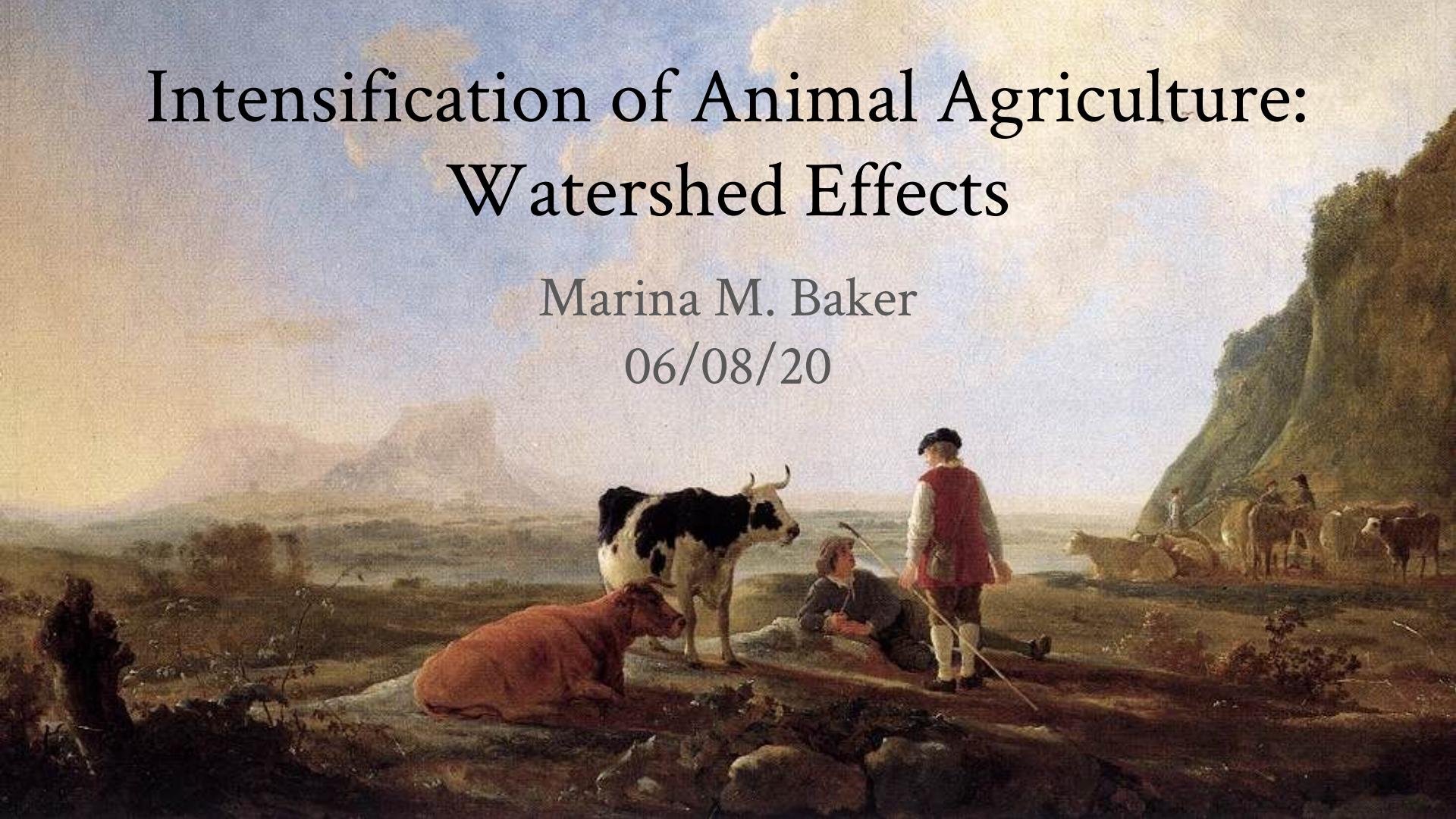


Intensification of Animal Agriculture: Watershed Effects

Marina M. Baker
06/08/20



Agricultural Intensification



Larger Scale



More Technology



Higher Capital



Agricultural Waste and Watershed Ecology

MISSOURI COALITION FOR THE ENVIRONMENT'S

NUTRIENT POLLUTION 101

A HEALTHY MISSOURI LAKE...
...has natural levels of nitrogen and phosphorus that are safe for our families and pets to swim and recreate in.

