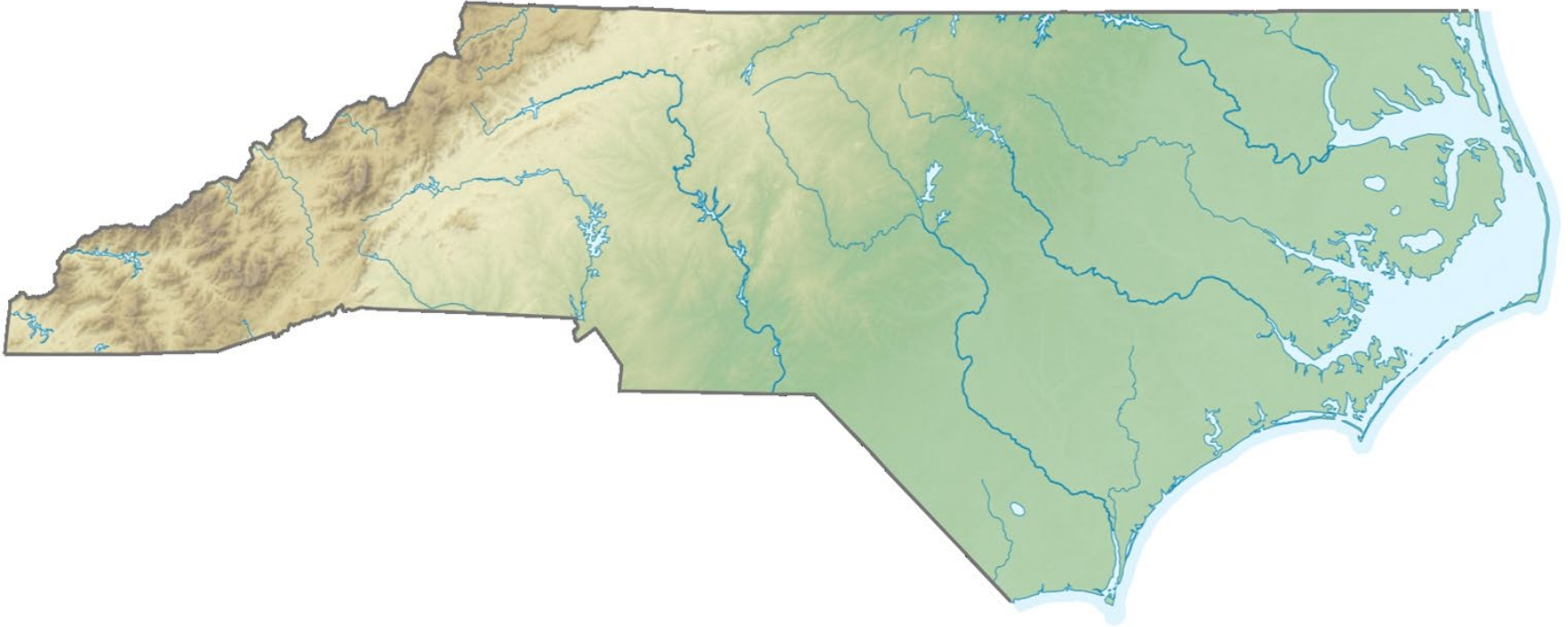


North Carolina: Environment 101

Leadership North Carolina Class XXIX

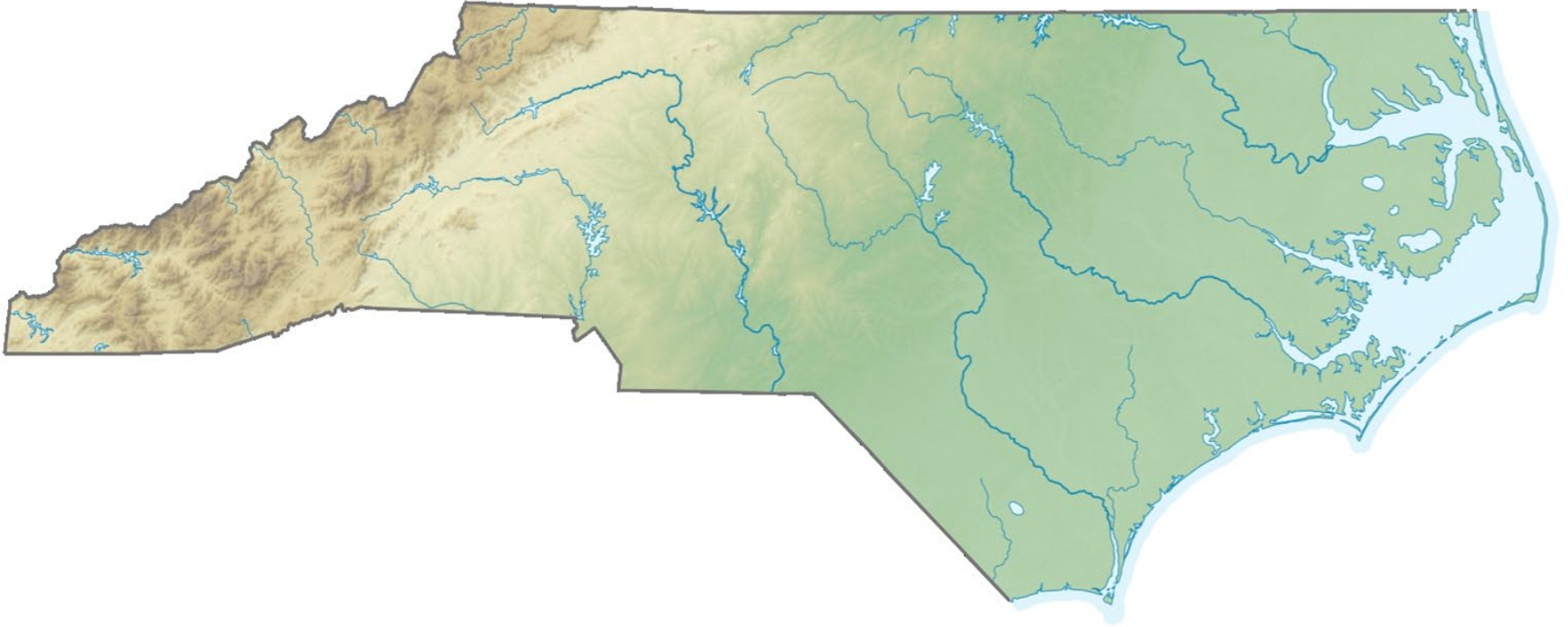
06 April 2022, Asheville NC



Dr. Amy Knisley
Environmental Studies
Warren Wilson College

Land and Water

Air and Climate



but first, a little context...

River Miles:

◆ RI 1400
29,900

◆ SC

◆ NC 37,800

◆ AK 365,000
49,300

◆ VA

~500 miles E to W

Mt. Mitchell 6,684'



53,821 miles²
90.5% land, 9.5% water
28th in land area



Persons/square mile in 2020:

1-NJ (1263)
(219)

14-VA

15-NC (215)

50-AK (1.3)

19-SC

(170)

- ◆ 301 miles of coastline (=VA + SC)
- ◆ 7th of 23 coastal states (TX=6th, OR=8th)
- ◆ 6% of U.S. shoreline (excl. AK)

River Miles:

◆ RI 1400

◆ SC

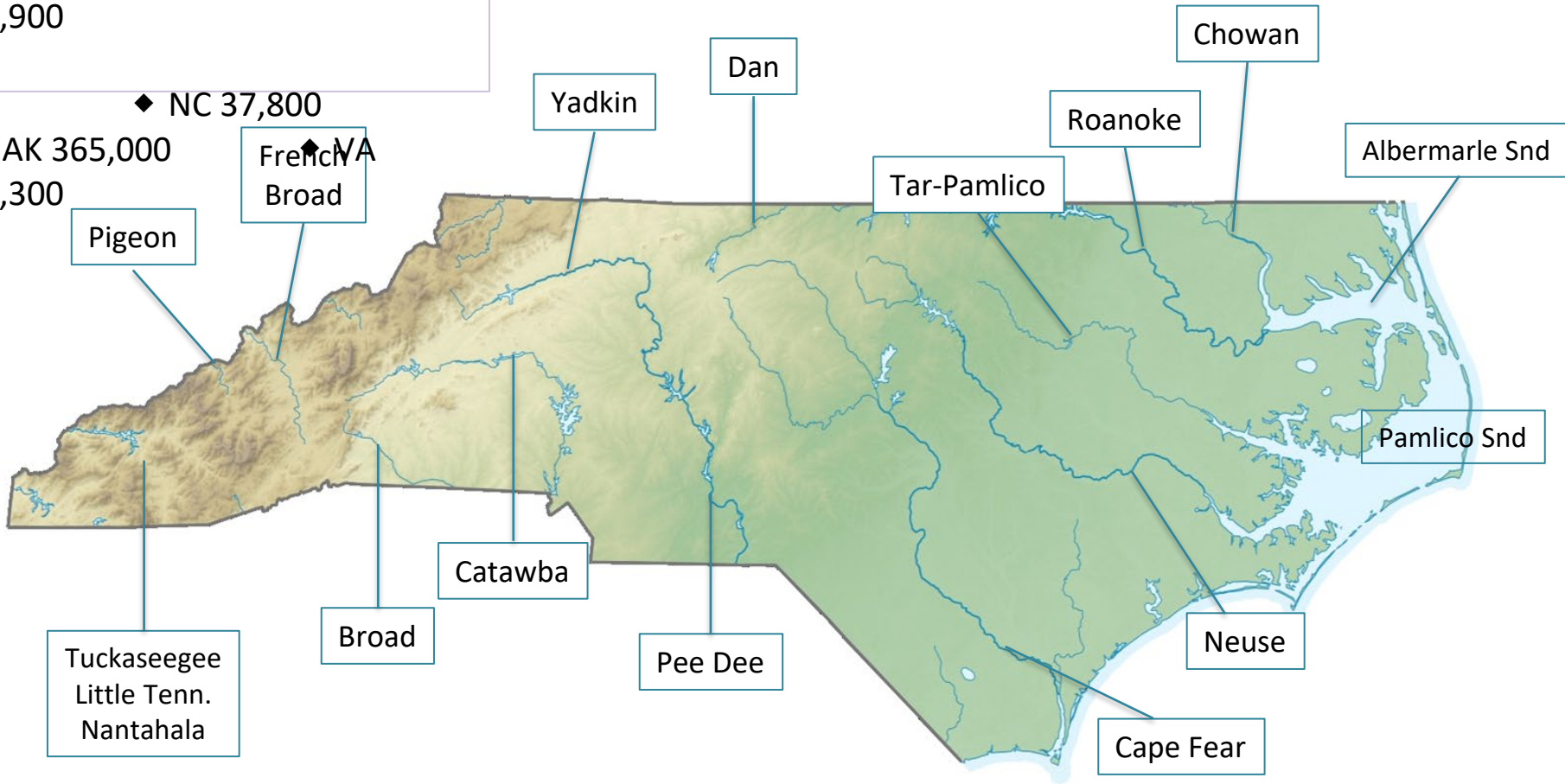
29,900

◆ NC 37,800

◆ AK 365,000

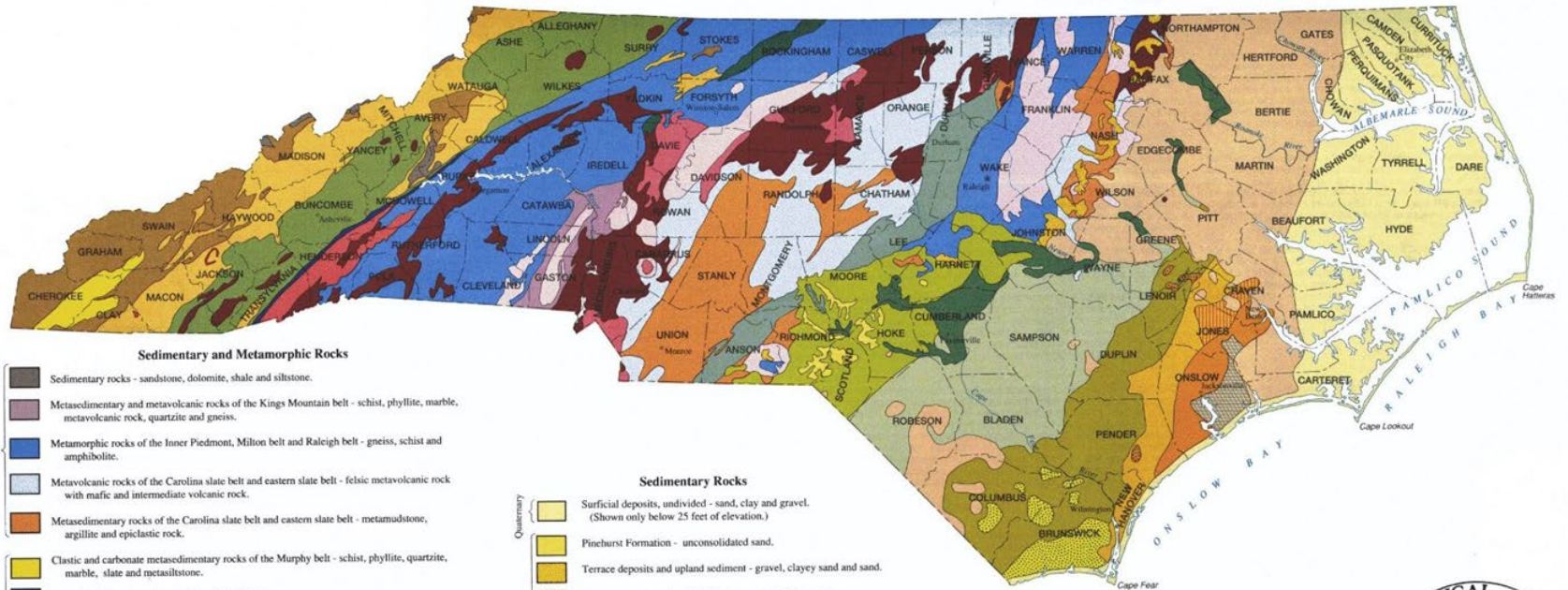
49,300

◆ VA
French Broad



“The rocks at the core of the Appalachian Mountains formed more than a billion years ago. At that time, all of the continents were joined together in a single supercontinent surrounded by a single ocean...”.

[Birth of the Mountains: The Geologic Story of the Southern Appalachian Mountains](#), US Geological Survey, c. 1998.



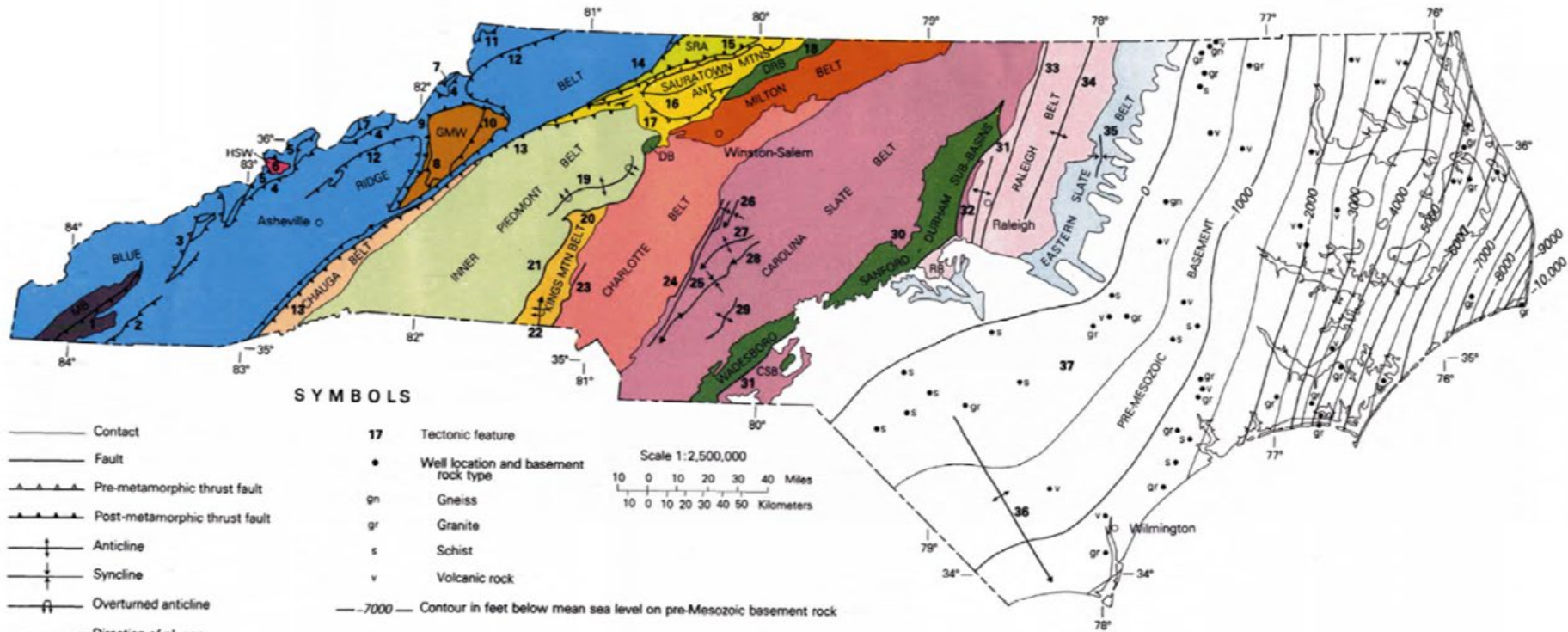
Sedimentary and Metamorphic Rocks

- Sedimentary rocks - sandstone, dolomite, shale and siltstone.
- Metasedimentary and metavolcanic rocks of the Kings Mountain belt - schist, phyllite, marble, metavolcanic rock, quartzite and gneiss.
- Metamorphic rocks of the Inner Piedmont, Milton belt and Raleigh belt - gneiss, schist and amphibolite.
- Metavolcanic rocks of the Carolina slate belt and eastern slate belt - felsic metavolcanic rock with mafic and intermediate volcanic rock.
- Metasedimentary rocks of the Carolina slate belt and eastern slate belt - metamudstone, argillite and epiclastic rock.
- Clastic and carbonate metasedimentary rocks of the Murphy belt - schist, phyllite, quartzite, marble, slate and metasilstone.
- Brevard fault zone - schist, marble and phyllonite.
- Clastic metasedimentary and metavolcanic rocks of the Ocoee Supergroup, Grandfather Mountain Formation, Mount Rogers Formation and quartzite of the Sauratown Mountains anticlinorium - slate, metasilstone, schist, metagraywacke, calc-silicate granofels, quartzite and felsic metavolcanic rock.
- Clastic metasedimentary rock and mafic and felsic metavolcanic rock of the Ashe Metamorphic Suite, Tallulah Falls Formation and Alligator Back Formation - gneiss, schist, metagraywacke, amphibolite and calc-silicate granofels.
- Felsic gneiss derived from sedimentary and igneous rocks in the northern outcrop area; biotite gneiss in the southern outcrop area; locally migmatitic and mylonitic. Locally and variably interlayered with amphibolite, calc-silicate granofels and rare marble, intruded by Late Proterozoic mafic and felsic plutons.

