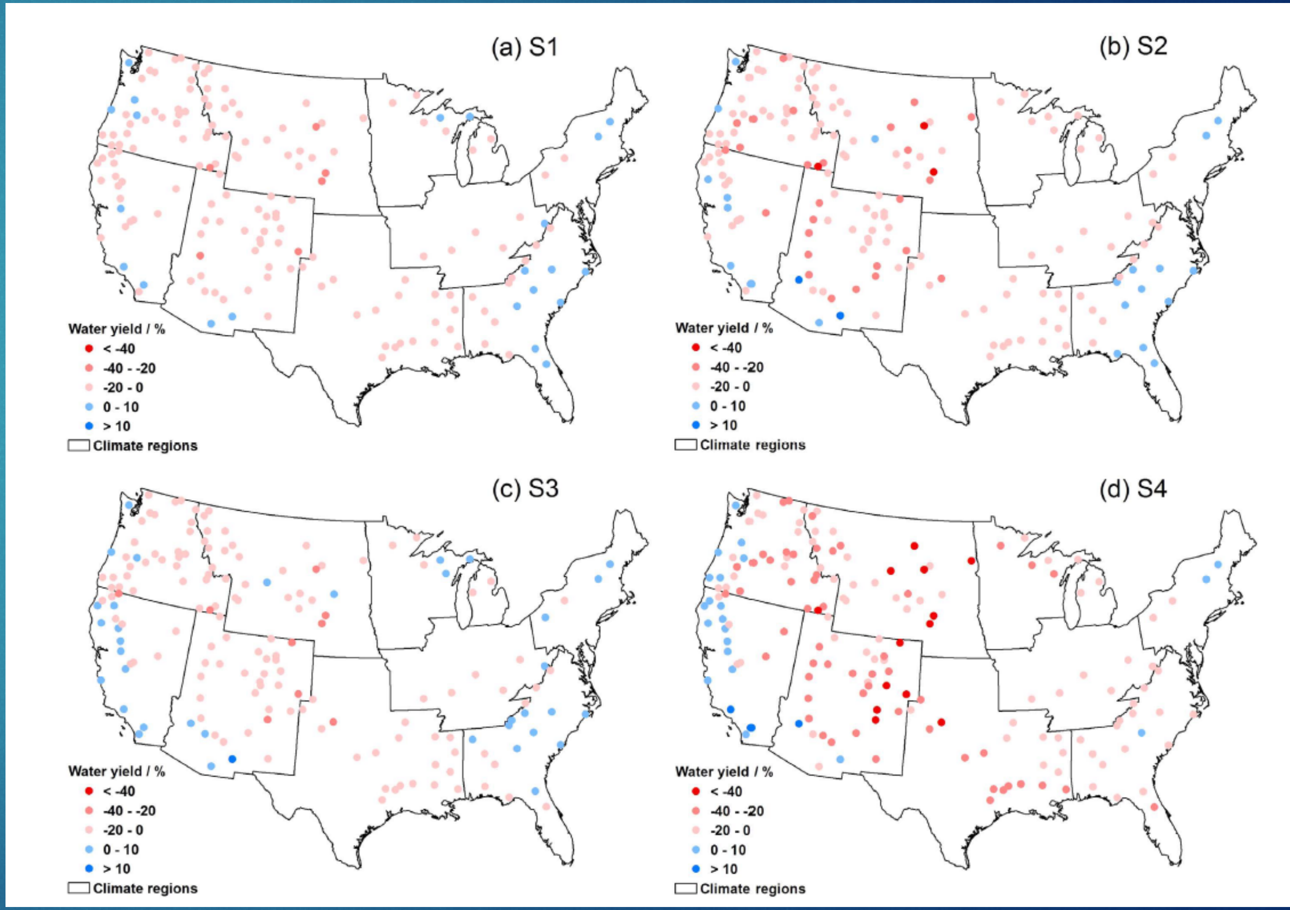
The Southern Blue Ridge (SBR) Boundaries



The red line shows the SBR boundary, which encompasses over 9.4 million acres and some of the largest blocks of unfragmented forests in the country. The color blocks distinguish different river basins. Several cities outside the SBR receive significant drinking water from the mountain headwaters.

Water is abundant in the SBR, but researchers are documenting change

- Researchers have documented a 0.9° (F) temperature increase per decade since the 1980s in the SBR (Caldwell 2016)
- Historic precipitation is variable, but precipitation events are becoming more extreme (Caldwell, personnel comm.)
- Future evapotranspiration (ET) is predicted to be more than precipitation, leading to decreased water in streams. (Duan et al 2016)



And the trees are changing….

- In the mid-20th century, forests were dominated by drought and fire tolerant species like oaks and hickories.
- Timber harvest for forest products, fire suppression, pests (such as the Chestnut blight) and a rising temperature in the SBR are changing the forests.
- Maples and poplars are becoming dominant species. *A poplar can use 4x the amount of water as an oak.*
- Researchers have documented up to an 18% decline of water in streams as maples and poplars come to dominate