...has **low levels of chlorophyll-a** in the water so it is clear.

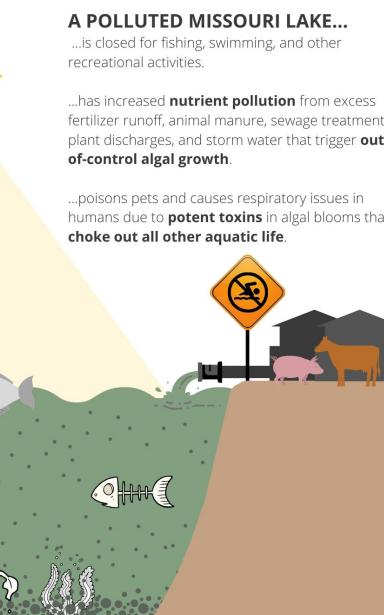
...and allows **sunlight and oxygen** reach even the lowest levels of the lake and create habitats for fish and other aquatic life.



A POLLUTED MISSOURI LAKE...
...is closed for fishing, swimming, and other recreational activities.

...has increased **nutrient pollution** from excess fertilizer runoff, animal manure, sewage treatment plant discharges, and storm water that trigger **out-of-control algal growth**.

...poisons pets and causes respiratory issues in humans due to **potent toxins** in algal blooms that **choke out all other aquatic life**.



MCE 50 YEARS
Missouri Coalition for the Environment
1969 - 2019

- Nutrient Pollution

- Organic nitrogen & phosphorus
- Animal waste, cropland runoff, industrial waste, road runoff

- Eutrophication

- Overgrowth of plant/algae matter
- Hypoxia
- Aquatic life
- Human health
- Property values

USDA Census of Agriculture

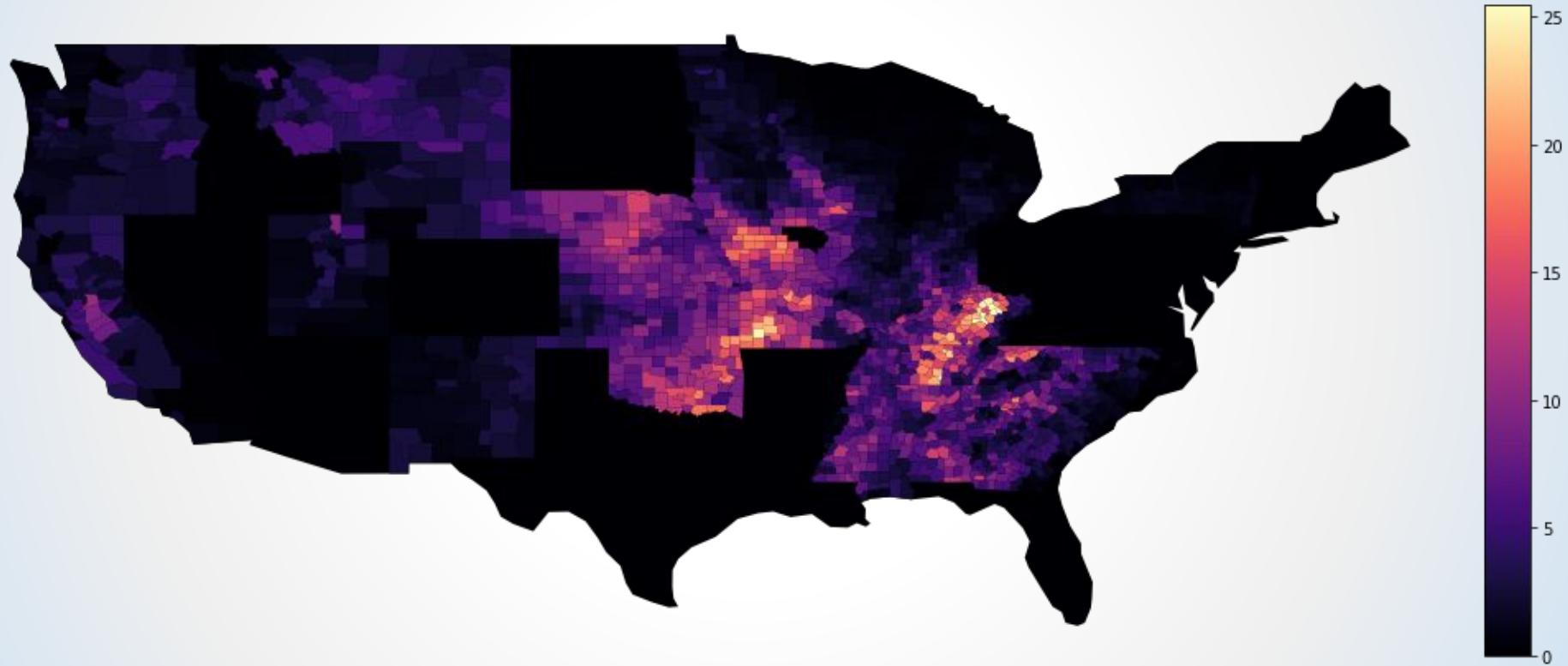
The Census of Agriculture is a complete count of U.S. farms and ranches and the people who operate them.