Sedimentary Rocks

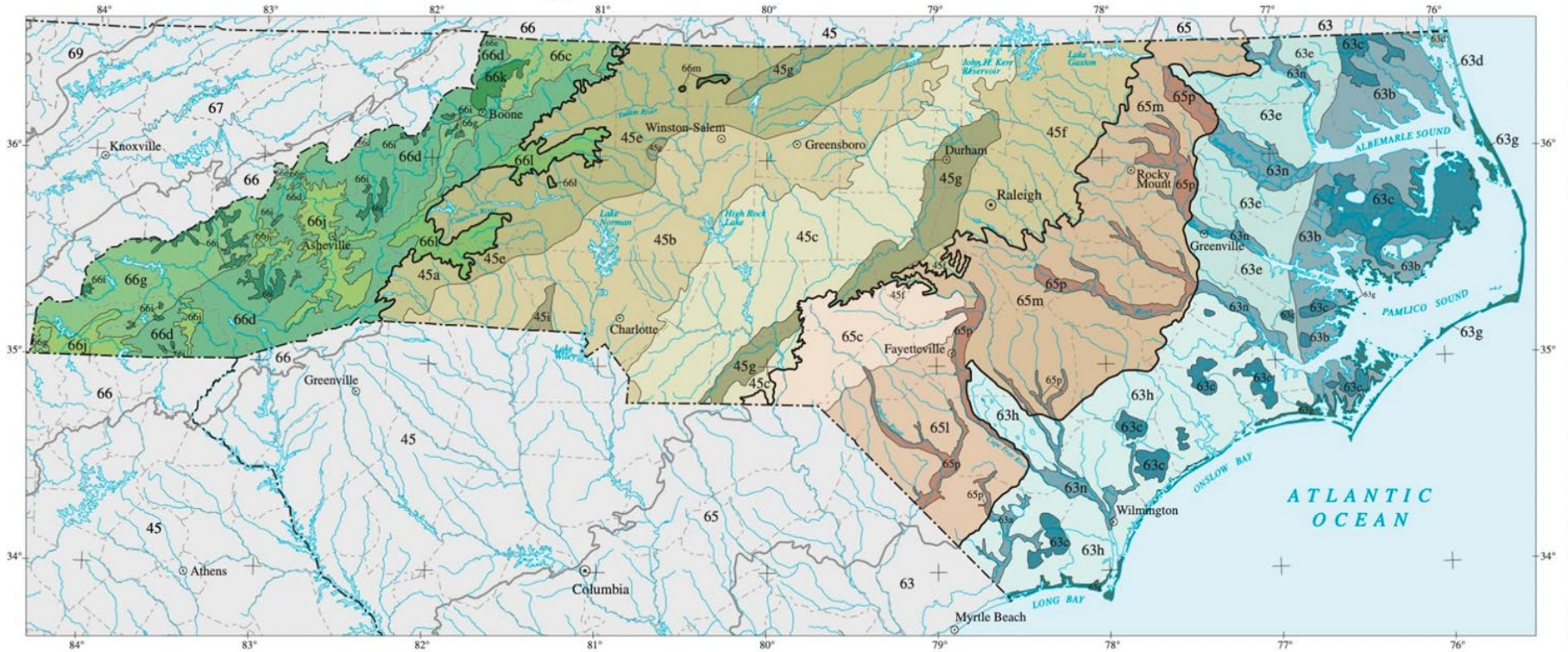
- Surficial deposits, undivided - sand, clay and gravel. (Shown only below 25 feet of elevation.)
- Pinchurst Formation - unconsolidated sand.
- Terrace deposits and upland sediment - gravel, clayey sand and sand.
- Waccamaw Formation - fossiliferous sand with silt and clay.
- Yorktown Formation and Duplin Formation, undivided - Yorktown Formation- fossiliferous clay and sand. Duplin Formation- shelly sand, sandy marl and limestone.
- Belgrade Formation, undivided - Pollockville Member- oyster-shell mounds in sand matrix. Haywood Landing Member- fossiliferous clayey sand.
- River Bend Formation - sandy, molluscan-mold limestone.
- Castle Hayne Formation - Spring Garden Member- molluscan-mold limestone.
- Comfort Member and New Hanover Member, undivided -
- Dan River Group, undivided - Stoneville Formation - conglomerate, sandstone and mudstone. Cow Branch Formation - mudstone. Pine Hall Formation - sandstone, mudstone and conglomerate.
- Chatham Group, undivided - Sanford Formation - conglomerate, sandstone and mudstone. Cummock Formation - sandstone and mudstone. Pekin Formation - conglomerate, sandstone and mudstone.





MAP SHOWING MAJOR LITHO-TECTONIC FEATURES

Ecoregions of North Carolina



45 Piedmont

- 45a Southern Inner Piedmont
- 45b Southern Outer Piedmont
- 45c Carolina Slate Belt
- 45e Northern Inner Piedmont
- 45f Northern Outer Piedmont
- 45g Triassic Basins
- 45i Kings Mountain

63 Middle Atlantic Coastal Plain

- 63b Chesapeake-Pamlico Lowlands and Tidal Marshes
- 63c Nonriverine Swamps and Peatlands
- 63d Virginian Barrier Islands and Coastal Marshes
- 63e Mid-Atlantic Flatwoods
- 63g Carolinian Barrier Islands and Coastal Marshes
- 63h Carolina Flatwoods
- 63n Mid-Atlantic Floodplains and Low Terraces

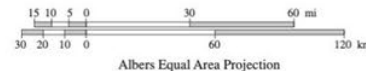
65 Southeastern Plains

- 65c Sand Hills
- 65l Atlantic Southern Loam Plains
- 65m Rolling Coastal Plain
- 65p Southeastern Floodplains and Low Terraces

66 Blue Ridge

- 66c New River Plateau
- 66d Southern Crystalline Ridges and Mountains
- 66e Southern Sedimentary Ridges
- 66g Southern Metasedimentary Mountains
- 66i High Mountains
- 66j Broad Basins
- 66k Amphibolite Mountains
- 66l Eastern Blue Ridge Foothills
- 66m Sauratown Mountains

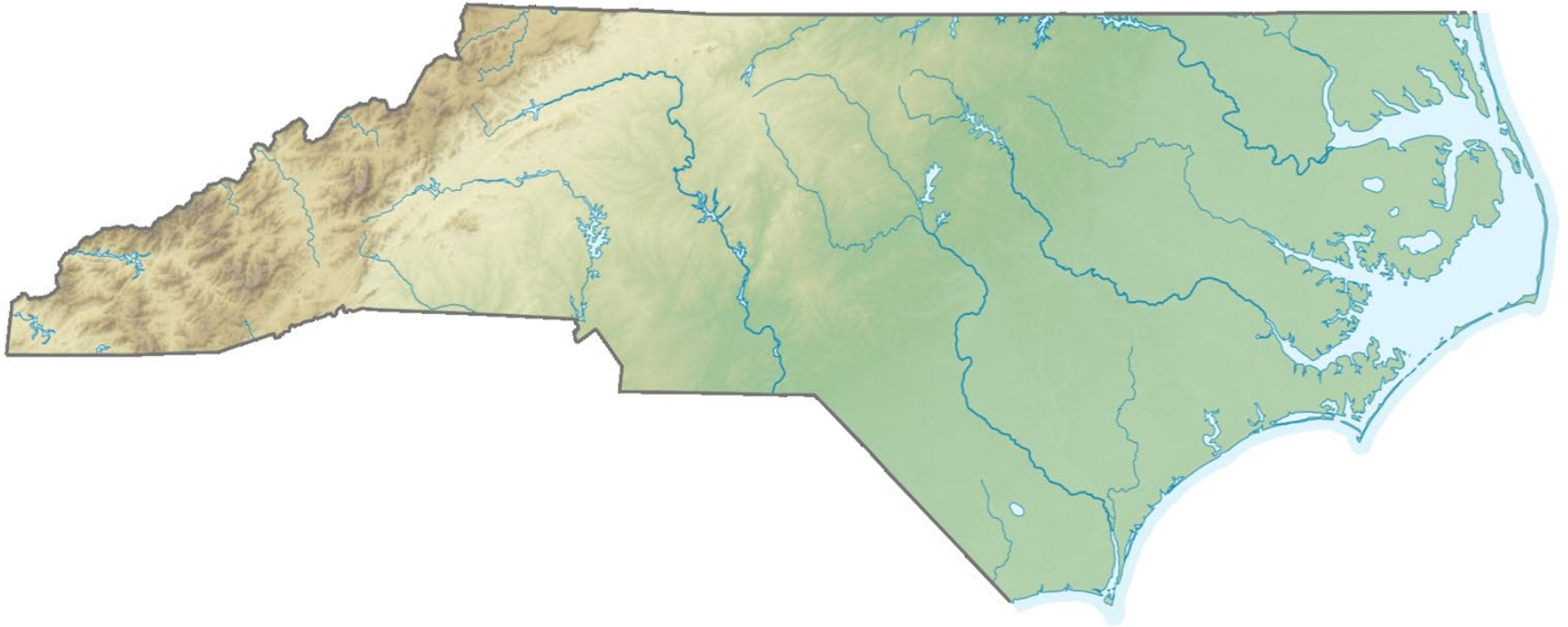
- Level III ecoregion
- Level IV ecoregion
- - - County boundary
- - - State boundary




Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. The approach used to compile this map is based on the premise that ecological regions can be identified through the analysis of the patterns of biotic and abiotic phenomena that reflect differences in ecosystem quality and integrity. These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The relative importance of each characteristic varies from one ecological region to another regardless of the hierarchical level. The Ecoregions of North Carolina map was compiled at a scale of 1:250,000. Compilation of this map is part of a collaborative project primarily between the US EPA, USDA-NRCS, NC DENR, as well as with other state and federal agencies. Comments and suggestions regarding this map should be addressed to Glenn Griffith, USDA-NRCS, 200 SW 35th Street, Corvallis, OR 97333, (541) 754-4465, email: griffith.glenn@epa.gov, or to James Omernik, U.S. EPA - NHEERL, 200 SW 35th Street, Corvallis, OR 97333, (541) 754-4458, email: omernik.james@epa.gov.

Land and Water


Air and Climate






Eastern Cougar
(*Felis concolor*)


extinct



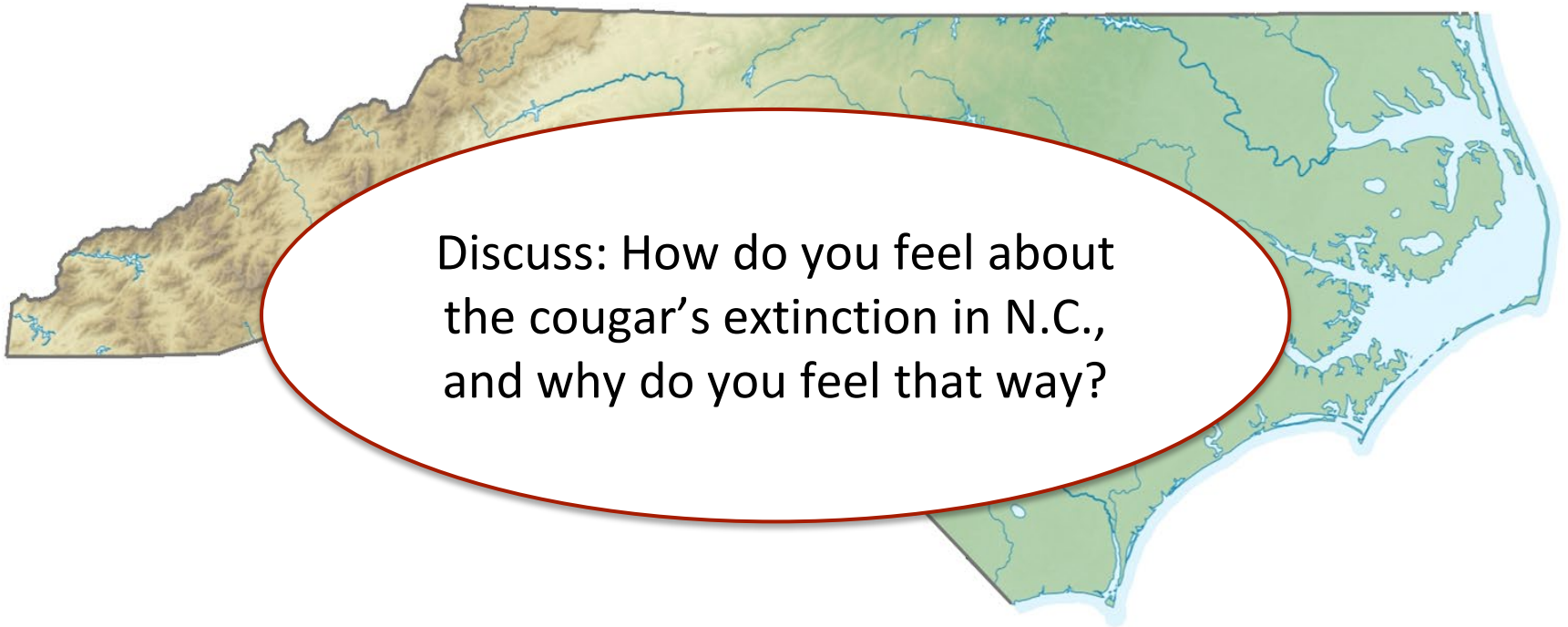
“Cougars were extirpated from North Carolina in the late 1800s, and since then, there has been no substantiated evidence of wild cougars living anywhere in the state. However, the NCWRC still periodically receives reports from the public about sightings of cougars or cougar tracks. Investigations into these sightings by NCWRC biologists reveal that they are nearly always misidentifications of both domestic and wild animals.”



Diamondback Terrapin
(*Malaclemys terrapin*)

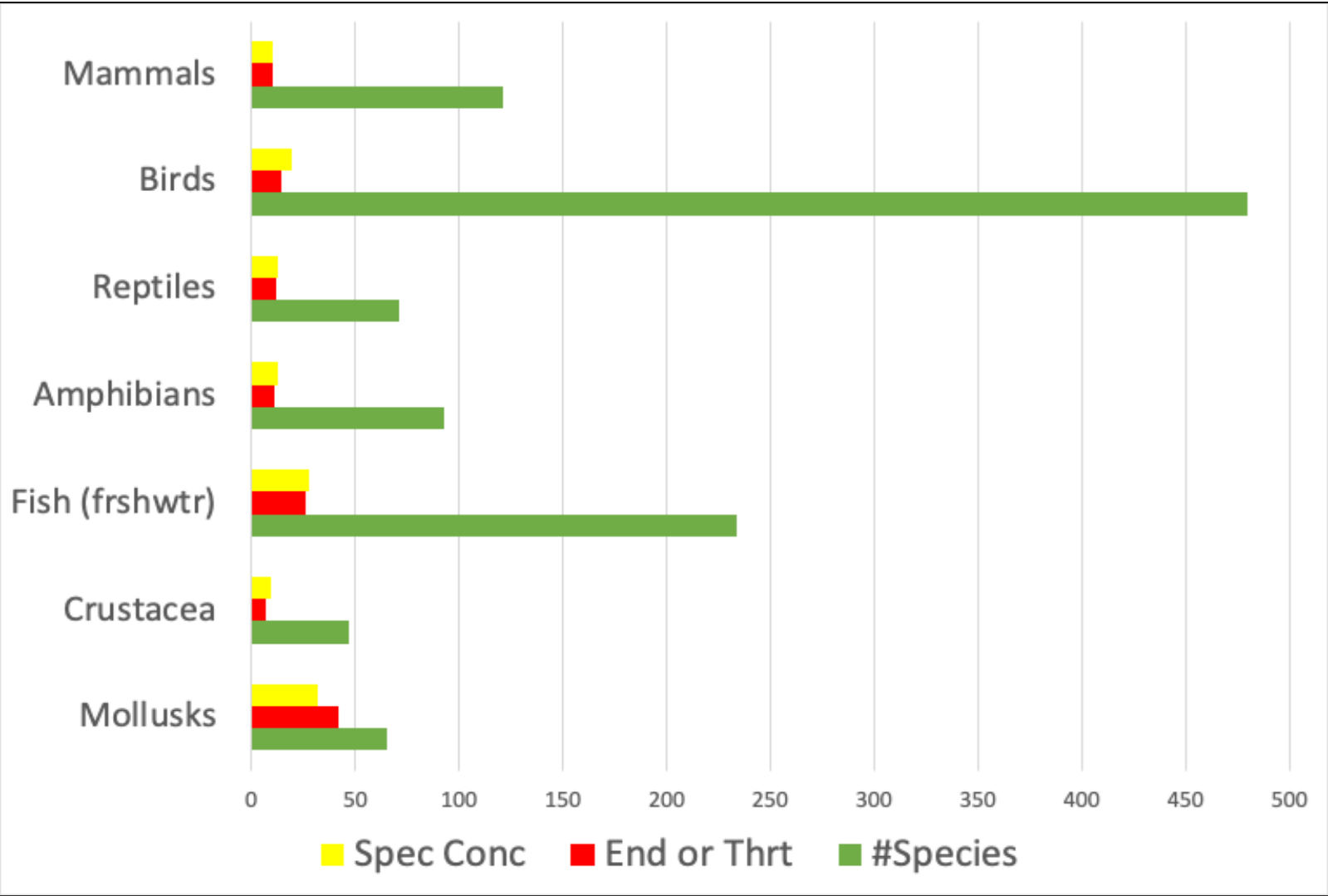


Great Blue Heron
(*Egretta thula*)



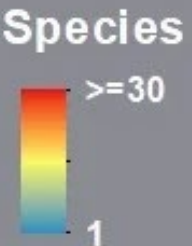
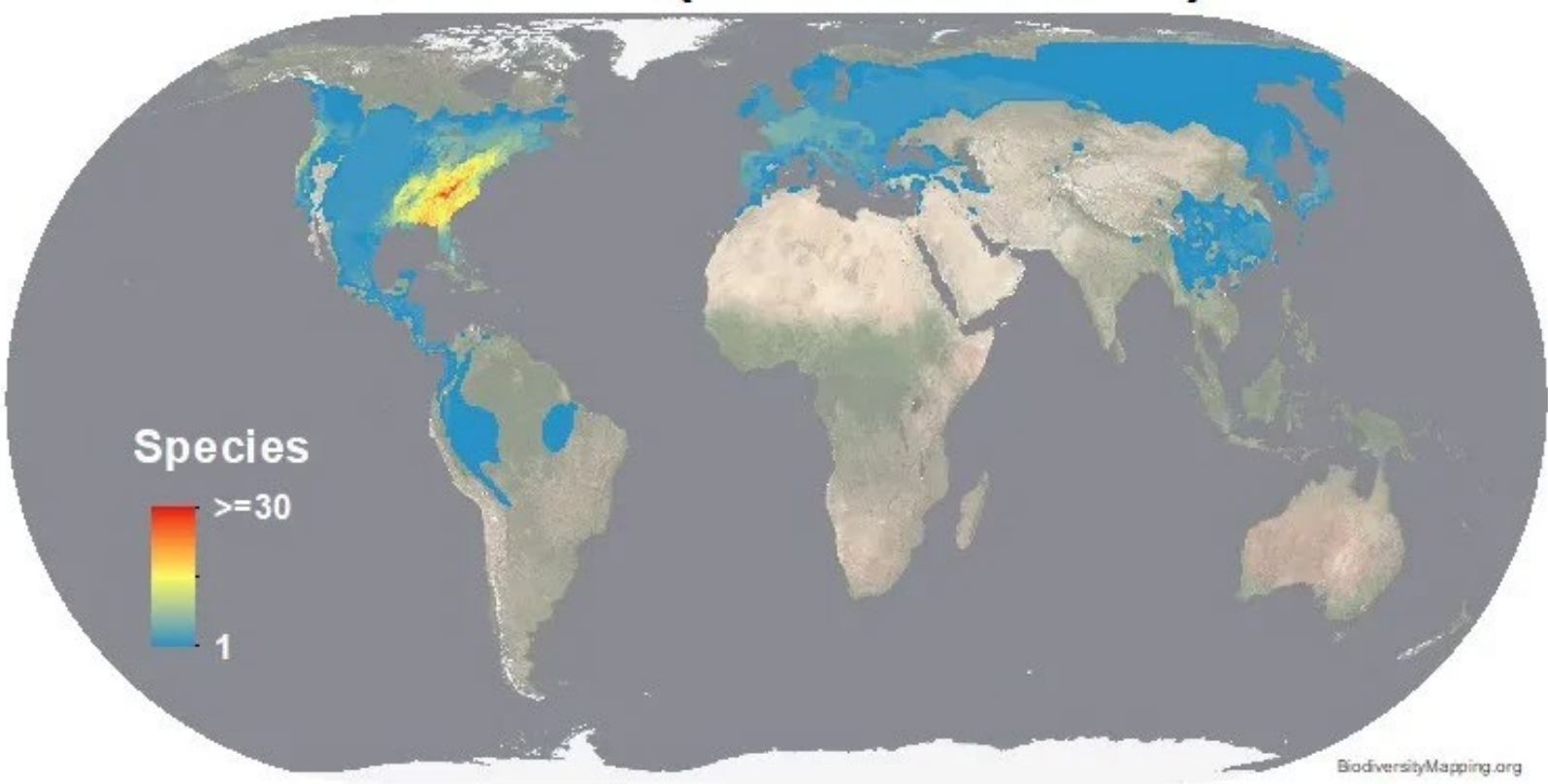
Discuss: How do you feel about the cougar's extinction in N.C., and why do you feel that way?