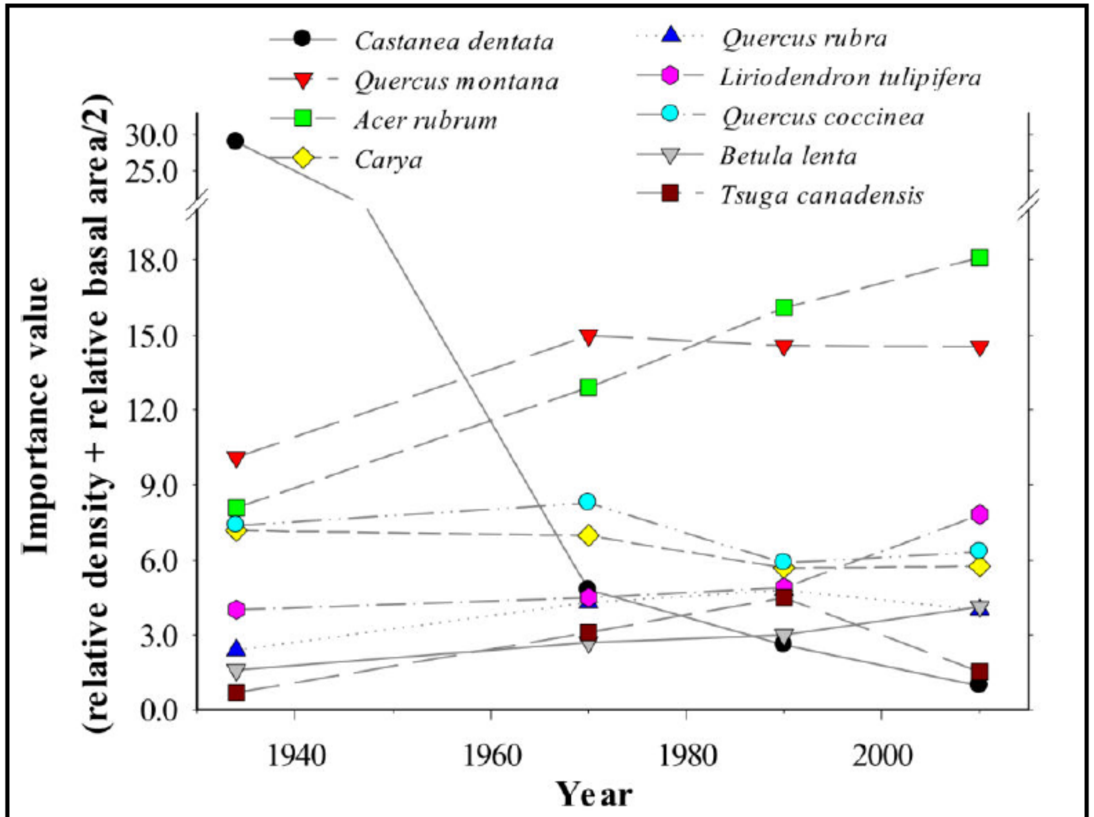
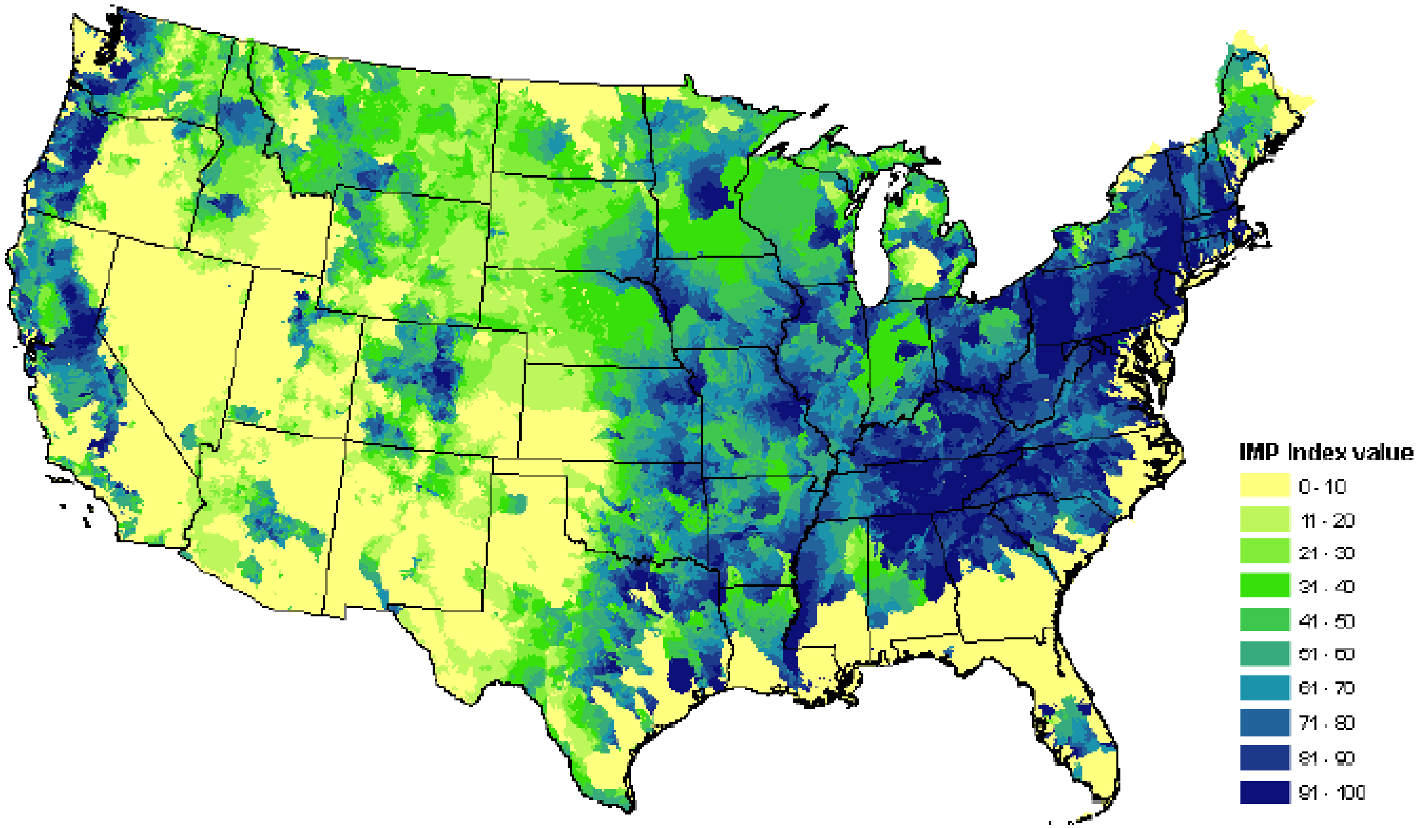


Figure 1. Long-term changes in forest species composition in Coweeta reference watersheds (Elliott and Miniat, unpublished; (Elliott and Vose 2011). Species importance value, a combination of basal area and density, is shown for years when periodic forest surveys were conducted.