Even small plots of land - whether rural or urban - growing fruit, vegetables or some food animals count if \$1,000 or more of such products were raised and sold, or normally would have been sold, during the Census year.

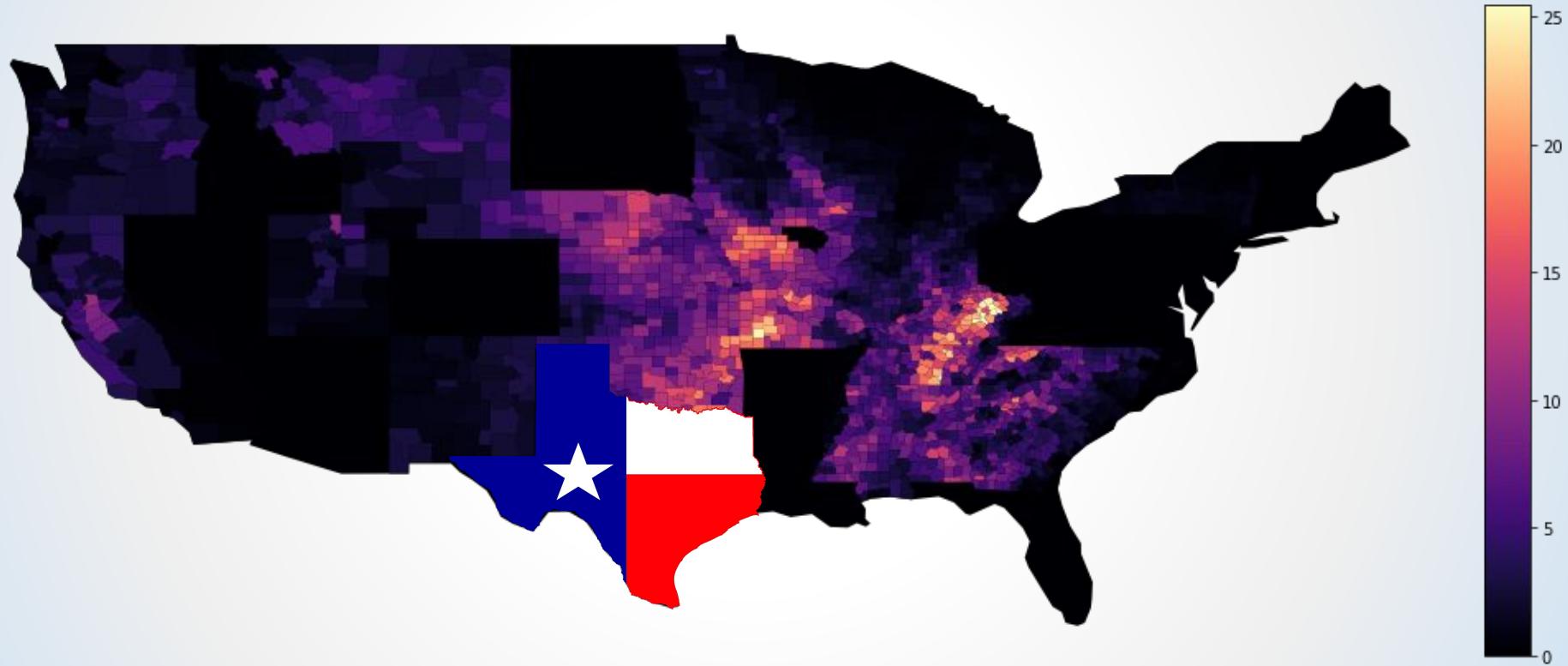
The Census of Agriculture, taken only once every five years, looks at land use and ownership, operator characteristics, production practices, income and expenditures.