Of 1111 species total in these groups, 246 (22%) are either Endangered, Threatened, or of Special Concern



Biodiversity Hotspots
Conservation Priorities

Caudata (Salamanders)



- 1. E
- 2. Sa
- 3. C
- 4. T
- exc
- rept
- 5. FI
- 6. FI
- 7. K
- 8. S
- 9. C
- Data
- Acad

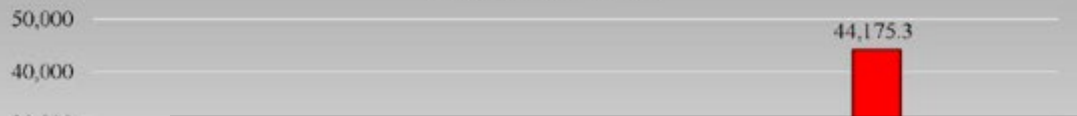
- 1 - 3
- 3 - 6
- 6 - 9
- 9 - 12
- 21 - 24
- 24 - 27
- >27

ential

al

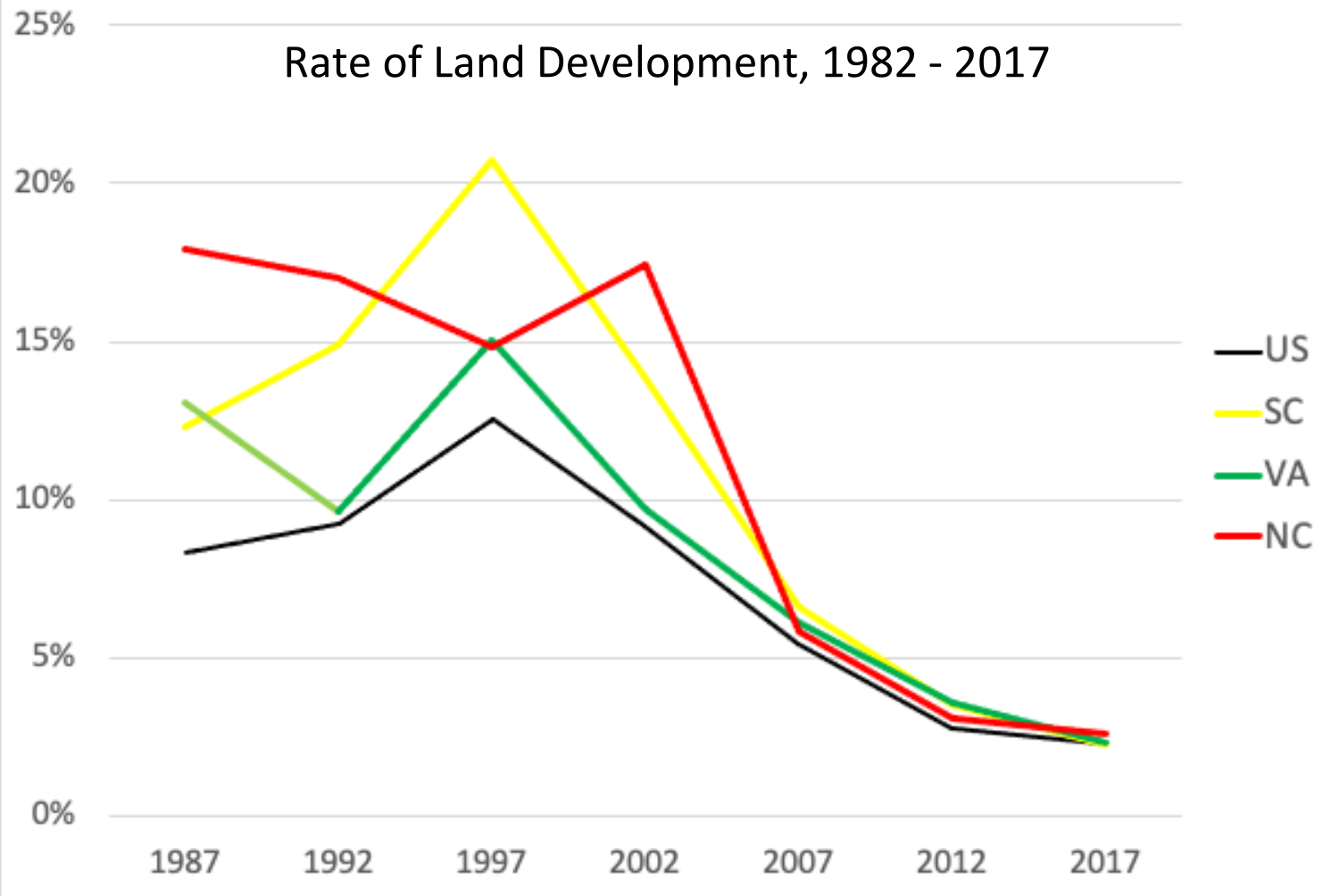
Land Use

Net Change in Land Cover/Use Between 1982 and 2017
Thousands of Acres

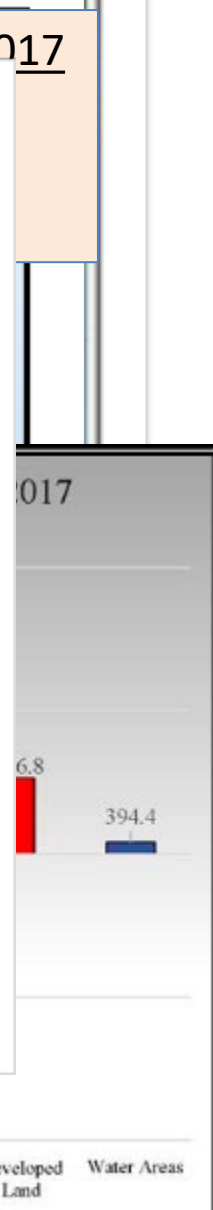


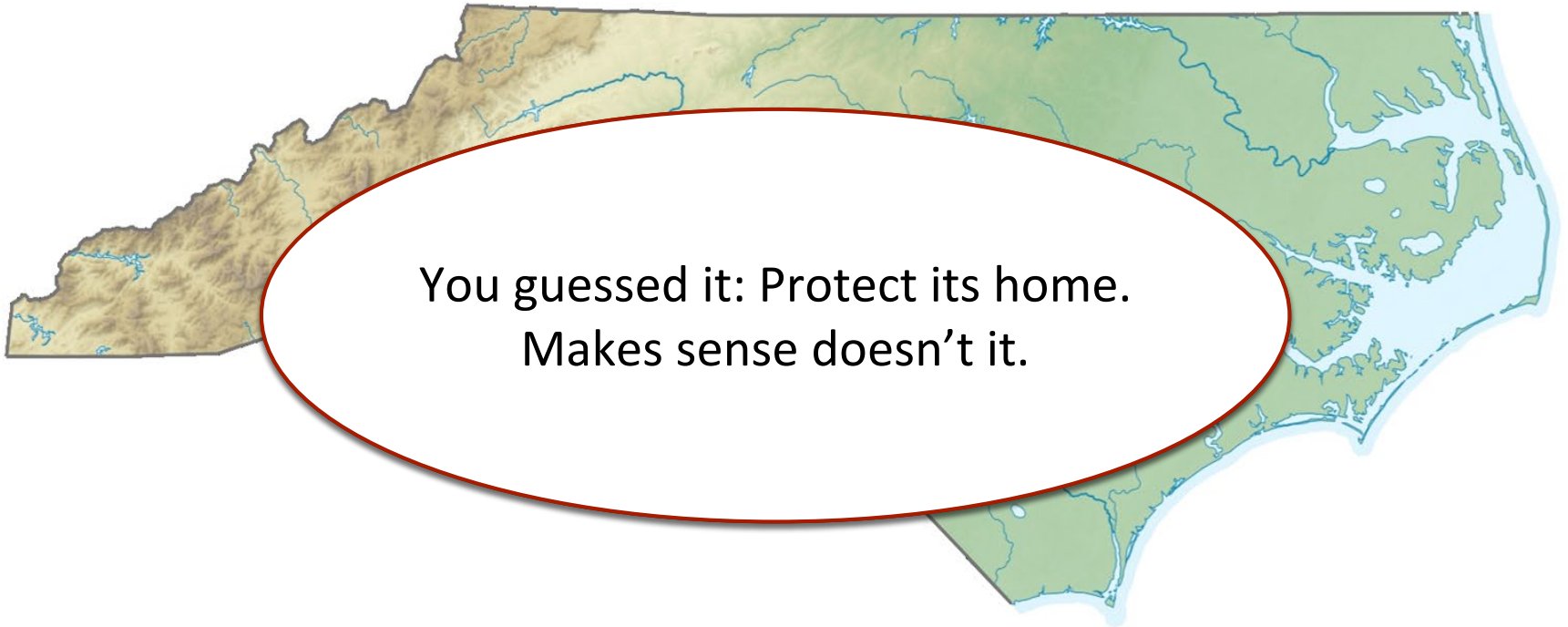
Developed land 1982-2017

Rate of Land Development, 1982 - 2017



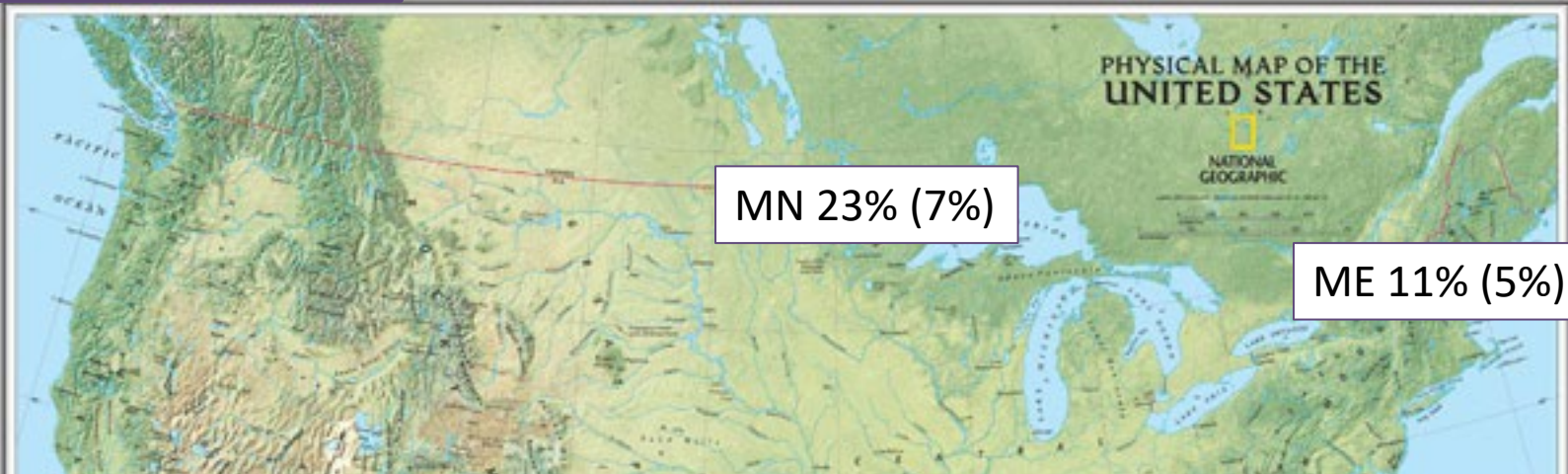
- US
- SC
- VA
- NC



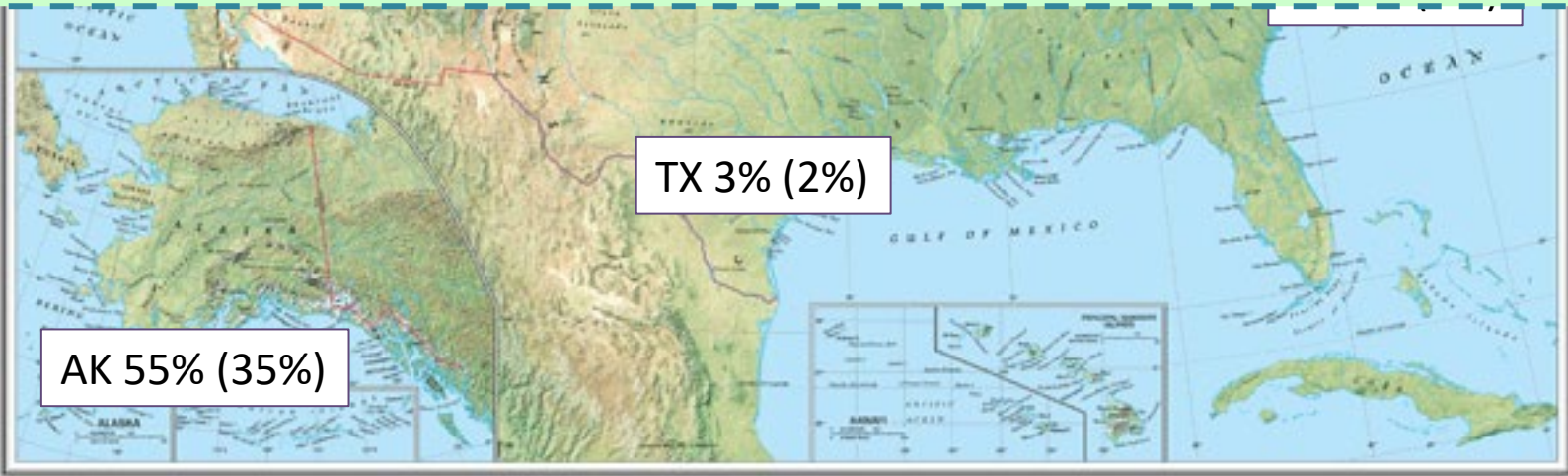


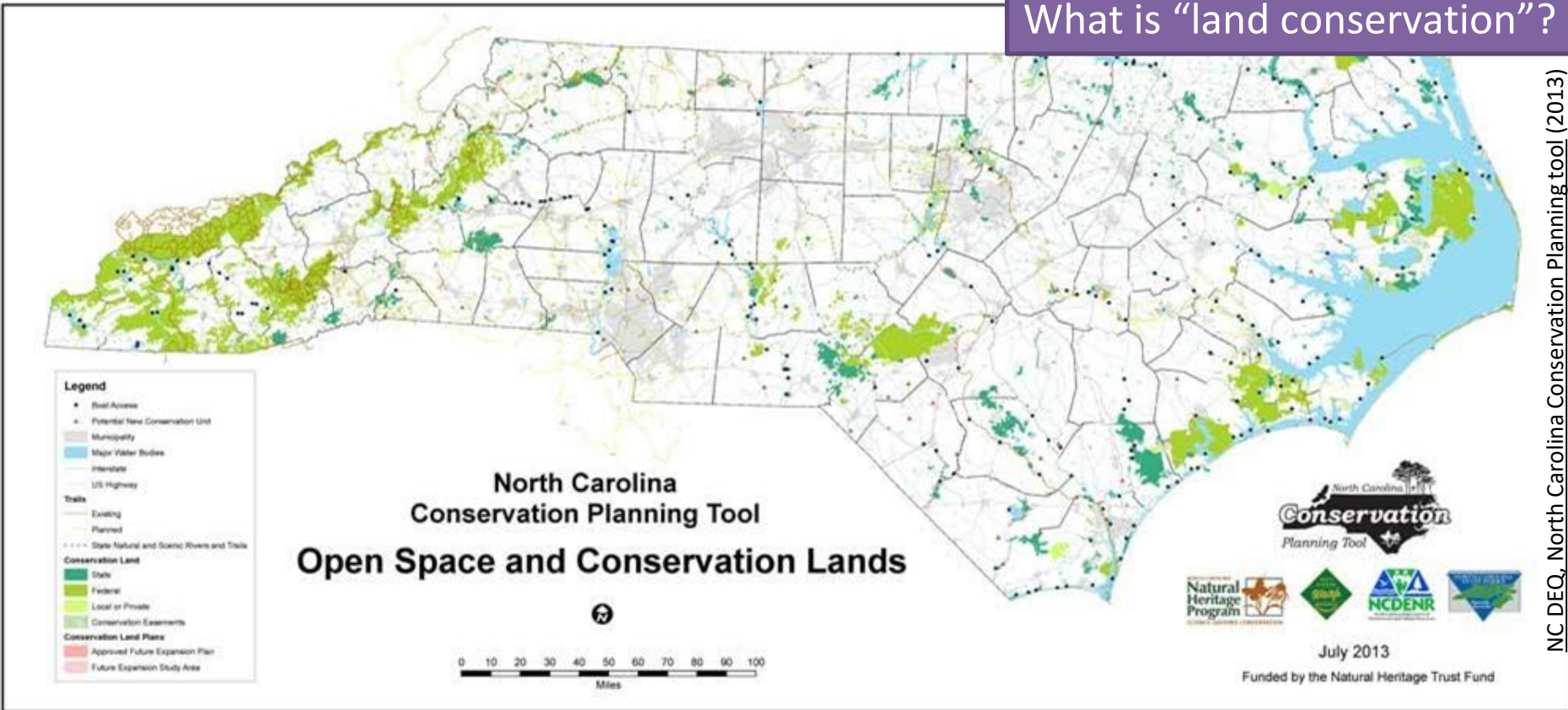
You guessed it: Protect its home.
Makes sense doesn't it.