Courtesy of Caldwell and Miniat from Coweeta Hydrological Laboratory

Forests to Faucets



SURFACE DRINKING WATER IMPORTANCE INDEX, IMP. AREAS WITH HIGHER (BLUE) VALUES REPRESENT AREAS MOST IMPORTANT FOR SURFACE DRINKING WATER.

The SBR: Forest and Water Connections

- The SBR provides significant drinking water to people both inside and outside the region

- The area also supports tremendous aquatic diversity with at least 66 at-risk aquatic species, 20 of which are federally-listed as threatened or endangered

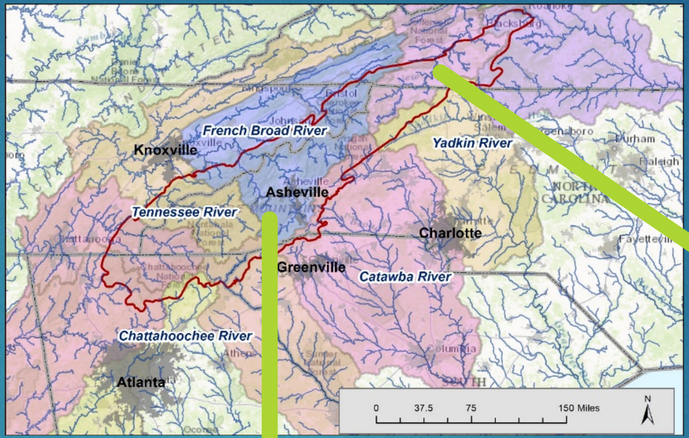
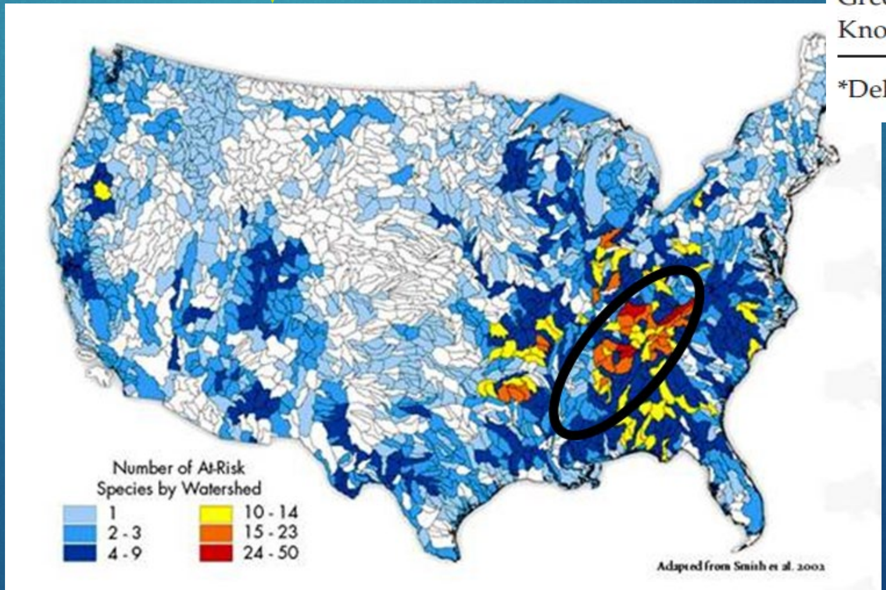


Table 1. Caldwell et al 2016 research showing major cities receiving water from the SBR

City, State	Human population served	Percentage of water supply originating in the southern Appalachian mountain region (%)
Greater Atlanta, Georgia area*	2 100 000	8–13
Charlotte, North Carolina	788 000	40
Greenville, South Carolina	350 000	57–100
Knoxville, Tennessee	236 000	57

*Dekalb and Gwinnett counties and the city of Atlanta.



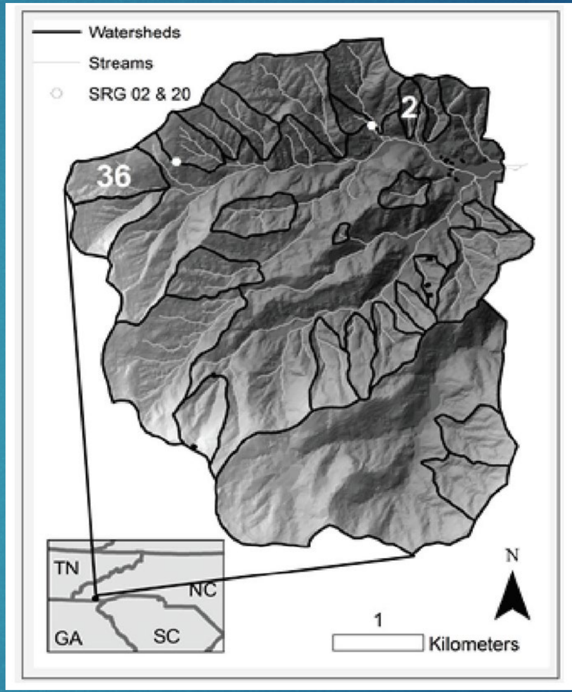
Current forest-water research at Coweeta Hydrologic Laboratory