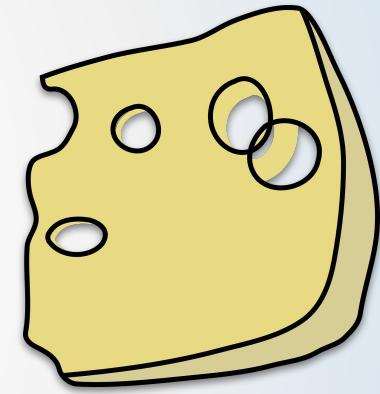
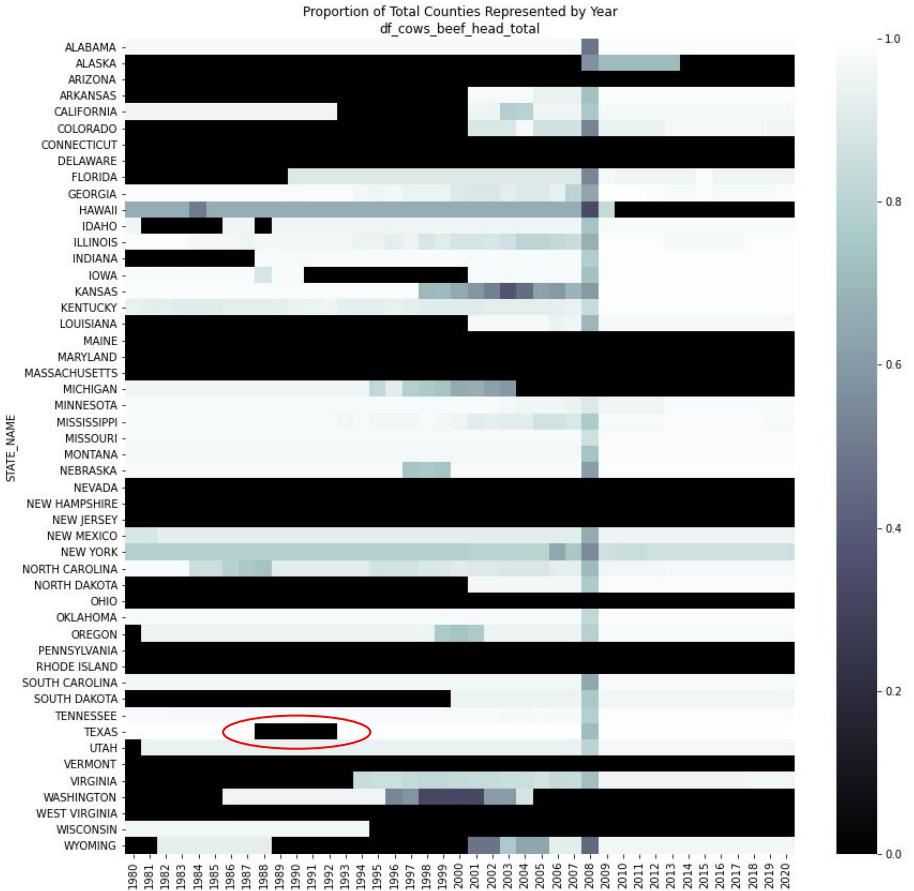


Cows, Beef, Head per Square Kilometer, by County, 1988



Cows, Beef, Head per Square Kilometer, by County, 1988





Proportion of Total Counties Represented by Year
df_chicken_broilers_head_total



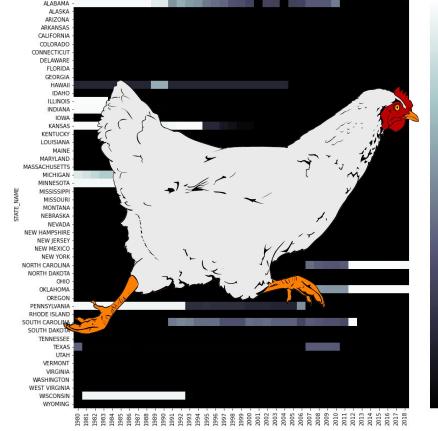
Proportion of Total Counties Represented by Year
df_chicken_broilers_head_total