Protected Land, 2017



“...15-30% of the land in any state or ecoregion will need to be [protected] in order for our native biodiversity to be effectively conserved.” *Conservation in America: A Status Report*. Defenders of Wildlife (2002)





2018 NC land conservation trust fund awards:

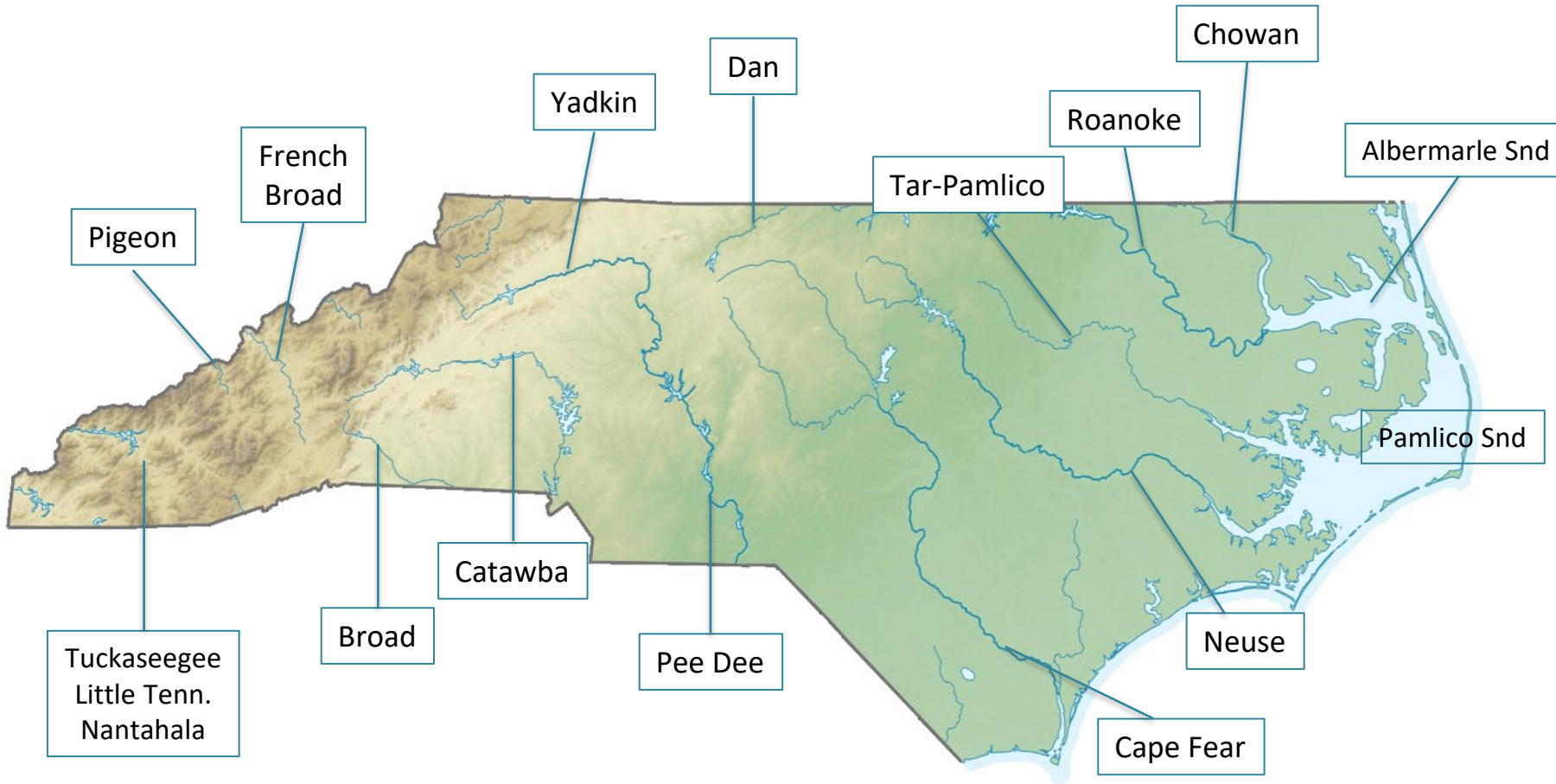
- ❖ Clean Water Management (\$24.6m; \$65m req. FY19)
- ❖ Parks and Recreation (\$28.3m (FY17))
- ❖ Agricultural Dev. & Farmland Preservation (\$4.6m)

NC Natl Wild and Scenic Rivers:

- ❖ New, Chattooga, Lumber, and Horsepasture
- ❖ Over 100 eligible rivers.

In FY 2008 the trust funds had \$289 million available. Funding levels crashed until FY 2013, which saw modest increases. Total FY 2018 funding for the the three trust funds was about \$42.5 million, and FY 2019 funding is \$32.5m. Conservation Trust for NC, 2018.

Land and Water



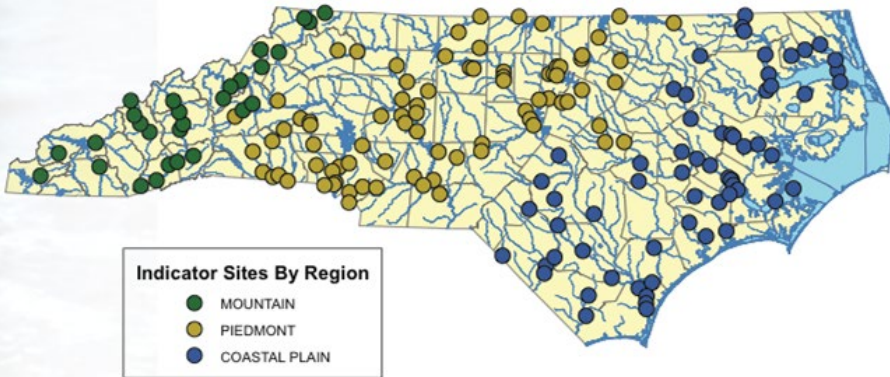
Point source program:
National Pollution Discharge Elimination System permits.

Ambient program:
Ambient water quality standards, based on use classification.

Duke Power Asheville Plant NPDES permit (2006) re "Outfall 001" (Ash Pond Treatment System)

EFFLUENT CHARACTERISTICS	LIMITS	
	Monthly Average	Daily Maximum
Flow		
Oil and Grease	15.0 mg/L	20.0 mg/L
Total Suspended Solids	30.0 mg/L	100.0 mg/L
pH	6 ≤ pH ≤ 9	
Total Arsenic		
Total Selenium ²		
Total Copper		
Total Nitrogen (NO ₂ +NO ₃ +TKN)		
Total Phosphorus		
Chronic Toxicity ³		

Map 2: Water Quality Sampling Sites Across the State

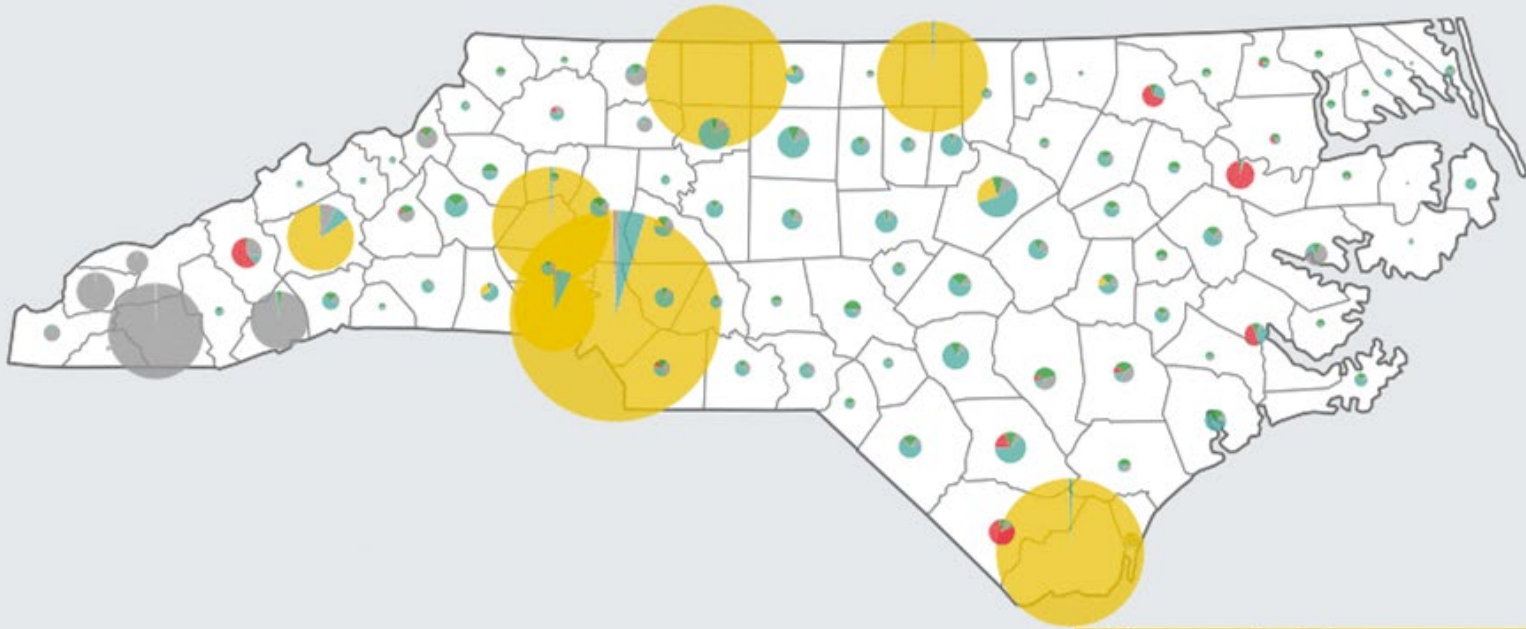


Key pollutants:
Sediment, Nutrients, Metals, Oil and Grease, Toxins, Pathogens

Key sources:
Land disturbance; Agriculture;
Impermeable surfaces; Waste water

Water quality is managed under the framework of the 1972 Clean Water Act

North Carolina water use by category, 2015



North Carolina
(water withdrawals, million gallons per day)

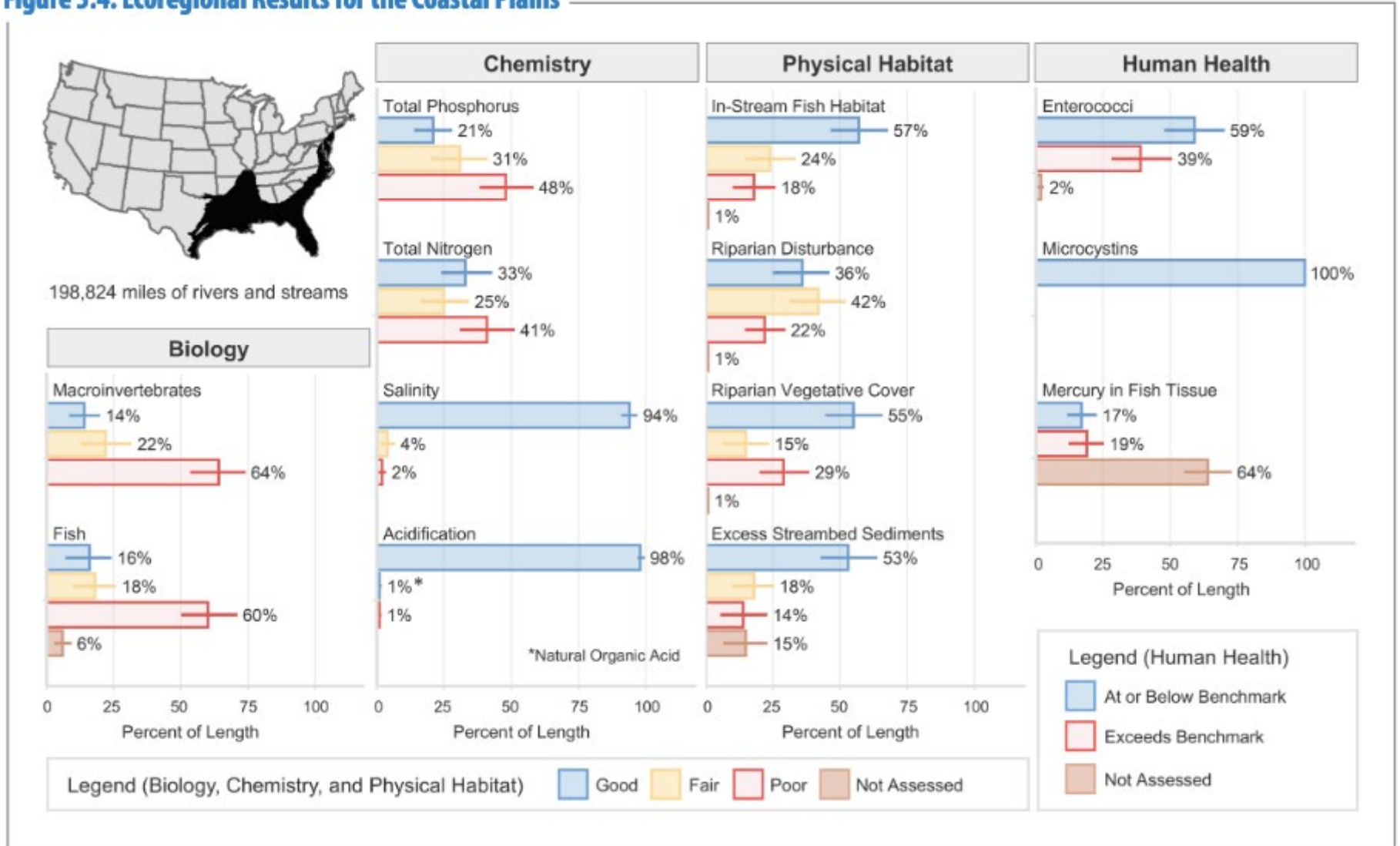
Thermoelectric	7,539
Other	1,277
Public supply	938
Irrigation	325
Industrial	193



<https://owi.usgs.gov/vizlab/water-use-15/>

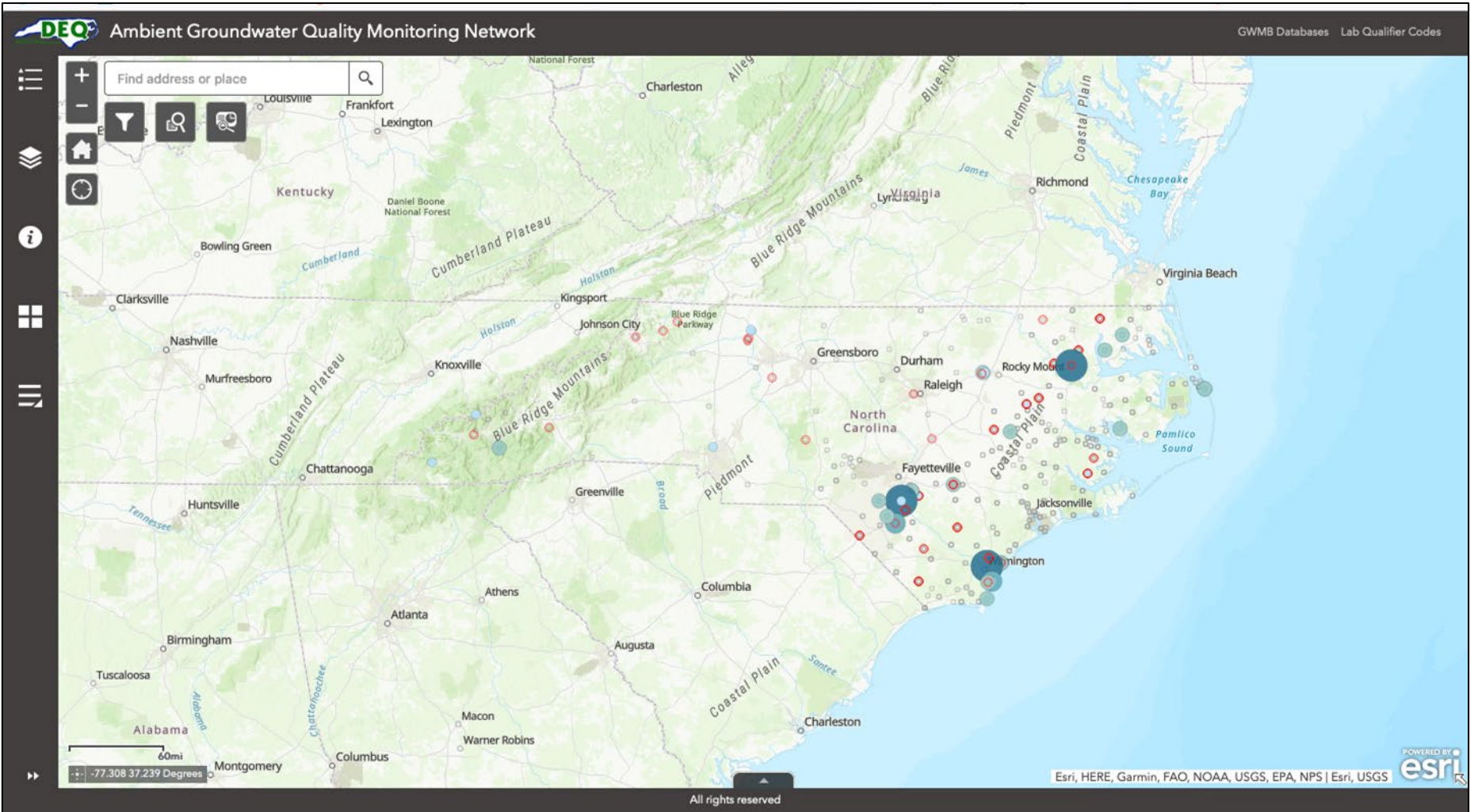
EPA National Rivers and Streams Assessment, 2013-2014

Figure 5.4. Ecoregional Results for the Coastal Plains



And then there's **groundwater**.

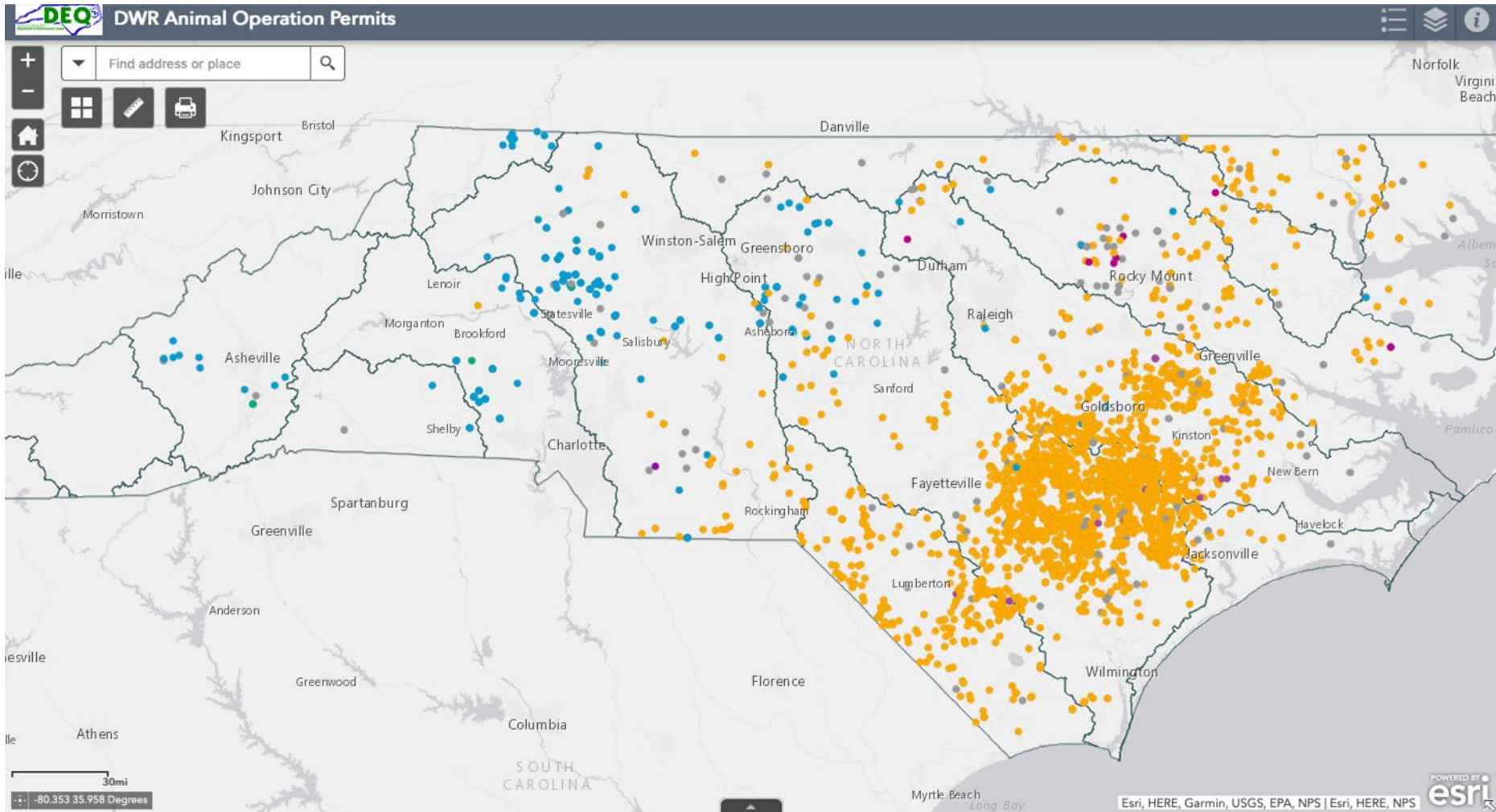
14% of NC residents drink from public supply wells; 36% from domestic wells.