Coweeta started two related studies with the 2016 wildfires:

- 40+ streams of different fire severity (including several streams with no burns) were sampled quarterly for water quality
- 6 streams (3 burned, 3 unburned) were sampled intensively for storm runoff events and weekly water quality samples
- Forest Inventory Analysis plots for vegetation were set up

Coweeta launched a paired watershed study to look at controlled burning effects on vegetation, water quantity and water quality

Combined, these experiments will give us insight into both wildfire and controlled fire effects on water



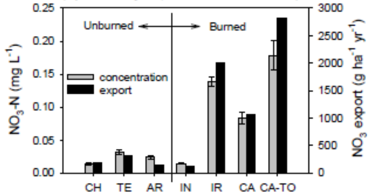
Two of Coweeta's 16 laboratory watersheds are looking at controlled burning effects on water

A weir at the bottom of the watershed

Coweeta Wildfire findings

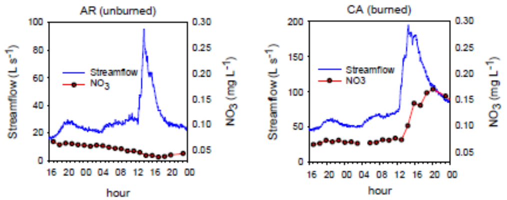
Water Quality (NO_3-N)

Mean annual NO_3-N concentration and total export from weekly grab samples (April water year, 4/1/2017 - 3/31/2018)



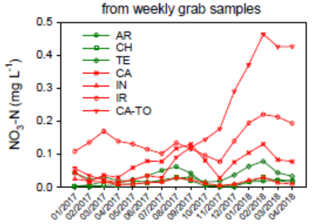
Stream NO_3-N concentrations and annual export were elevated in burned watersheds (mean 0.10 mg L^{-1}) relative to unburned watersheds (mean 0.02 mg L^{-1}).

Streamflow and NO_3-N concentrations during Aug 31, 2017 storm (Precipitation (P) = 49 mm)



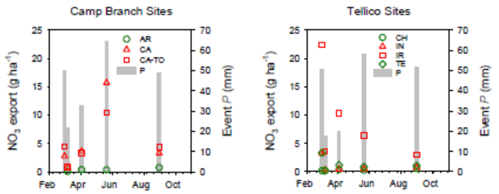
During storm events, stream NO_3-N concentrations in burned watersheds increased up to 370%, while NO_3-N concentrations in unburned watersheds typically decreased.

Monthly mean NO_3-N concentrations from weekly grab samples



Mean monthly NO_3-N concentration in the most severely burned watershed (CA-TO) reached 0.46 mg L^{-1}, well above the maximum monthly NO_3-N in unburned (0.08 mg L^{-1}) watersheds.

Total NO_3-N export during five sampled storm events

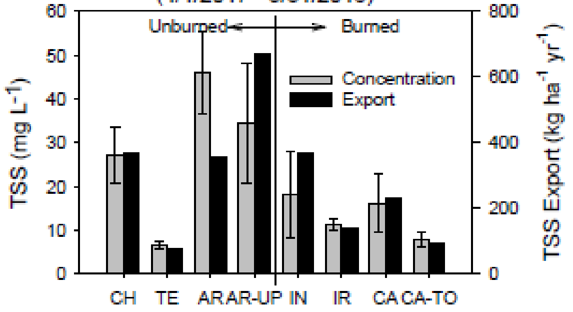


Higher storm NO_3-N concentrations coupled with greater streamflow in burned watersheds resulted in higher NO_3 export during sampled storm events than that of unburned watersheds.

Note: AR-UP unburned watershed not shown because upstream road management suspected to result in elevated NO_3 concentrations.

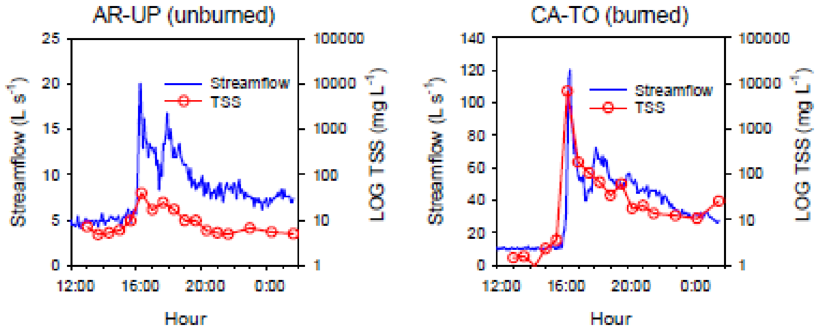
Water Quality (TSS)

April WYR mean TSS concentrations from weekly grab samples (4/1/2017 - 3/31/2018)



Mean stream TSS concentrations and annual export were lower in burned (17.5 mg L^{-1}) than unburned (28.6 mg L^{-1}) watersheds, suggesting that the wildfires did not increase sediment delivery to streams under baseflow conditions.

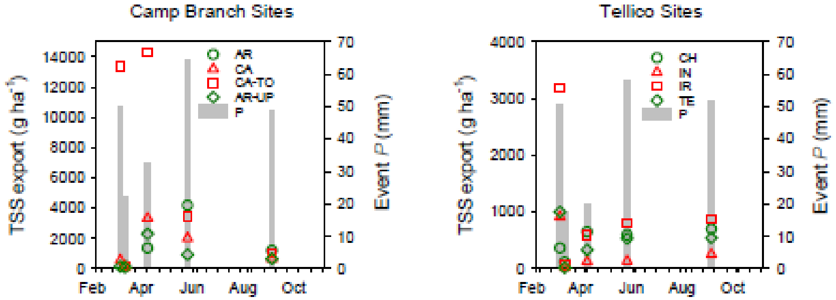
Streamflow and TSS concentrations during March 2, 2017 storm (P = 50 mm)



TSS concentrations collected during storm events in burned watersheds (max 9353 mg L^{-1}) greatly exceeded concentrations in unburned watersheds (max 787 mg L^{-1}) during some sampled storm events.