Proportion of Total Counties Represented by Year
df_cows_beef_head_total

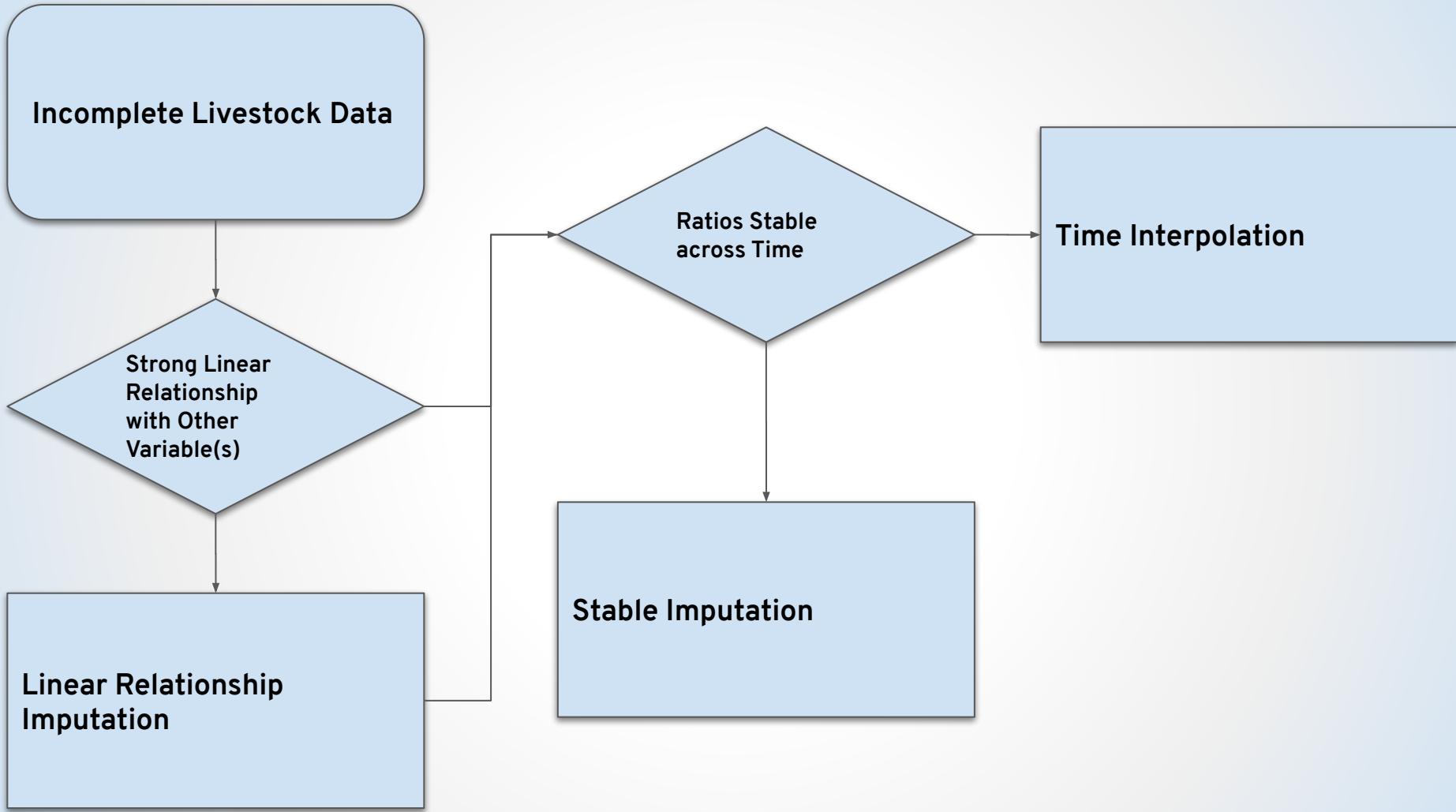


Proportion of Total Counties Represented by Year
df_chicken_layers_head_total