NB: [NC DEQ 25 March 2022 Press Release re: Groundwater contamination from Chemours plant.](#)

NC DEQ Division of Water Resources, [Ambient Groundwater Quality Monitoring Network](#) (2022)
US Geological Survey [National Water Dashboard](#).

Concentrated Animal Feeding Operations stress streams in the east.



NC DEQ Division of Water Resources, [Animal Feeding Operations Map](#) (2022)

NC DEQ Division of Water Resources, [Data, Statistics and Maps](#)

NC DEQ DWR monitors surface water quality. About 13,700 “Assessment Units” (stream segments, lakes, etc.) are sampled on a rolling basis. According to the latest data, approximately 3,750 AUs are “impaired.”

Figure 3: Overall

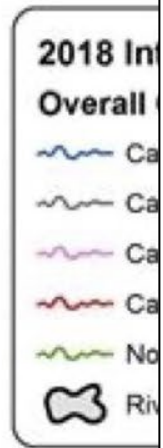
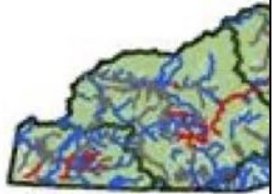
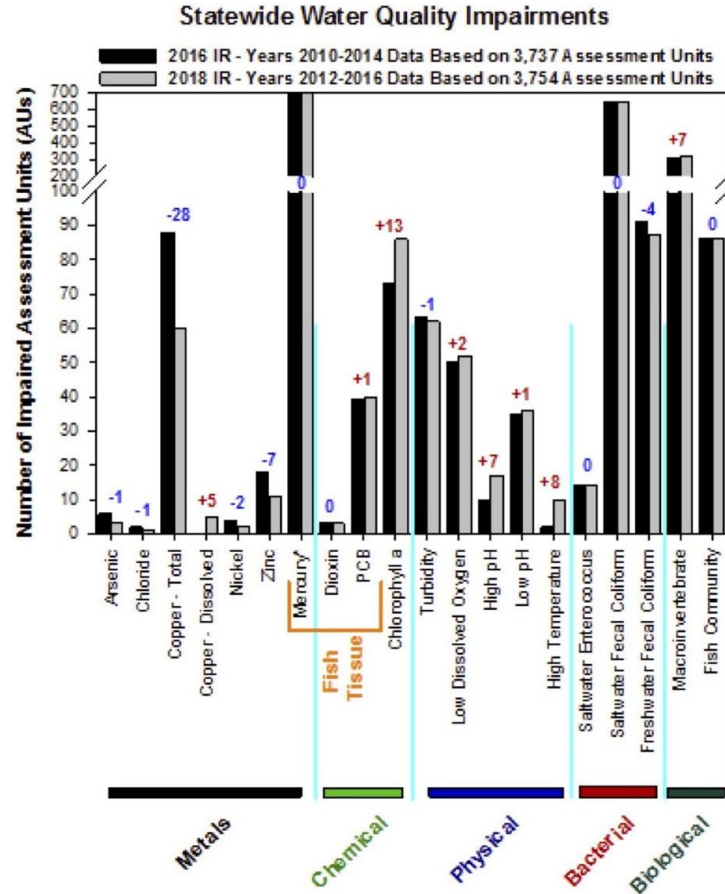


Figure 4: Statewide Water Quality Impairments (Exceeding Criteria) for Integrated Reporting (IR) Years 2016 and 2018



d Report



Enter: A WWC hope squad!



Land and Water

Air and Climate



But first: break time!

National Ambient Air Quality Standards: Six “Criteria Pollutants”

Pollutant [links to historical tables of NAAQS reviews]	Primary/ Secondary	Averaging Time	Level	
Carbon Monoxide (CO)	primary	8 hours	9 ppm	
		1 hour	35 ppm	
Lead (Pb)	primary and secondary	Rolling 3 month average	0.15 µg/m ³ ⁽¹⁾	
Nitrogen Dioxide (NO₂)	primary	1 hour	100 ppb	
	primary and secondary	1 year	53 ppb ⁽²⁾	
Ozone (O₃)	primary and secondary	8 hours	0.070 ppm ⁽³⁾	
Particle Pollution (PM)	PM _{2.5}	primary	1 year	12.0 µg/m ³
		secondary	1 year	15.0 µg/m ³
		primary and secondary	24 hours	35 µg/m ³
	PM ₁₀	primary and secondary	24 hours	150 µg/m ³
Sulfur Dioxide (SO₂)	primary	1 hour	75 ppb ⁽⁴⁾	
	secondary	3 hours	0.5 ppm	

Hazardous Air Pollutants

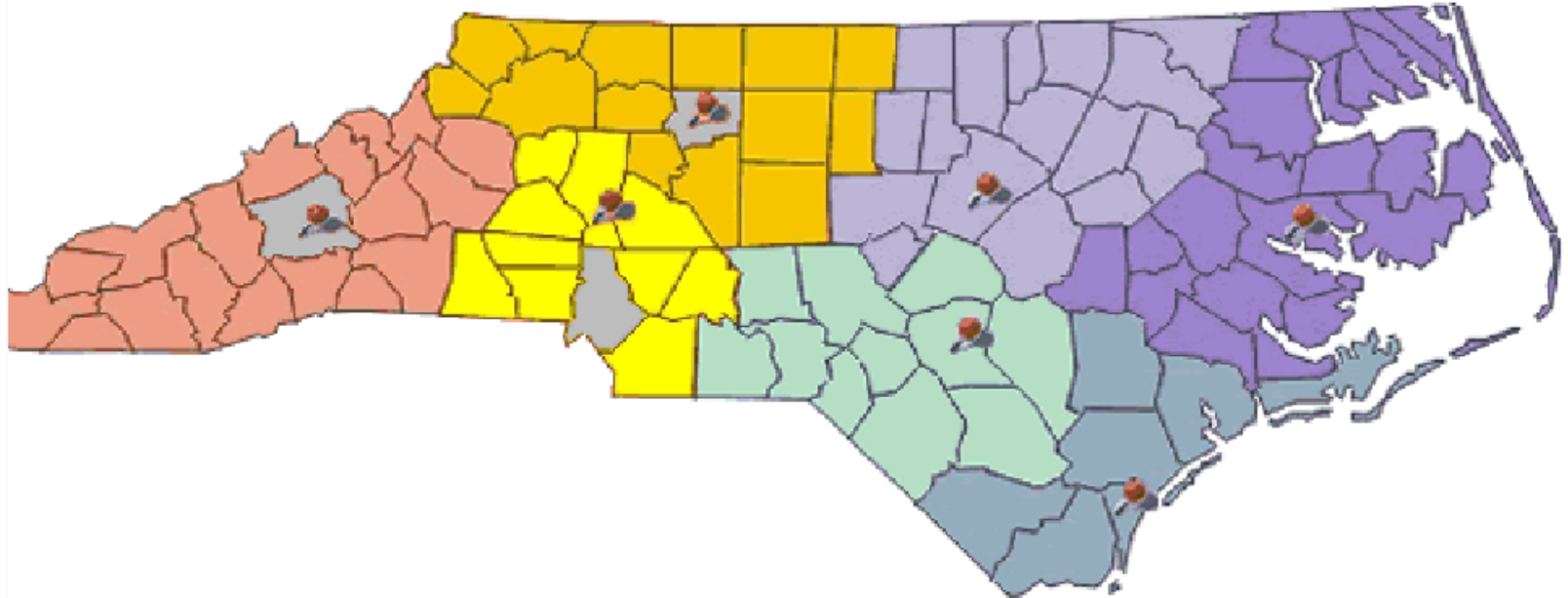
187 Federally-listed:

- ◆ Metals, such as cadmium, mercury, chromium, and lead compounds.
- ◆ Solvents, such as trichloroethylene, hexane, and methylene chloride.
- ◆ Others, such as benzene, dioxin, asbestos, and toluene.

NC has added 21, including acetic, nitric and sulfuric acids; ammonia; bromine.

Air quality is managed under the framework of the 1970 Clean Air Act

Department of Environmental Quality



Map Legend

- | | |
|----------------------|---------------------|
| Asheville Region | Raleigh Region |
| Fayetteville Region | Washington Region |
| Winston-Salem Region | Wilmington Region |
| Mooresville Region | Local Program Areas |

To search for the regional office that serves your area, enter your county name below, e.g. *Wake*

Find my Regional Office

Locations of NC Ambient Air Quality Monitors

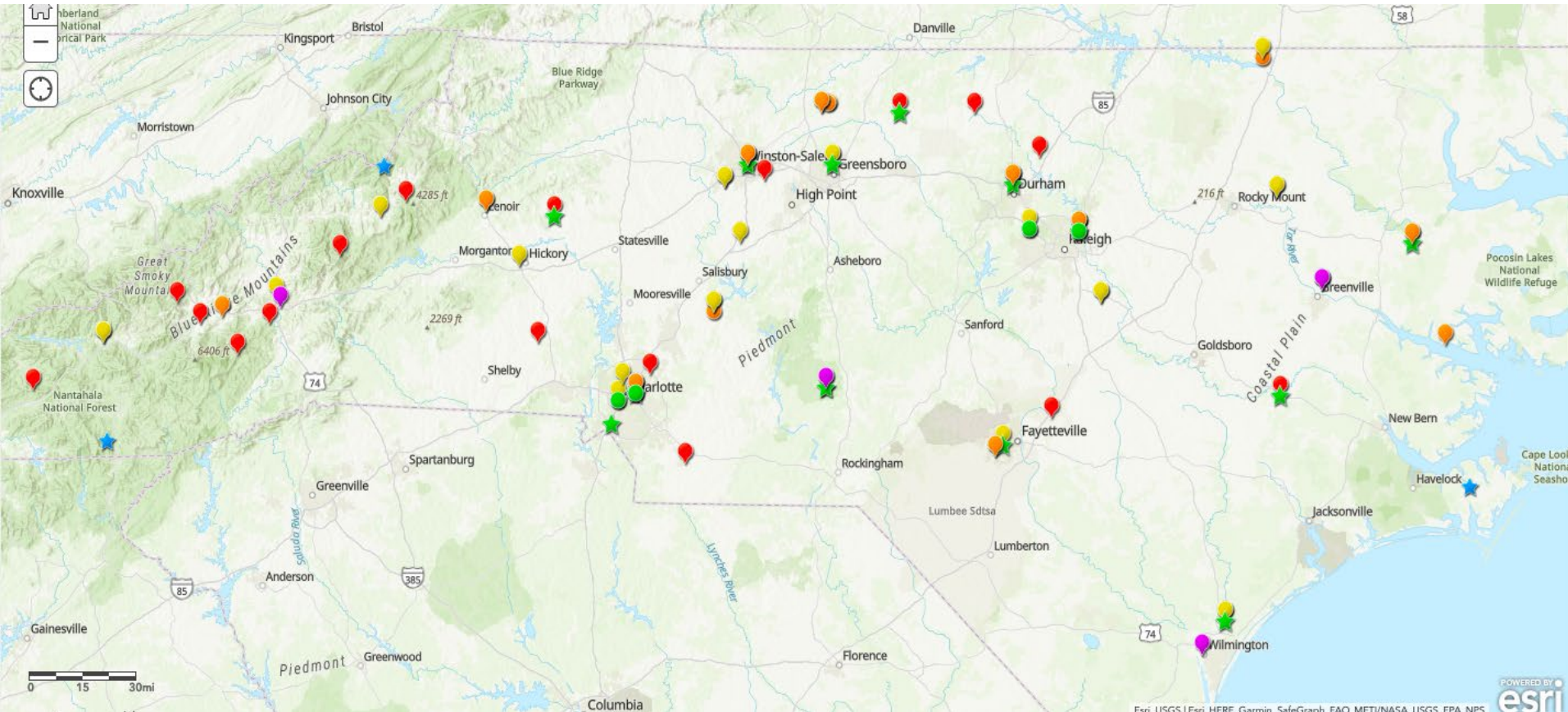
📍 Ozone (O3) (33)

🟢 Carbon Monoxide (CO) (4)

🟠 Nitrogen Dioxide (NO2) (8)

🟡 Nitrogen Oxides (NOy) (2)

🟤 Sulfur Dioxide (SO2) (10)



📍 Particulate Matter 2.5 (22)

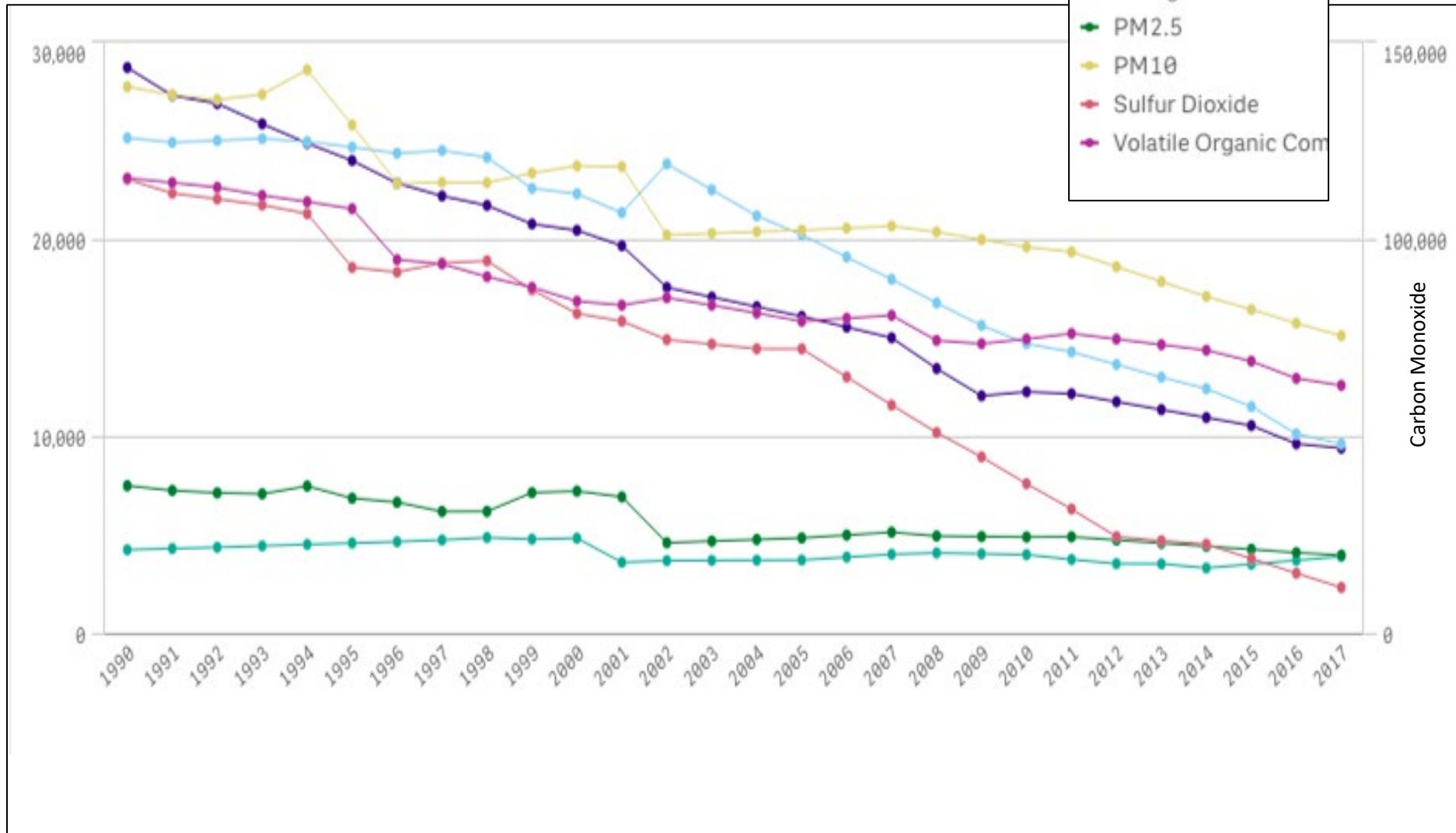
🟡 Urban Air Toxics (7)

🟢 Particulate Matter 10.0 (13)

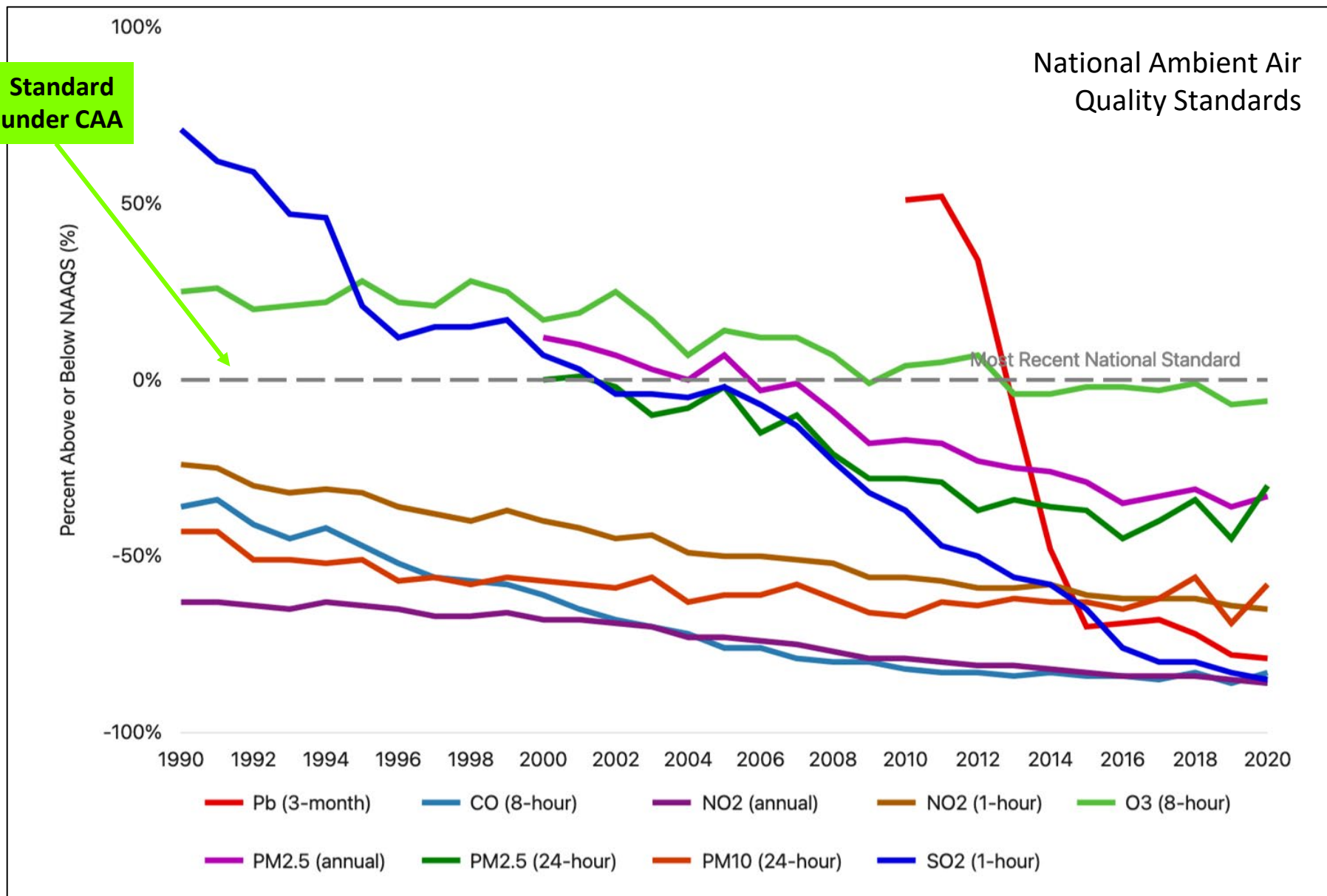
🌟 O3 + NOy + S (EPA CASTNET)

Live track NC AQ monitors [here](#).