Sample bottle collected at CA-TO during storm on 3/2/2017 showing high sediment concentrations (6571 mg L^{-1}).

Total TSS export during five sampled storm events



TSS export was greater in burned than unburned watersheds during five sampled storm events that occurred soon after the wildfires, but export in later storms was similar between burned and unburned watersheds.

TNC Assumptions*: Rx fire can help water resources

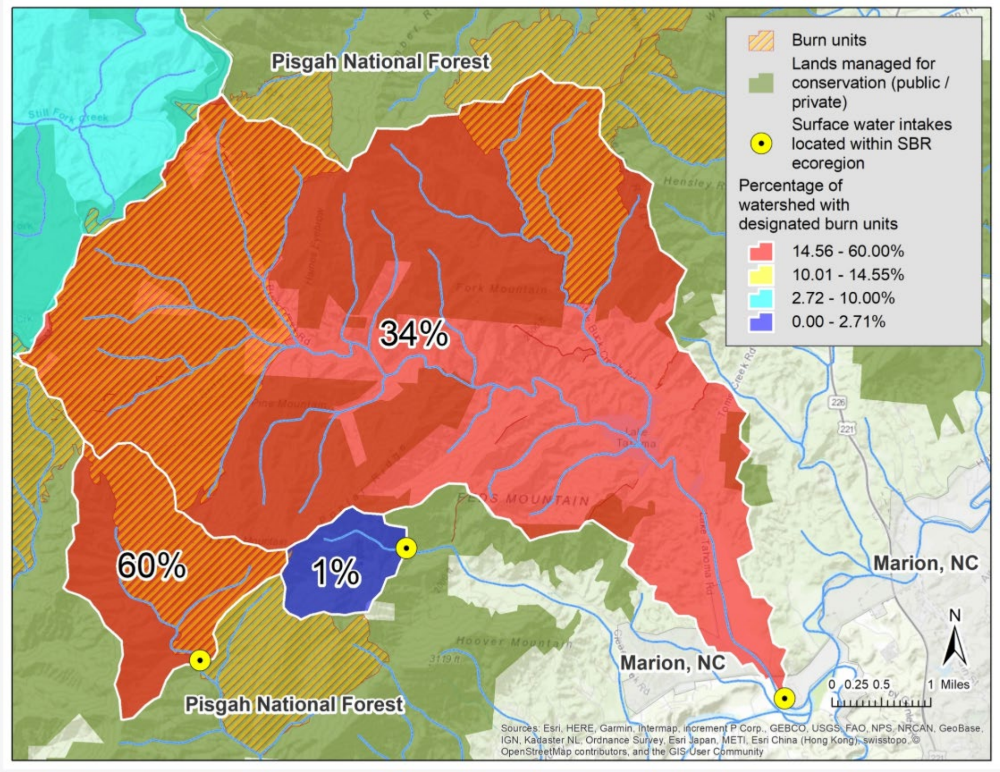
- The water quality impacts from a wildfire are much worse than a Rx fire (especially sediment and nitrate);
- A tulip poplar can use 4x the amount of water as an oak. If Rx helps keep a healthy mix of oaks, we are assisting with resilient water supplies (i.e. the amount of water);
- Aquatic species benefit from consistent water supplies and good water quality;
- Drinking water utilities also benefit from consistent water supplies and good water quality.

*We need to study all our assumptions as we do forest restoration.

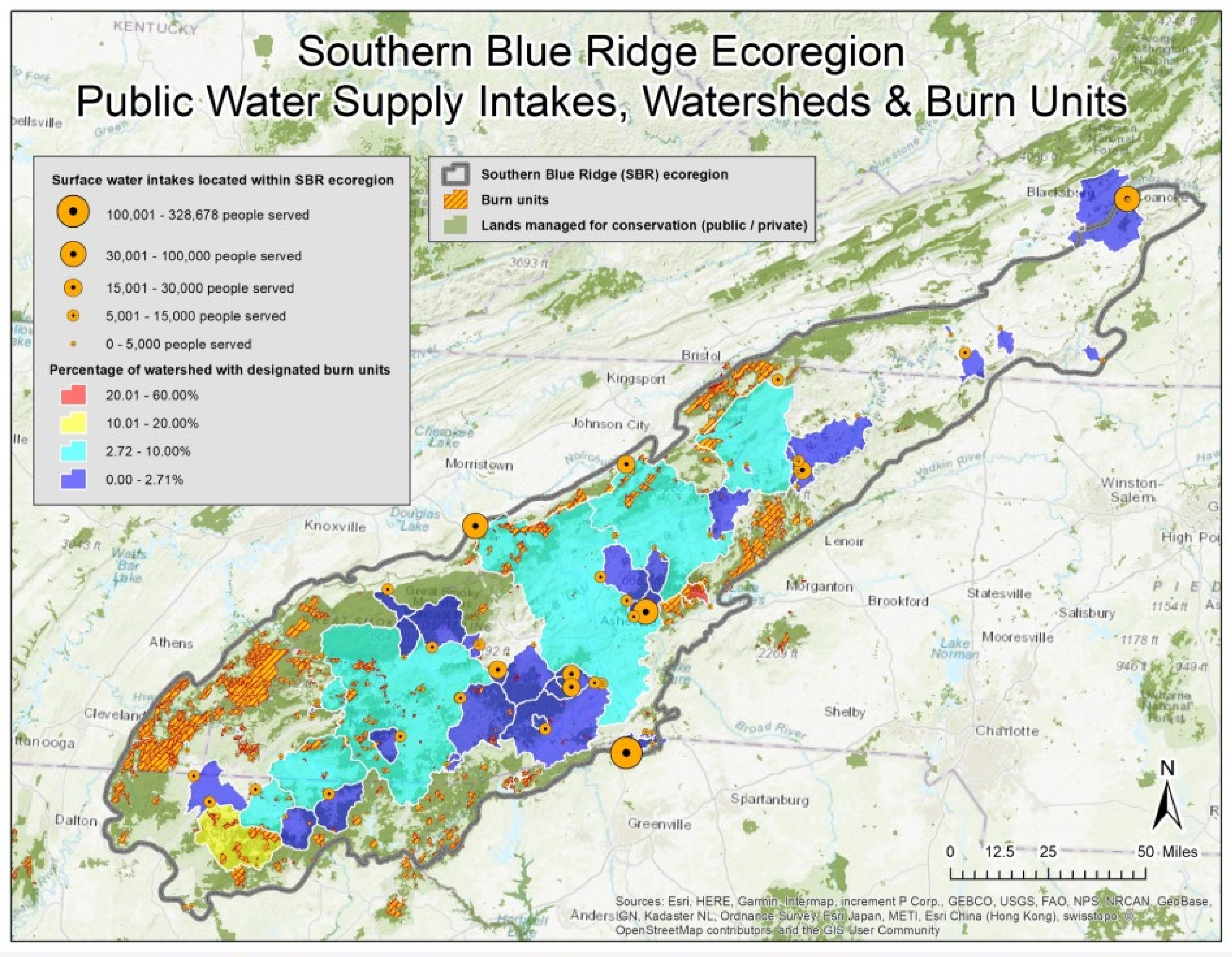
Deciding where to "burn for water"