Proportion of Total Counties Represented by Year
df_chicken_layers_head_total

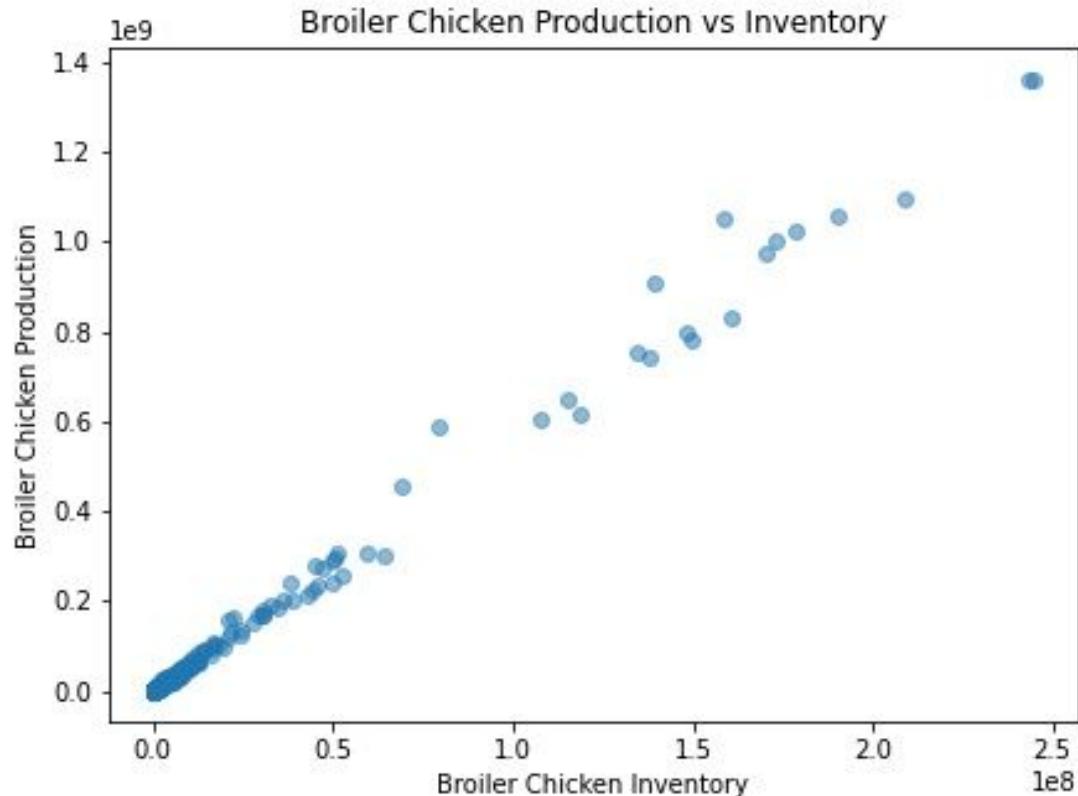




Incomplete Livestock Data

Strong Linear
Relationship
with Other
Variable(s)