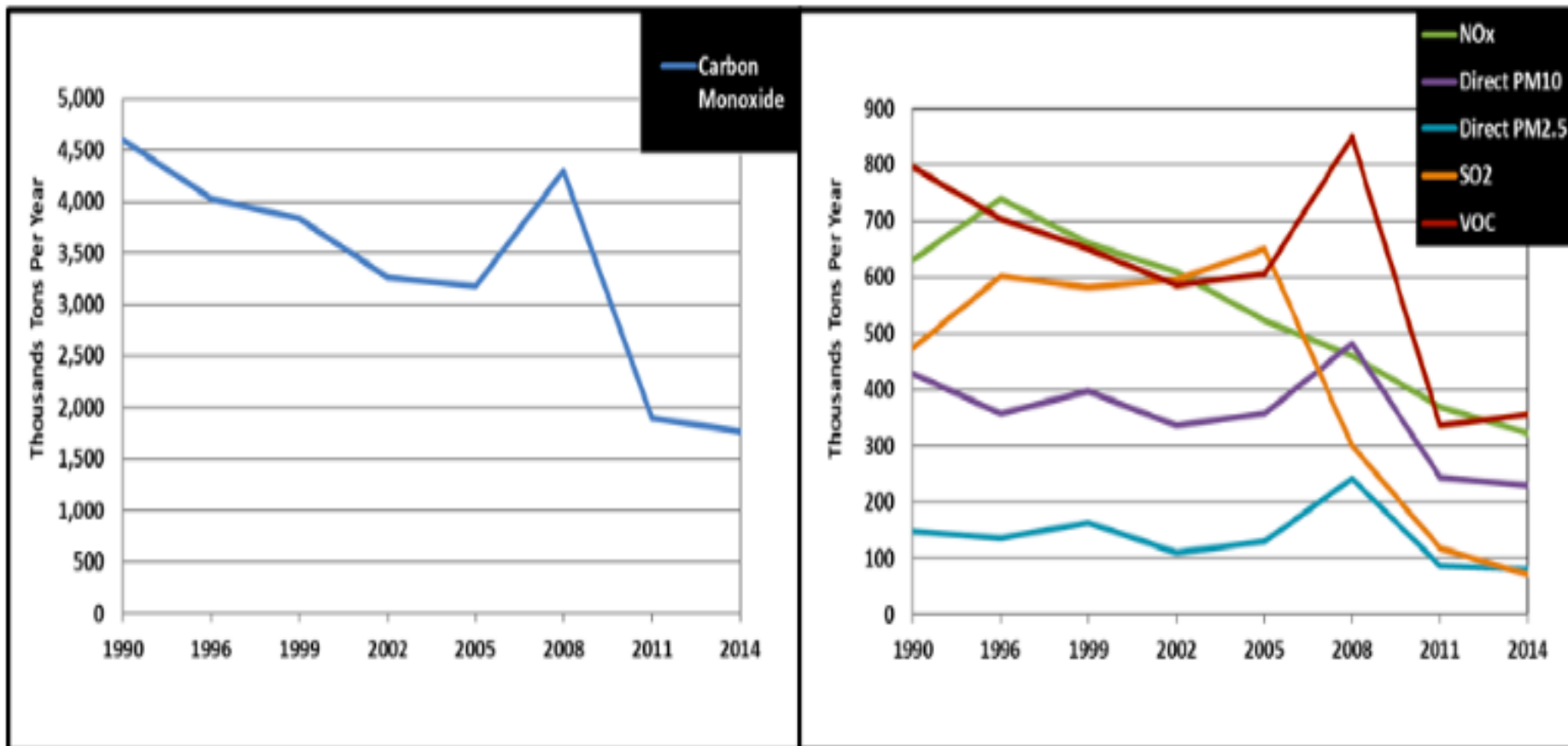
National Air Emissions, 1990-2017, in 1000 tons



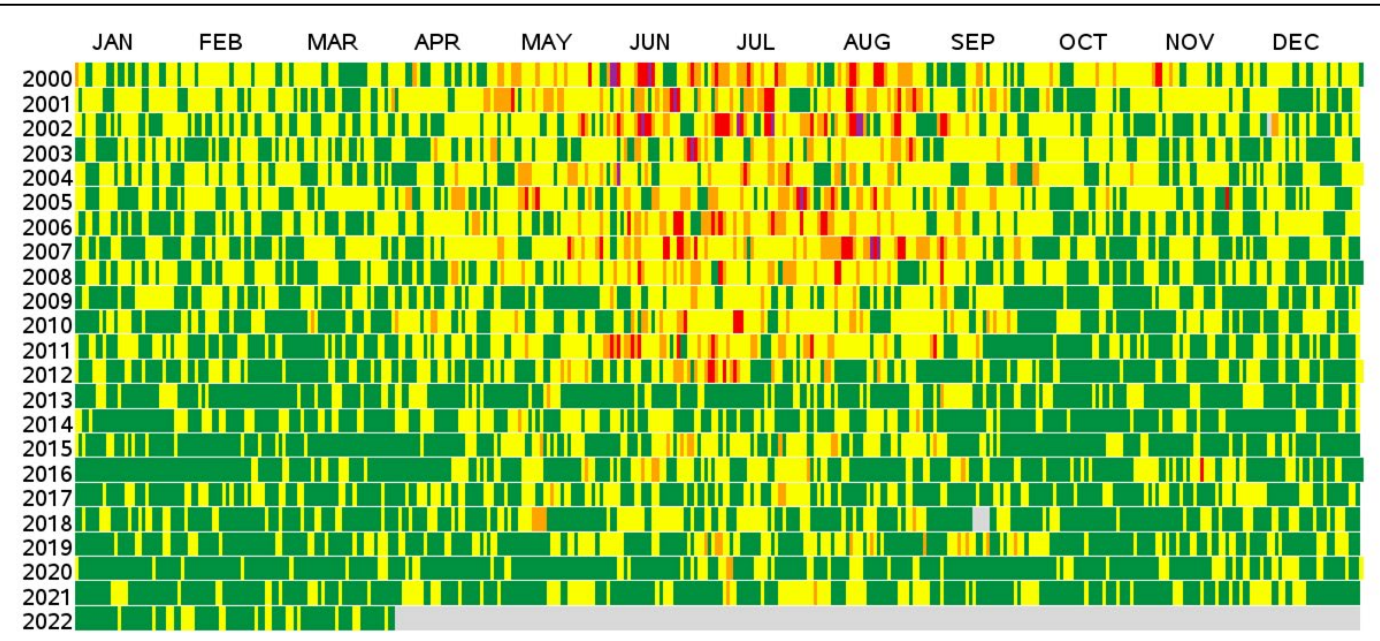
National Trends Against NAAQS Standards, 1990-2020



Annual Statewide Criteria Air Pollutant Emissions*

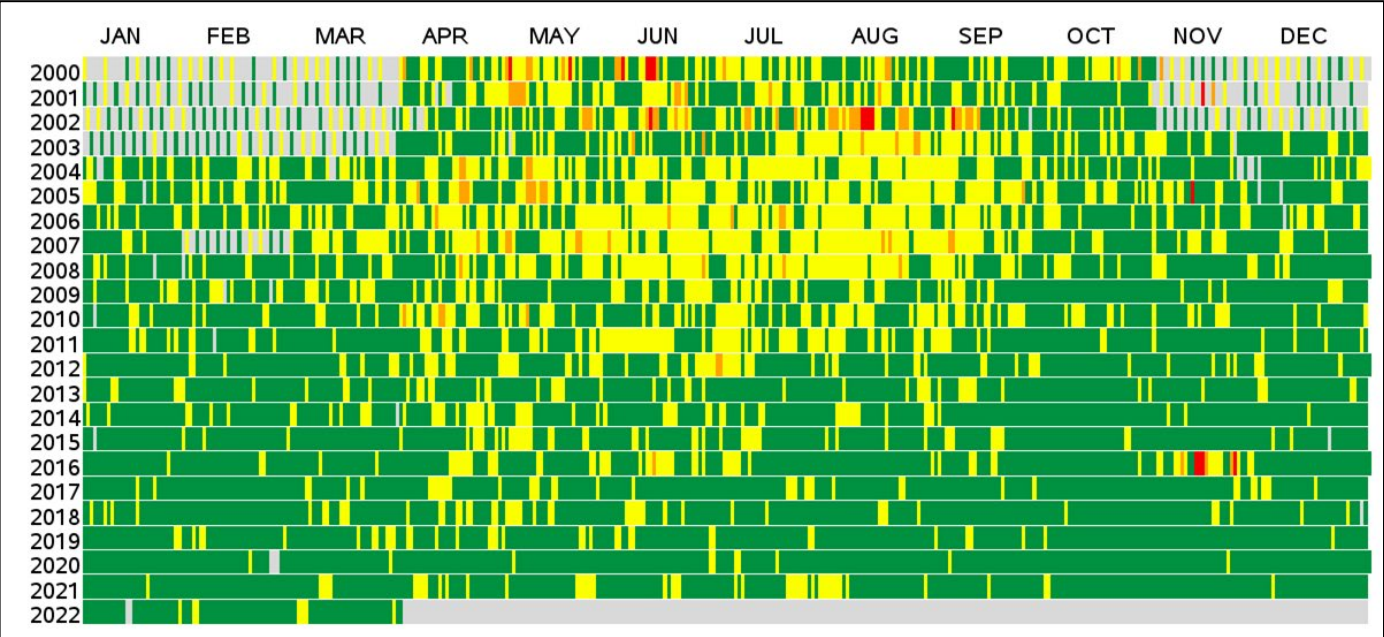


Mecklenburg County, NC



Daily Air Quality Index Values, 2000-2022

Buncombe County, NC



- Good (<= 50 AQI)
- Moderate (51-100 AQI)
- Unhealthy for Sensitive Groups (101-150 AQI)
- Unhealthy (151-200 AQI)
- Very Unhealthy (201-300 AQI)
- Hazardous (>= 301 AQI)

Looks like Blue Skies!! Yes but remember the ...

Hazardous Air Pollutants

187 Federally-listed:

- ◆ Metals, such as cadmium, mercury, chromium, and lead compounds.
- ◆ Solvents, such as trichloroethylene, hexane, and methylene chloride.
- ◆ Others, such as benzene, dioxin, asbestos, and toluene.

NC has added 21, including acetic, nitric and sulfuric acids; ammonia; bromine.

76,726 census tracts assessed for “... in toxics.
National average = 25

54.3% of NC cens

50

“Results indicate that Hispanics' ethnic status interacts with class, gender and age status to amplify disproportionate risk. In contrast, results

whiteness attenuates

class, gender

so TX.

“Our findings indicate that ... race and ethnicity are significantly related to cancer risks in Florida...”
From a 2011 study in Florida.

Risks are

→ Of the 10

→ 10+

“In Maryland...[c]ens.

highest proportion] of African-American residents were three times more likely to be high risk than those in the lowest quartile.... We observed substantial risk disparities for on-road and area sources [of air toxics] by race.” From a 2004 study in Maryland.

, up to 980

VA

SC

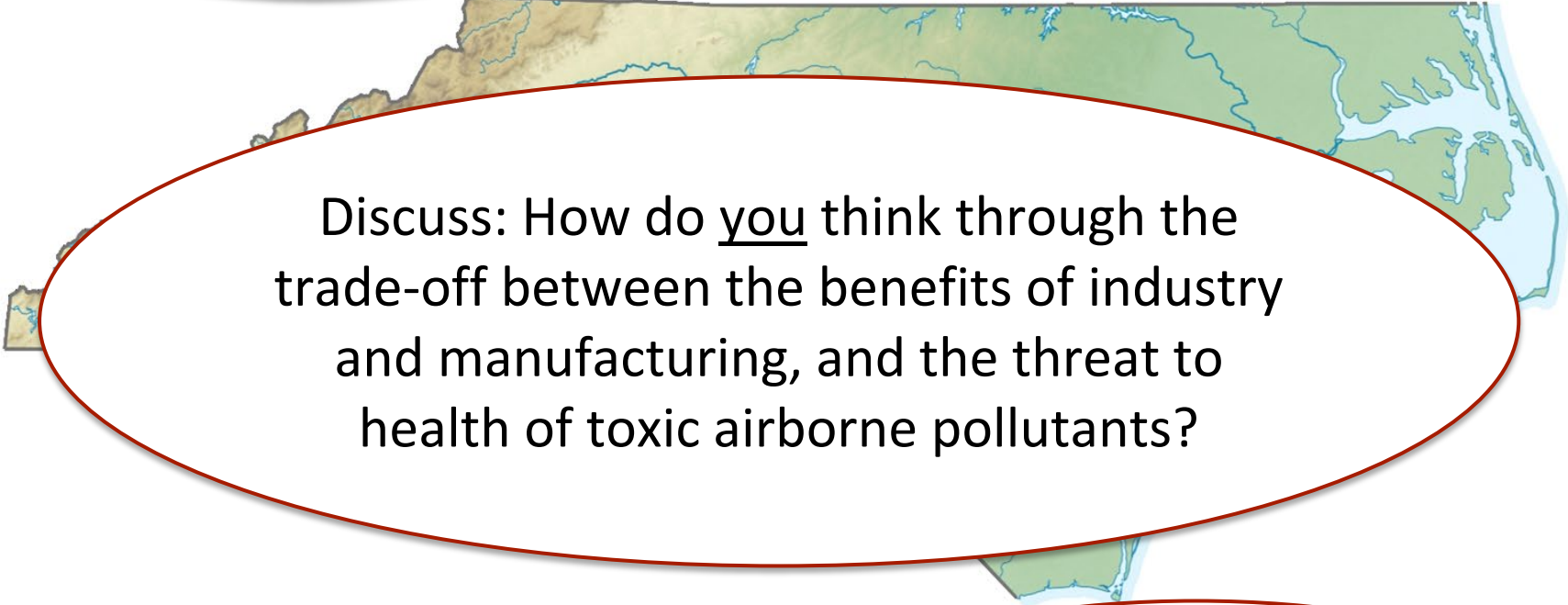
DC

GA

LA

Using health benchmarks available ~140 air toxics, EPA estimates “excess” cancer cases attributable to those pollutants. Assumes daily exposure over a 70 year lifetime. Calculated by

Good news! Toxic air emissions are declining.

A map of North Carolina showing its geographical features, including the coastline, major rivers, and topography. The map is partially obscured by a large red oval containing text.

Discuss: How do you think through the trade-off between the benefits of industry and manufacturing, and the threat to health of toxic airborne pollutants?

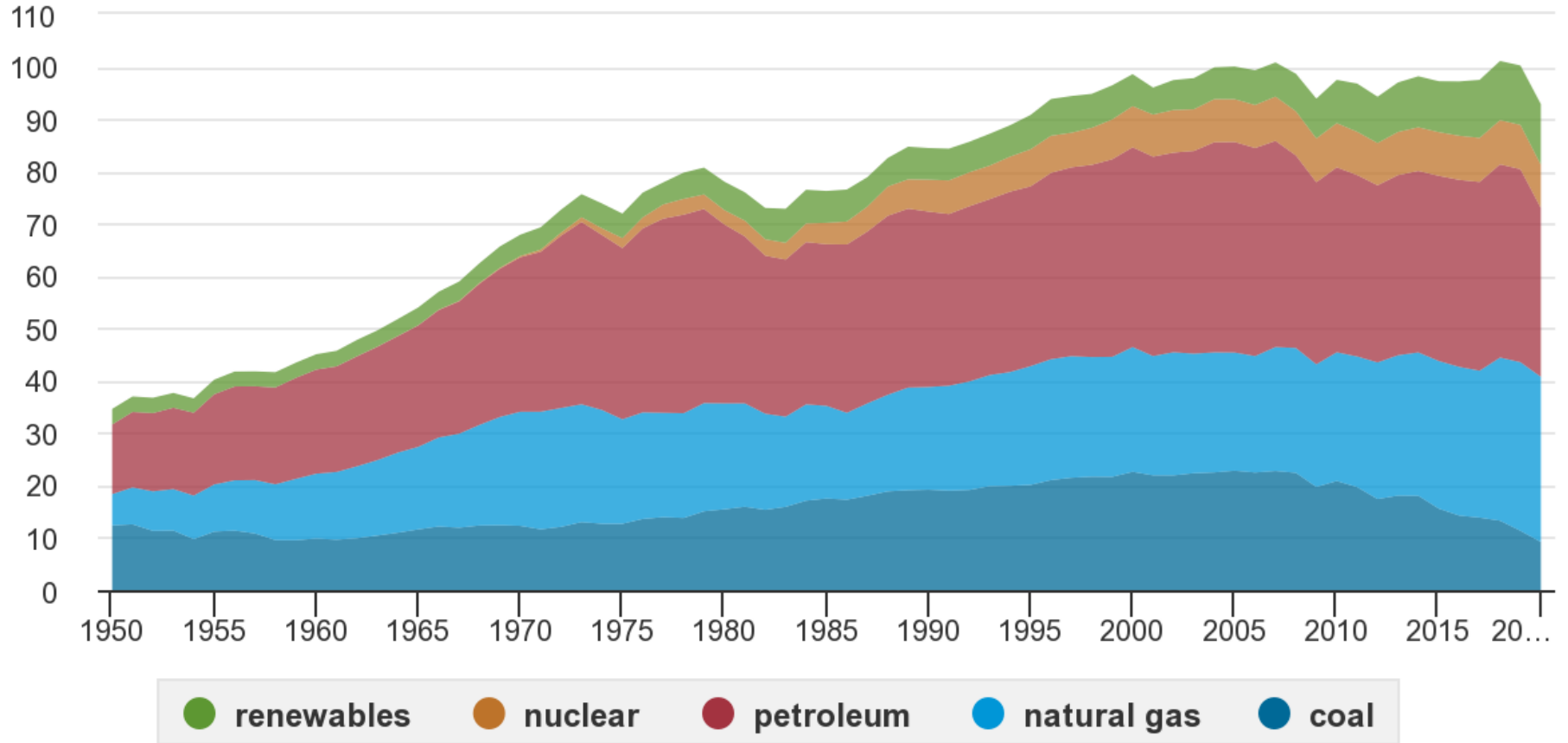
Bad news! They're still being emitted by the literal ton.

HAP = Federal hazardous air pollutants.
TAP = North Carolina-specific toxic air pollutants.
Source: North Carolina point source inventory.