Methods:

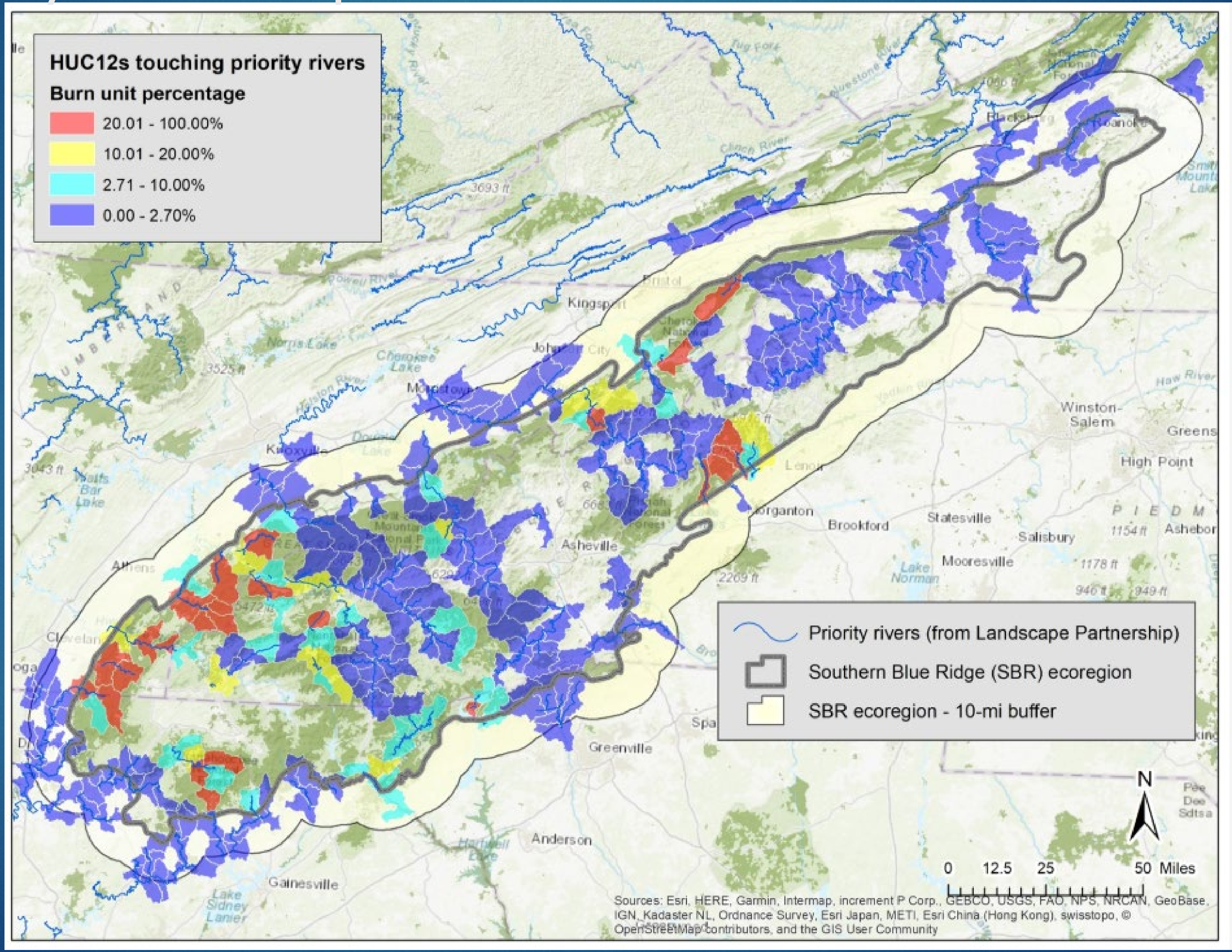
- Mapped surface drinking water intakes that served more than 25 people and had 15 service connections.
- Used GIS hydrology "pour points" to delineate the watersheds upstream of the drinking water pipes.
- Overlayed burn units, fire adapted vegetation, and conservation land.
- Calculated the percent acreage of burn units in the contributing watershed to a drinking water intake. Also calculated fire-adapted vegetation within the burn unit acreage.