U.S. primary energy consumption by major sources, 1950-2020

quadrillion British thermal units

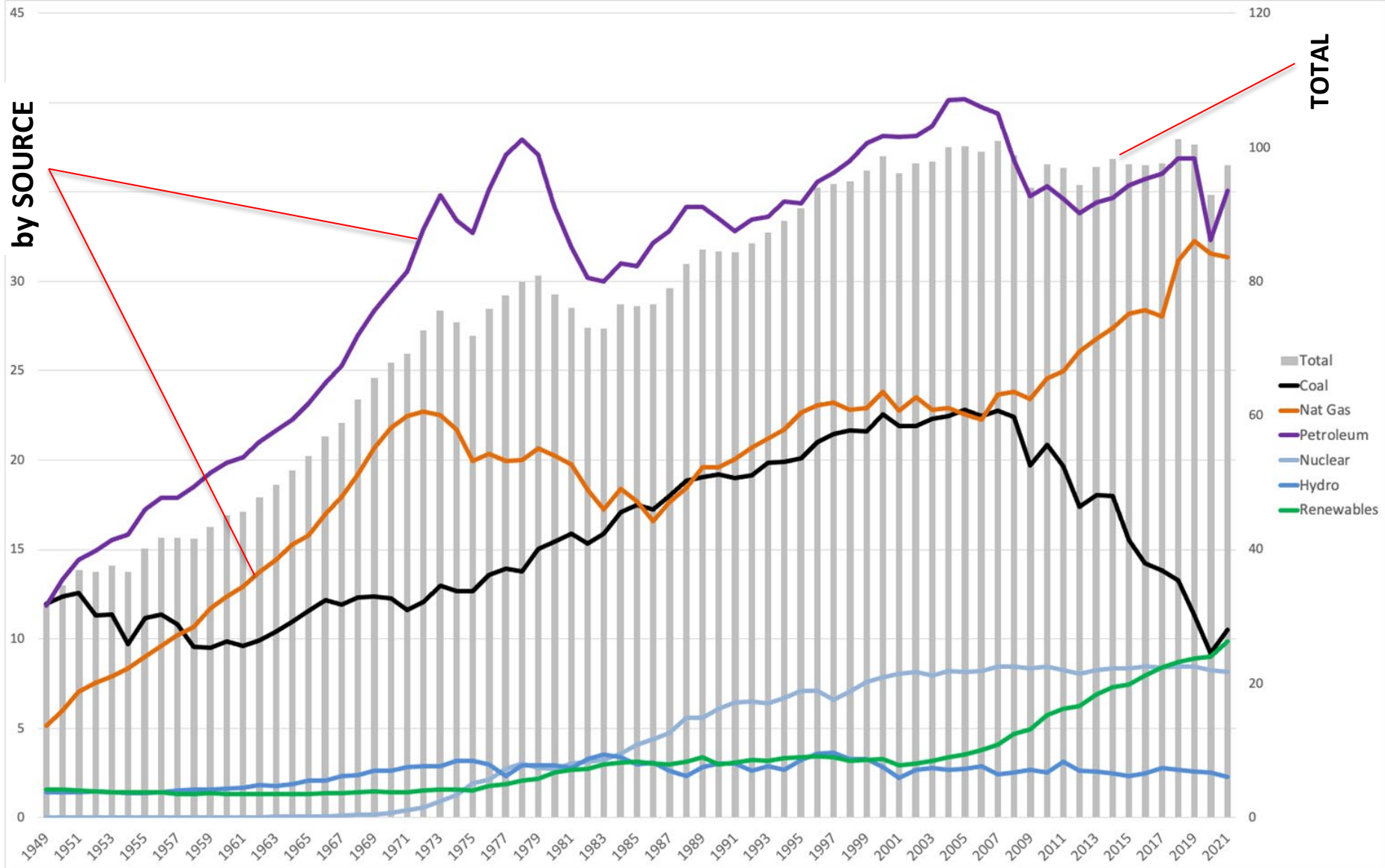


Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3, April 2021, preliminary data for 2020

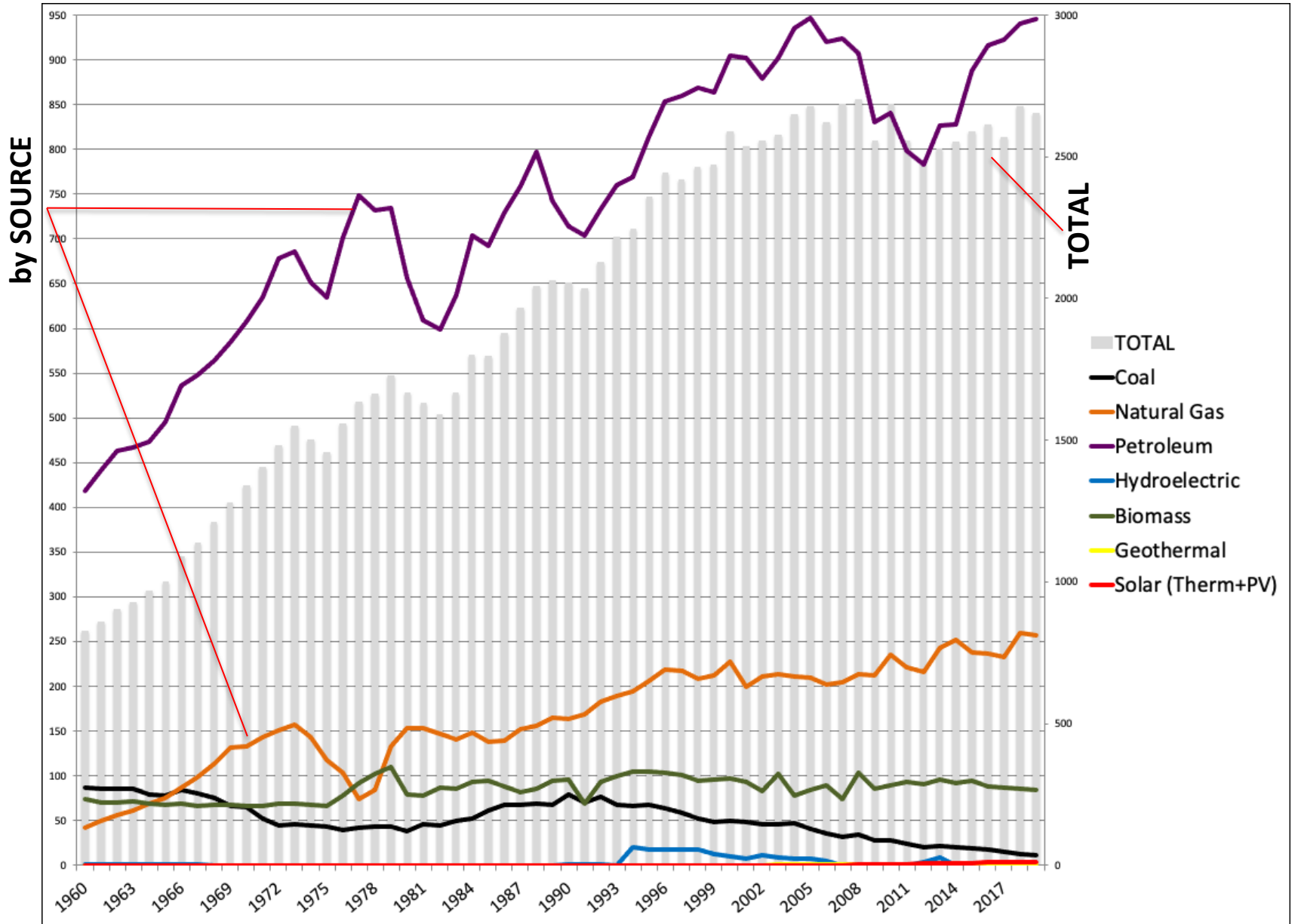


Note: Petroleum is petroleum products excluding biofuels, which are included in renewables.

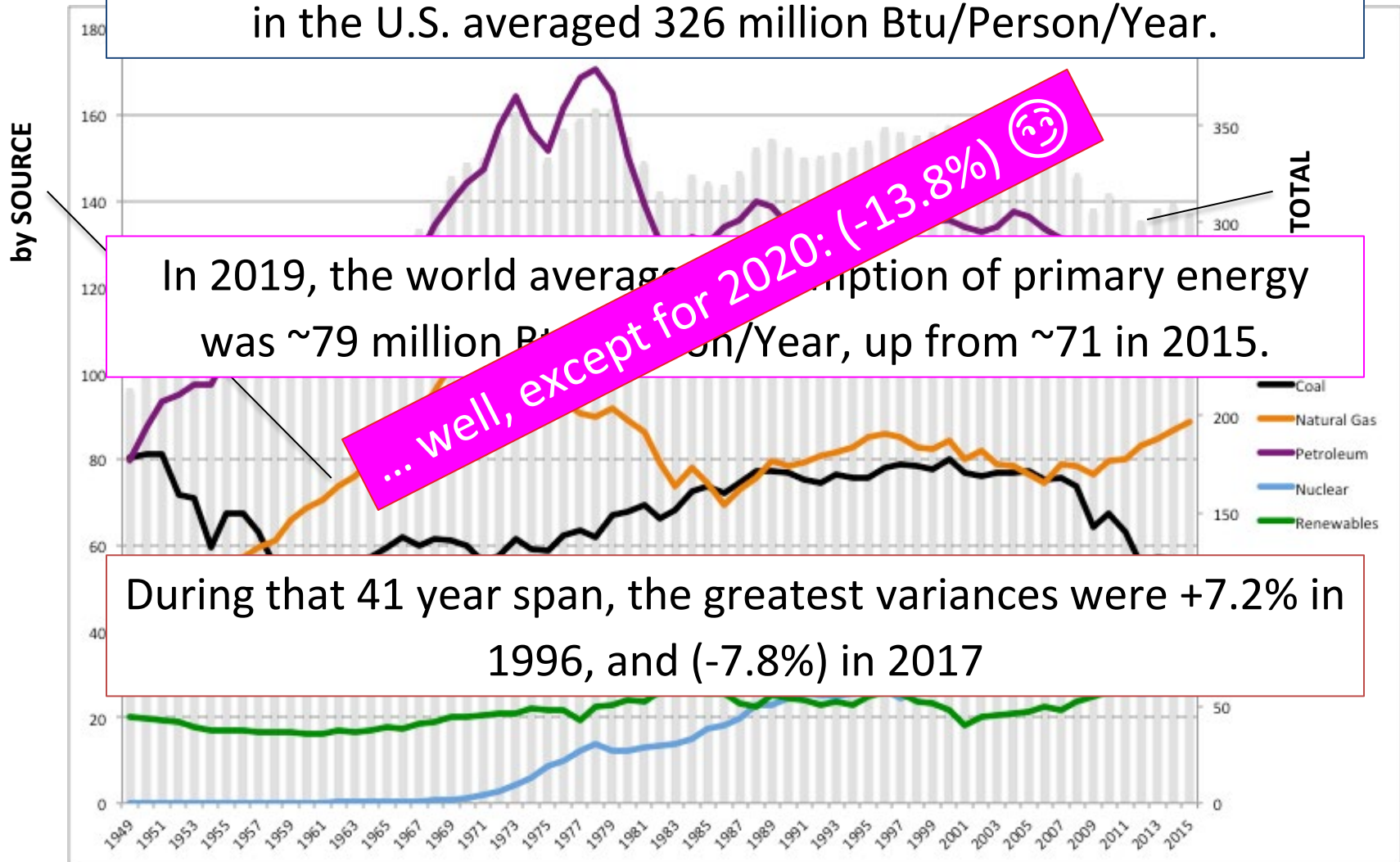
U.S. Energy Consumption, Quadrillion Btus, 1949-2021



N.C. Energy Consumption, Trillion Btus, 1960-2019

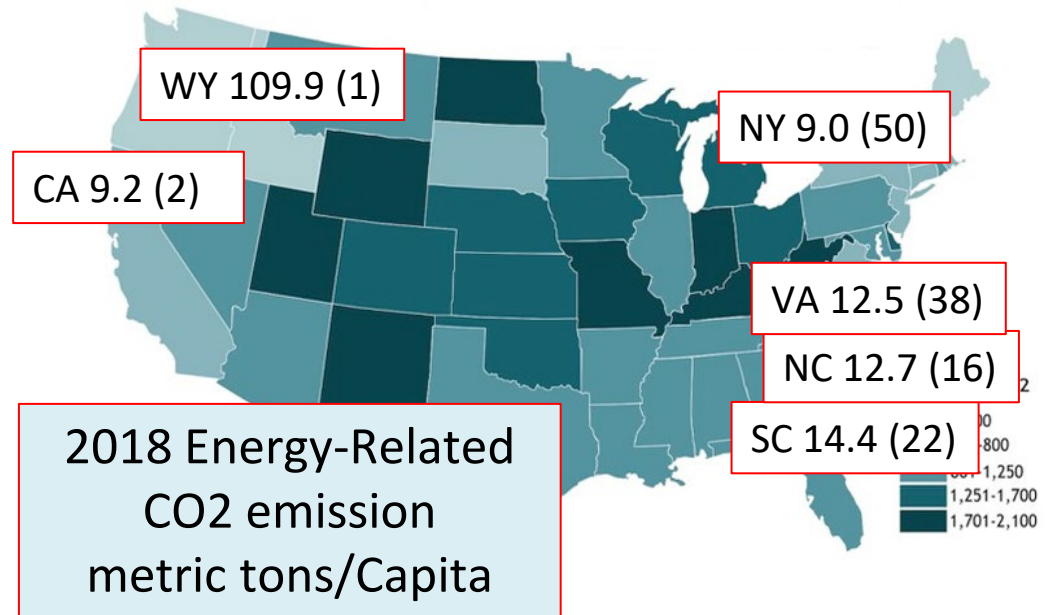
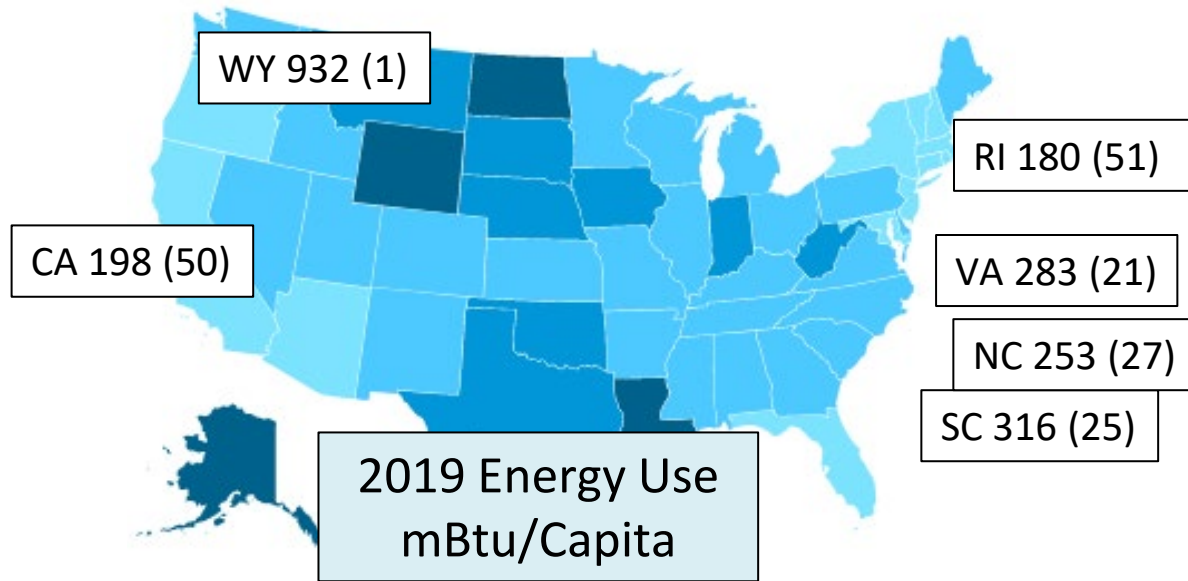


U From 1980 and 2021 the total per capita primary consumption in the U.S. averaged 326 million Btu/Person/Year.

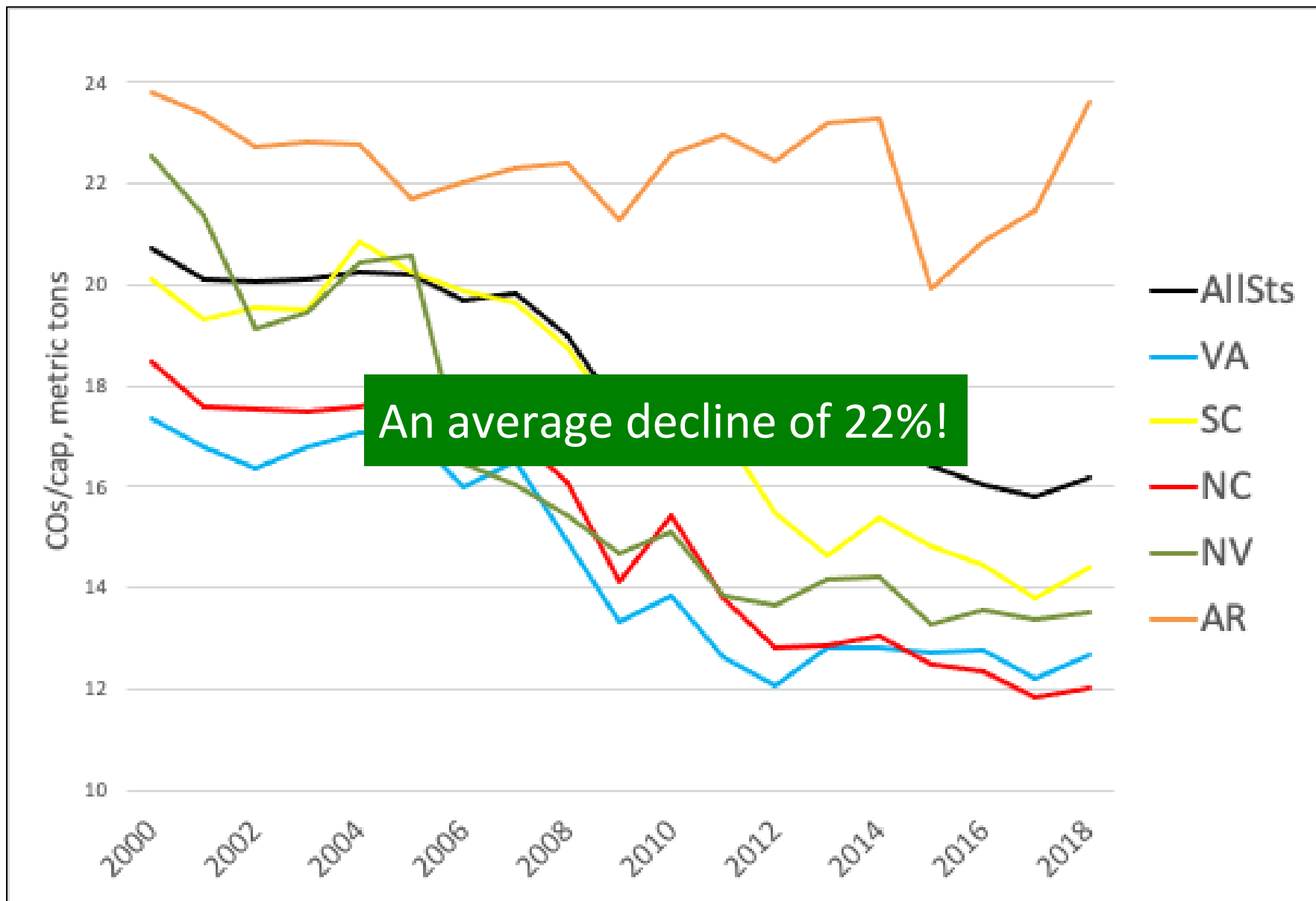


In 2019, the world average per capita consumption of primary energy was ~79 million Btu/Person/Year, up from ~71 in 2015.

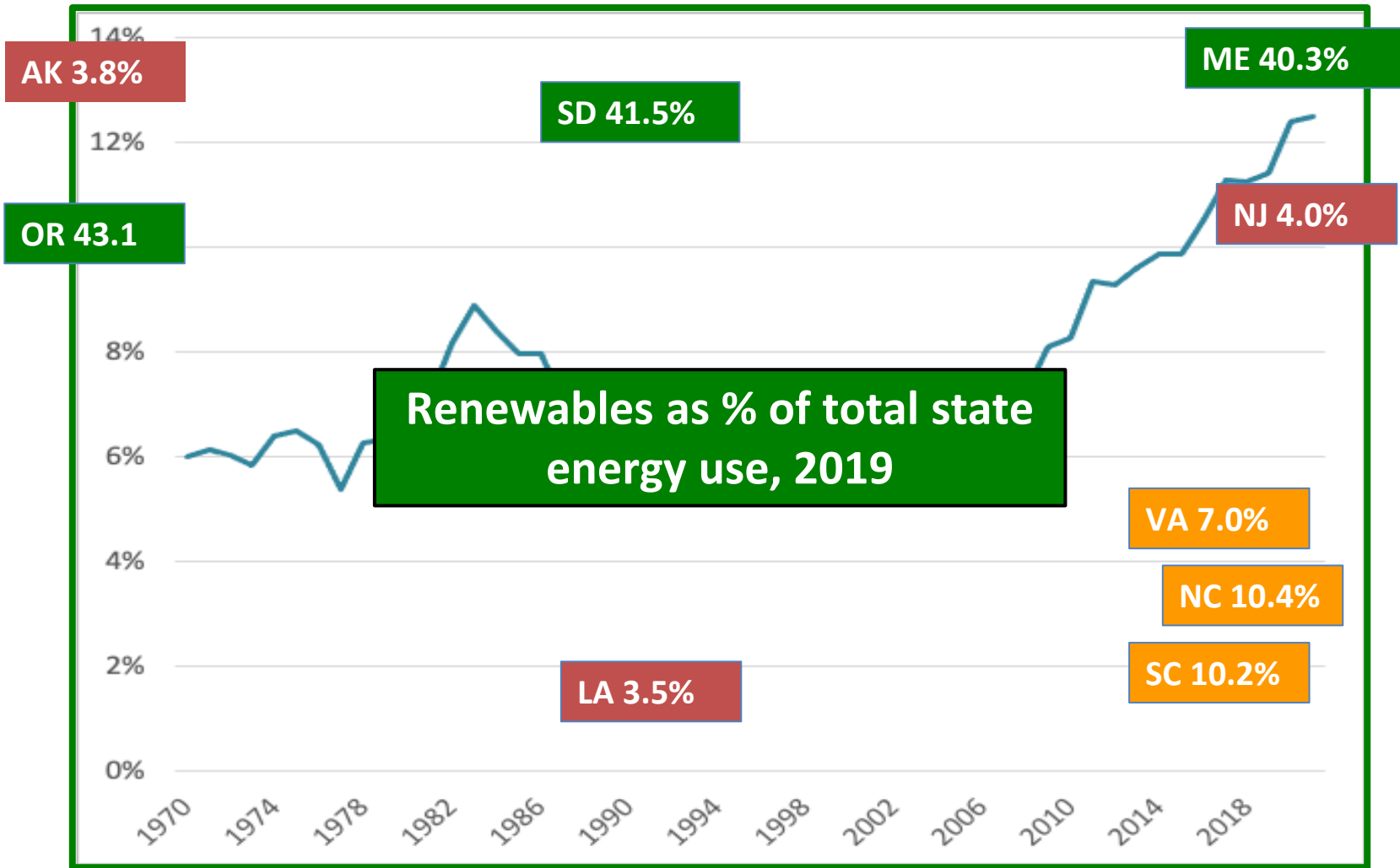
During that 41 year span, the greatest variances were +7.2% in 1996, and (-7.8%) in 2017



Per capita energy-related CO2 emissions by state, (2000–2018)



U.S. RENEWABLE Energy as % of total consumption, 1970-2021

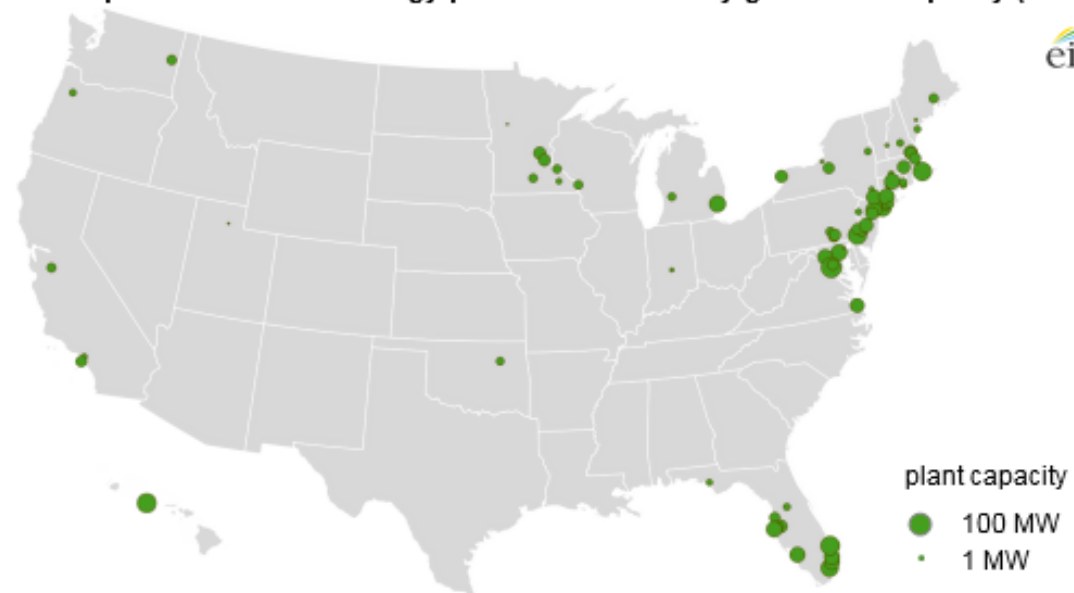


Maybe we should burn our trash for electricity?!?

APRIL 8, 2016

Waste-to-energy electricity generation concentrated in Florida and Northeast

Municipal solid waste-to-energy plants with electricity generation capacity (2015)



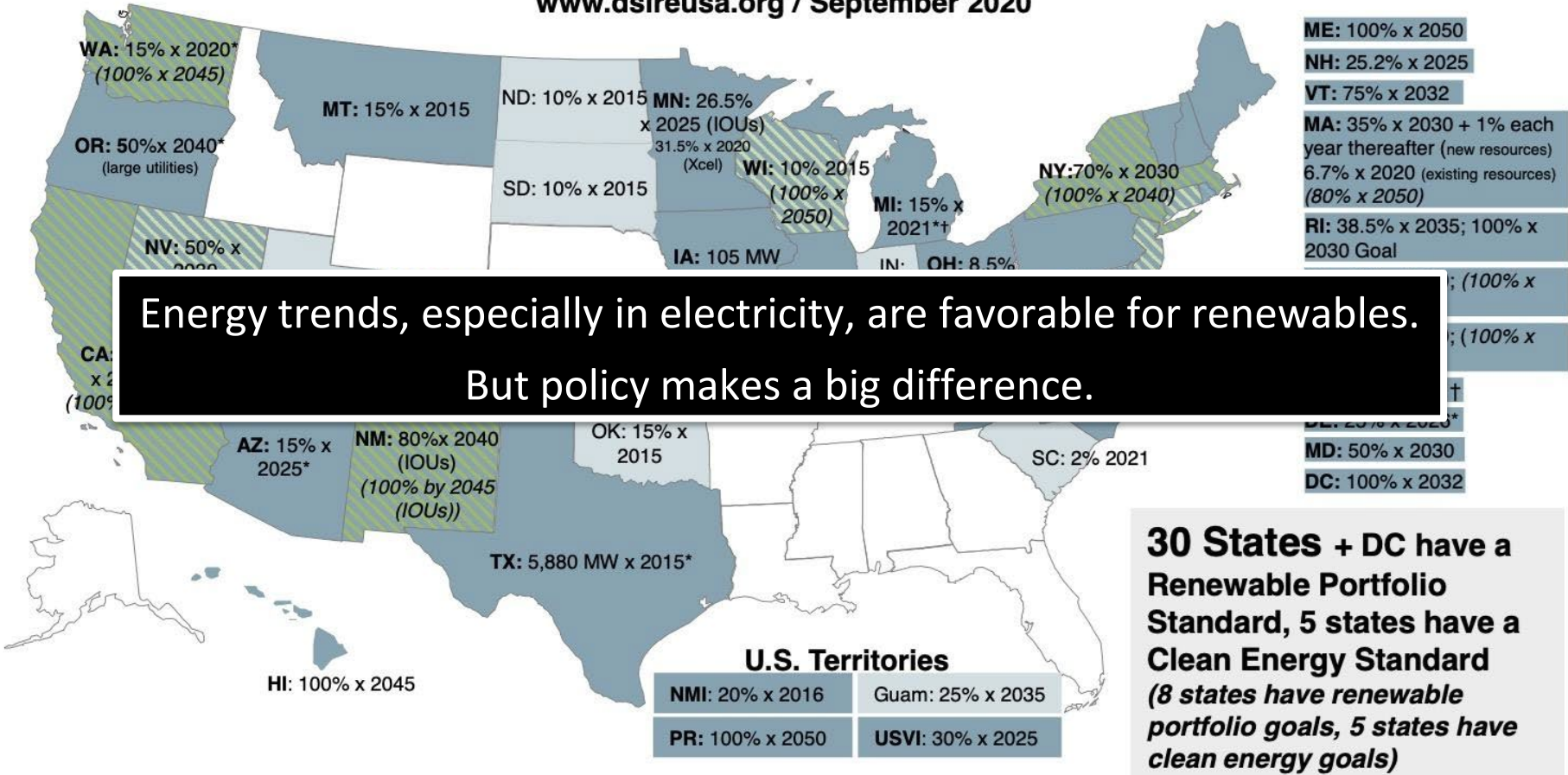
Source: U.S. Energy Information Administration, *Monthly Electric Generator Report*

In 2015 “the United States had 71 waste-to-energy (WTE) plants that generated electricity in 20 U.S. states.... WTE plants provided ... about 0.4% of total U.S. electricity generation in 2015.”

“In 2015] Florida's Palm Beach Renewable Energy Facility Number 2 became the first new WTE plant to come online since 1995 and the largest single WTE electricity generator in the United States.”

Renewable & Clean Energy Standards

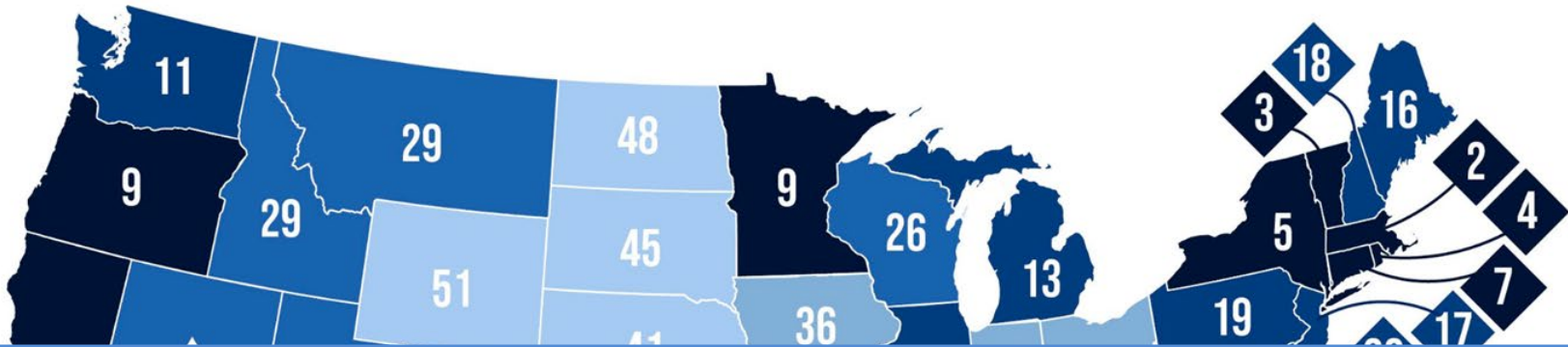
www.dsireusa.org / September 2020



Renewable portfolio standard
 Clean energy standard
 Renewable portfolio goal
 Clean energy goal

* Extra credit for solar or customer-sited renewables
 † Includes non-renewable alternative resources

THE 2020 STATE ENERGY EFFICIENCY SCORECARD



American Council for an Energy Efficient Economy. State Policy Scorecard program.

Utilities: Policies incentivizing utilities to invest in energy efficiency programs; financial incentives; strong Transp provisions

Renewables are grand. But how about our old friend efficiency? “Energy Efficiency Can Cut Energy Use and Greenhouse Gas Emissions in Half by 2050.” AEEE, Sept 2019.

Building Energy Efficiency: Building efficiency codes and compliance with them.

Appliance Standards: Efficiency standards and compliance, from microwaves to furnaces.

State Government-Led Initiatives: Financial incentives e.g. tax credits for efficient homes/renovations; credits for renewable energy production; zoning incentivizing wind and solar; state fleet efficiency.



- ◆ RANKS 31-40
- ◆ RANKS 41-51



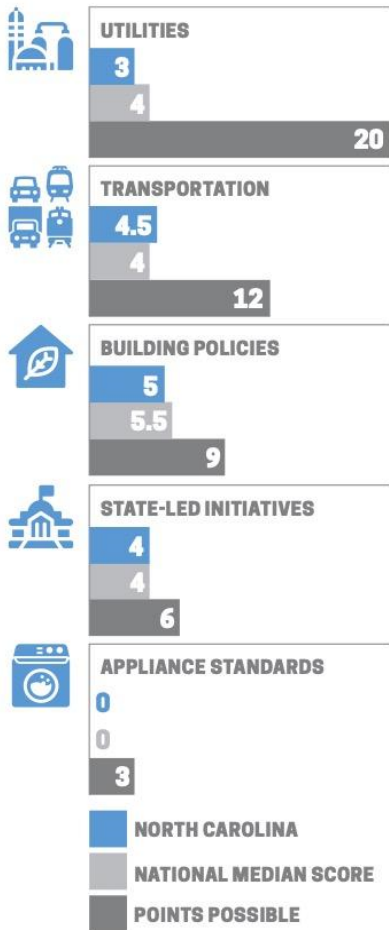
27

North Carolina tied for 27th in the 2020 State Energy Efficiency Scorecard, falling one position from 2019. The state earned 16.5 points out of a possible 50, 1 point more than it earned last year.

2020 STATE ENERGY EFFICIENCY SCORECARD

North Carolina

The state's levels of electricity savings remain around the national median. North Carolina's renewable portfolio standard includes efficiency as an eligible measure, but it does not create clear guidance for cost-effective energy efficiency investments. ACEEE completed a study in 2020 which found that policies to improve the energy efficiency of homes and buildings in North Carolina over the next two decades could restore jobs and save \$5.9 billion in electricity costs. Recommendations to meet this energy-savings potential include establishing minimum energy savings targets for utility programs, removing barriers to adoption of high-efficiency heat pumps, designing programs to encourage participation of large industrial customers in utility energy efficiency, and expanding programs for traditionally underserved rural, low-income, rental, agricultural, and small business customers.



UTILITIES

Utilities run electricity efficiency programs and some limited natural gas programs. The state has a renewable portfolio standard that offers credit for energy efficiency; however, the ability of industrial customers to opt out of energy efficiency programs limits achievable savings. North Carolina has approved performance incentives and lost revenue adjustment mechanisms for specific utilities.

TRANSPORTATION

The state has complete streets legislation, a comprehensive freight plan, a dedicated revenue stream for transit investments, and integrates transportation and land use planning. North Carolina also has more electric vehicle registrations per capita than most states. Governor Cooper's Executive Order 80 directed an increase in the number of registered zero-emission vehicles (ZEVs) to at least 80,000 statewide by 2025.

BUILDING ENERGY EFFICIENCY POLICIES

Residential and commercial buildings must comply with standards equivalent to the 2015 International Energy Conservation Code (IECC) with weakening amendments, making it similar to the 2012 IECC. The state conducts code training and outreach and has also partnered with DOE to undertake a residential energy code field study.

STATE GOVERNMENT-LED INITIATIVES

North Carolina offers two financial incentive programs for energy efficiency investments. The state government leads by example by requiring efficient buildings and fleets, benchmarking energy use, and encouraging the use of energy savings performance contracts. Several research centers within the state focus on energy efficiency, including the North Carolina Clean Energy Technology Center at North Carolina State University. In 2019 the state in partnership with the Nicholas Institute at Duke University released the North Carolina Energy Efficiency Roadmap to help the state meet its energy savings potential and achieve the goals of the state's Clean Energy Plan.

APPLIANCE STANDARDS

North Carolina has not set appliance standards beyond those required by the federal government.

And forested hills do more than dazzle the eye...

Net Carbon Emissions, North Carolina, (MMT CO₂e).

Sector	1990	2005	2012	2015	2017
Electricity Use	54.57	79.37	66.85	58.48	52.60
Residential/Commercial/Industrial Combustion*	26.77	26.02	18.66	21.15	20.92
Transportation	40.24	55.26	46.57	48.29	46.43
Agriculture	7.06	10.65	10.56	10.38	10.53
Waste Management	6.39	8.52	9.09	8.44	8.77
Industrial Processes	1.04	3.83	5.39	6.03	7.18
Natural Gas and Oil Systems	0.86	1.17	1.28	1.32	1.35
Gross Emissions**	136.92	184.81	158.39	154.08	147.79
Percent Reduction in Gross Emissions from 2005					20%
Net Carbon Sinks - Land Use, Land Use Changes and Forestry	-35.64	-32.66	-33.97	-34.16	-34.03
Net Emissions**	101.28	152.14	124.42	119.92	113.76
Percent Reduction in Net Emissions from 2005					25%

In million metric tons of carbon dioxide equivalent emissions (MMT CO₂e).

[Air Quality Trends in NC](#), NC DEQ
(2018)

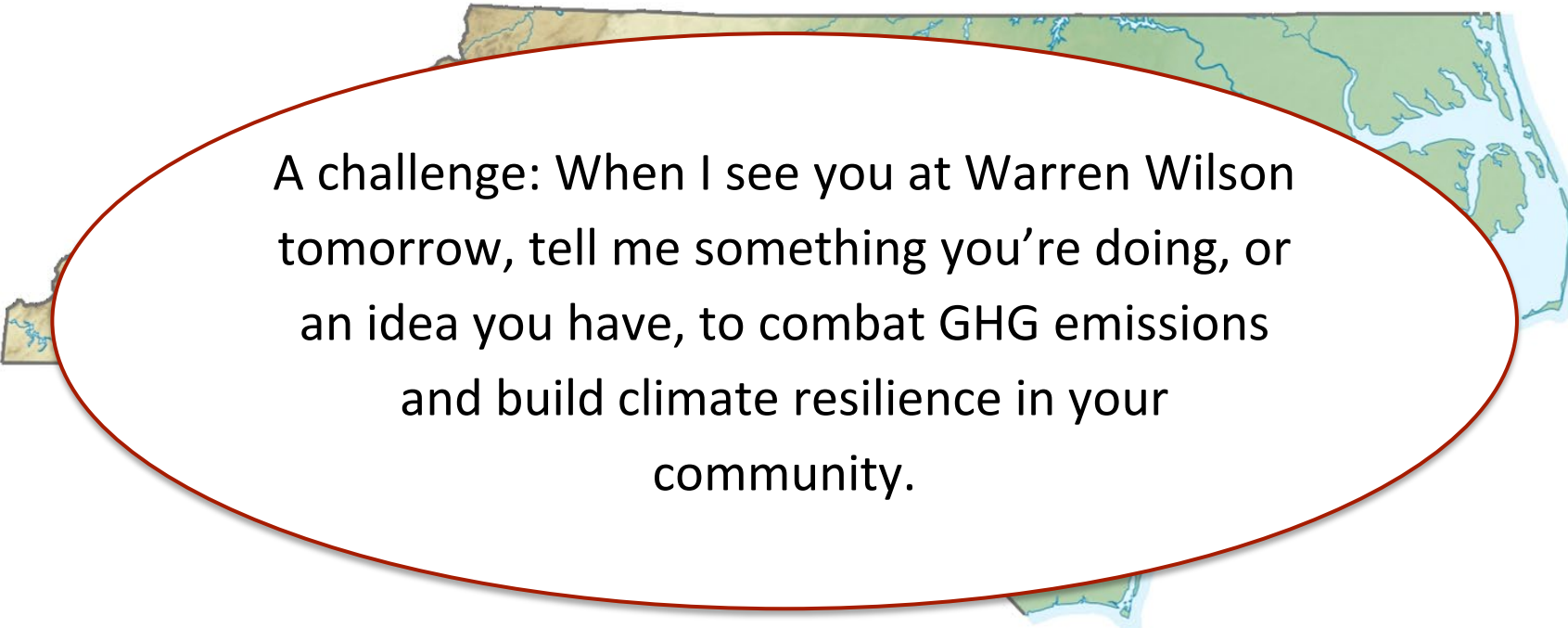
**Policy has successfully driven market forces in the direction of renewables.
And it can do more!!**

...plant a tree...



**Look into solarizing your house!
Buy a used electric vehicle!**

...and that's all folks!



A challenge: When I see you at Warren Wilson tomorrow, tell me something you're doing, or an idea you have, to combat GHG emissions and build climate resilience in your community.

Dr. Amy Knisley
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