Where to burn to influence drinking water



Where to burn near rivers with high biodiversity to help maintain baseflow



It requires more than maps

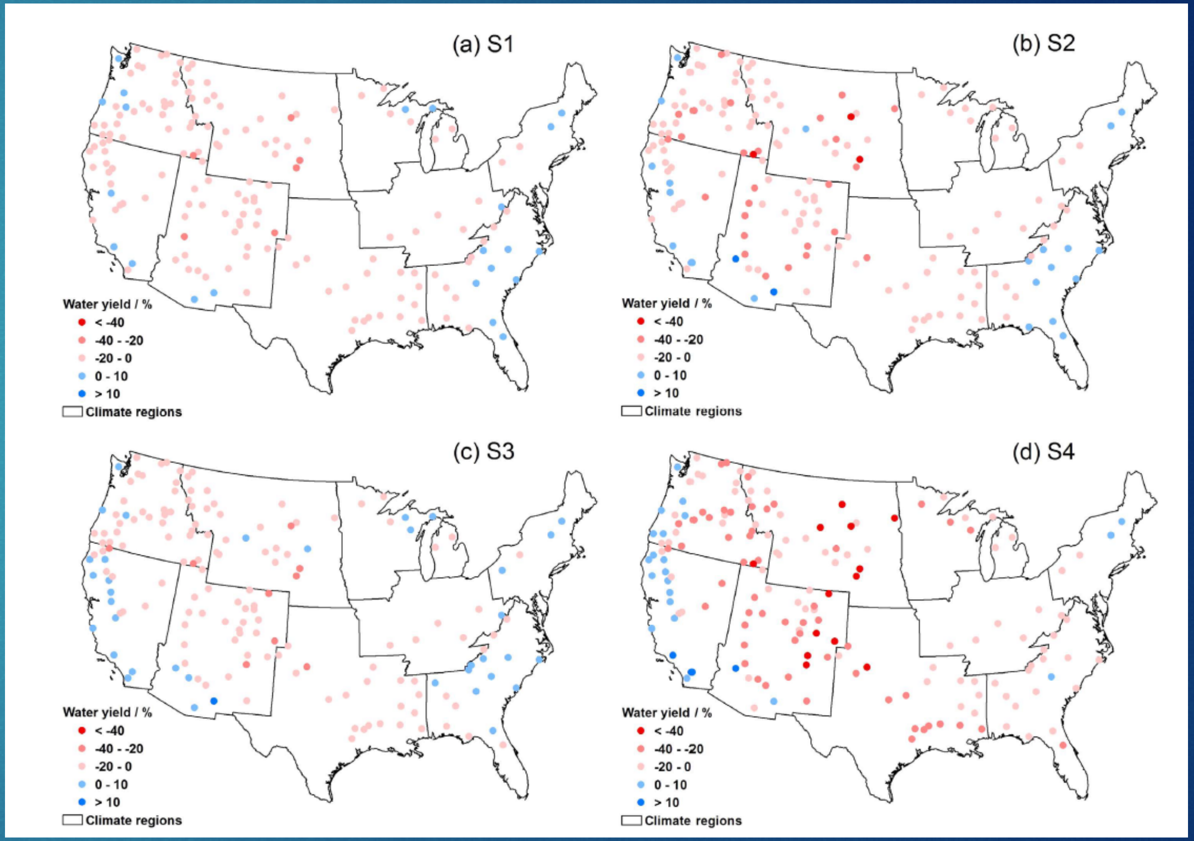
- Many water utilities are driven by the threat of poor water quality, rather than long-term water quality

- There are multiple reasons to restore forests and limited resources to restore- practitioners are still figuring out how to incorporate water

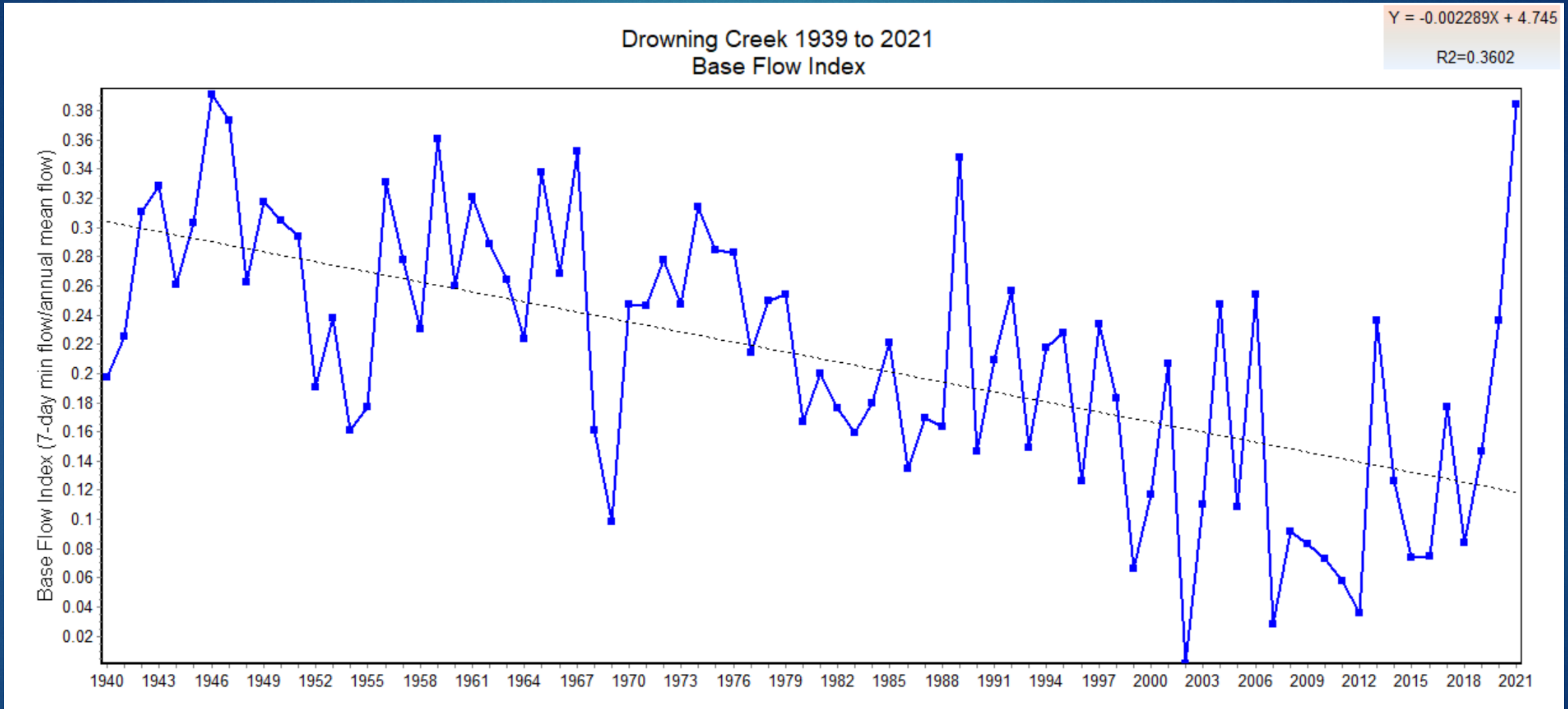
- Advanced water modeling is needed to understand how much restoration is needed.

How does this relate to the Sandhills

- In many scenarios, the Sandhills is supposed to get wetter with climate change.
  - Yet, that is on an annual basis and extreme events are likely
  - With sandy soils, the region can quickly enter a drought
- Urban growth and other factors can affect stream flows.
  - Drowning Creek shows declining baseflows
  - Smaller watersheds might also show declining flows.

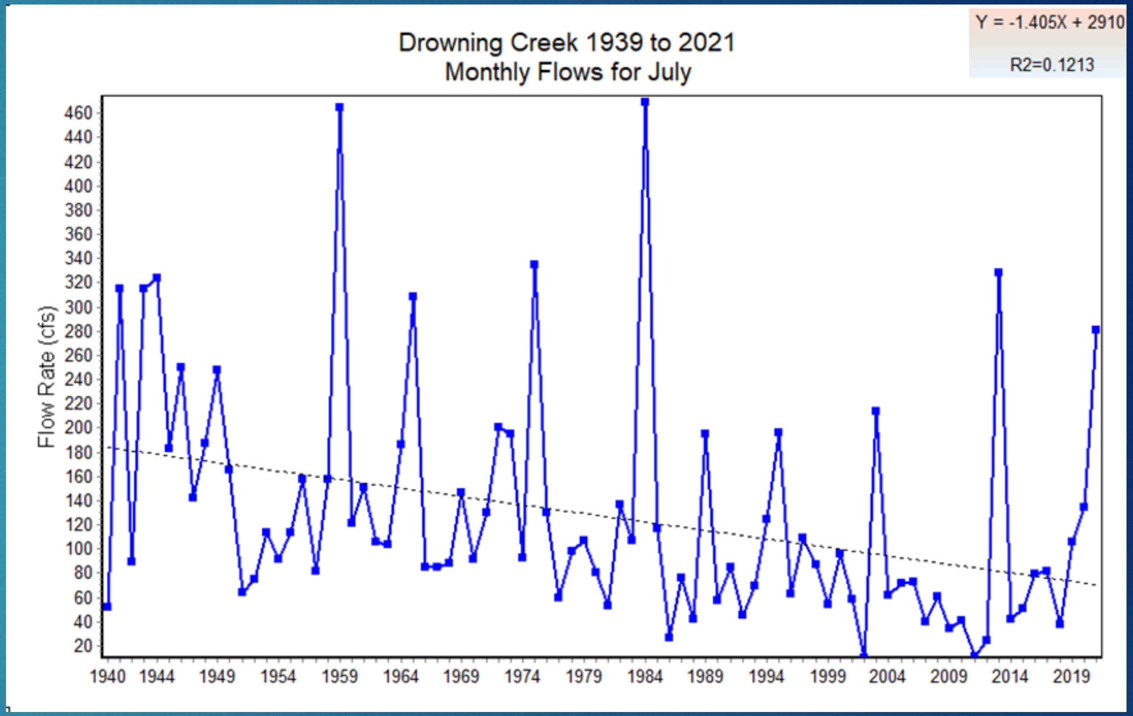


Drowning Creek



What do we need moving forward

- A decision about who we are trying to influence and an understanding of their needs:
  - A water utility? A town?
  - Water as a co-benefit to receive more grants?
  - Forestry practitioners? Landowners?
- Maps of places to restore, important aquatic species, etc
- Advanced water models that quantify forest restoration effects on stream flows specific to the Sandhills.



Group Discussion

- https://docs.google.com/presentation/d/1kuo4N1s4HBjKckZe-NR284v_KMAg-sXOXILgQjDMmBY/edit?usp=sharing
- What are some of the ideas that resonate with you from today's presentations?
- How would you intersect watershed protection and forest restoration with your work?
- What information would you need to better understand or incorporate watershed protection into your work?
- What are the incentives or levers to accomplish more watershed protection and forest restoration work?