Linear Relationship
Imputation



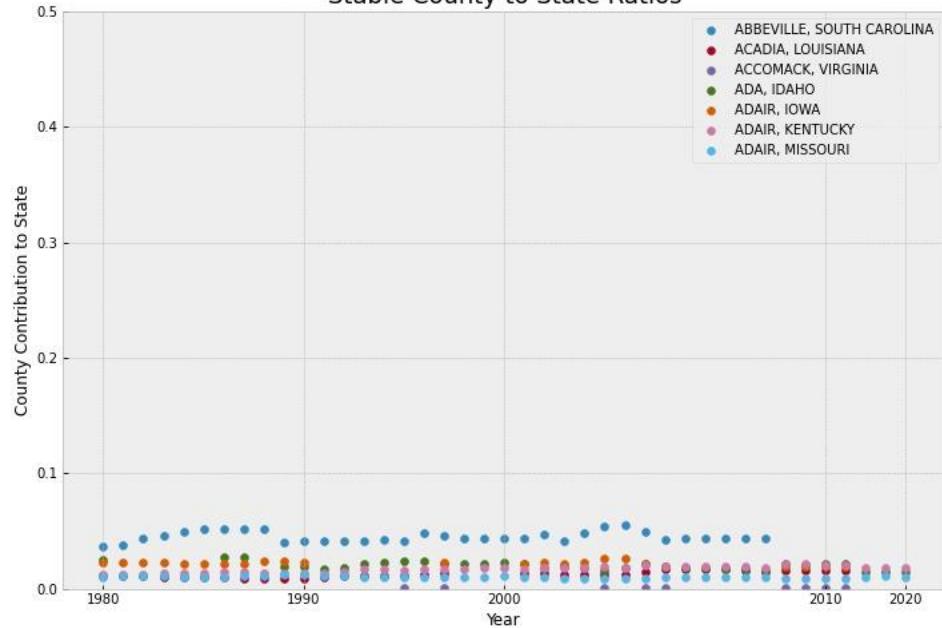
Livestock	Source Data	Imputed Data
Cows, Beef	<ul style="list-style-type: none"> ★ CATTLE, INCL CALVES - INVENTORY ★ CATTLE, COWS - INVENTORY 	<ul style="list-style-type: none"> ★ CATTLE, (EXCL MILK COWS & REPL HEIFERS) - INVENTORY ★ CATTLE, COWS, BEEF - INVENTORY
Cows, Milk		<ul style="list-style-type: none"> ★ CATTLE, COWS, MILK - INVENTORY ★ CATTLE, COWS, MILK - INVENTORY, AVG, MEASURED IN HEAD
Chickens, Layers	<ul style="list-style-type: none"> ★ EGGS - PRODUCTION, MEASURED IN EGGS 	<ul style="list-style-type: none"> ★ CHICKENS, (EXCL BROILERS) - INVENTORY ★ CHICKENS, LAYERS - INVENTORY, AVG, MEASURED IN HEAD ★ CHICKENS, LAYERS - INVENTORY
Chickens, Broilers	<ul style="list-style-type: none"> ★ CHICKENS, BROILERS - PRODUCTION, MEASURED IN HEAD 	<ul style="list-style-type: none"> ★ CHICKENS, BROILERS - INVENTORY
Hogs	<ul style="list-style-type: none"> ★ HOGS - SALES, MEASURED IN HEAD ★ HOGS, BREEDING - INVENTORY ★ HOGS - PIG CROP, MEASURED IN HEAD 	<ul style="list-style-type: none"> ★ HOGS - INVENTORY

Incomplete Livestock Data

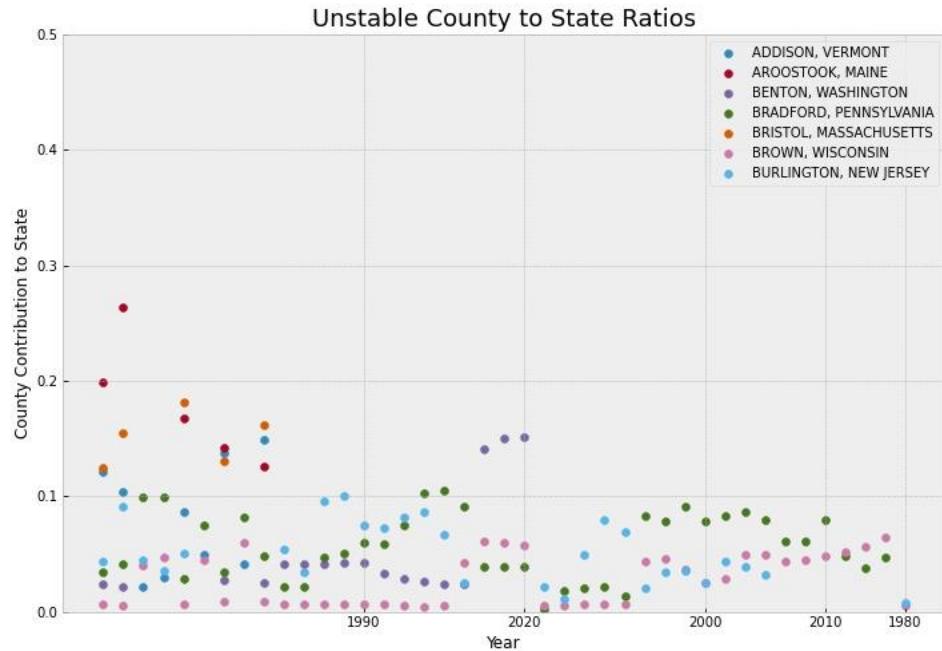
Ratios Stable
across Time

Time Interpolation

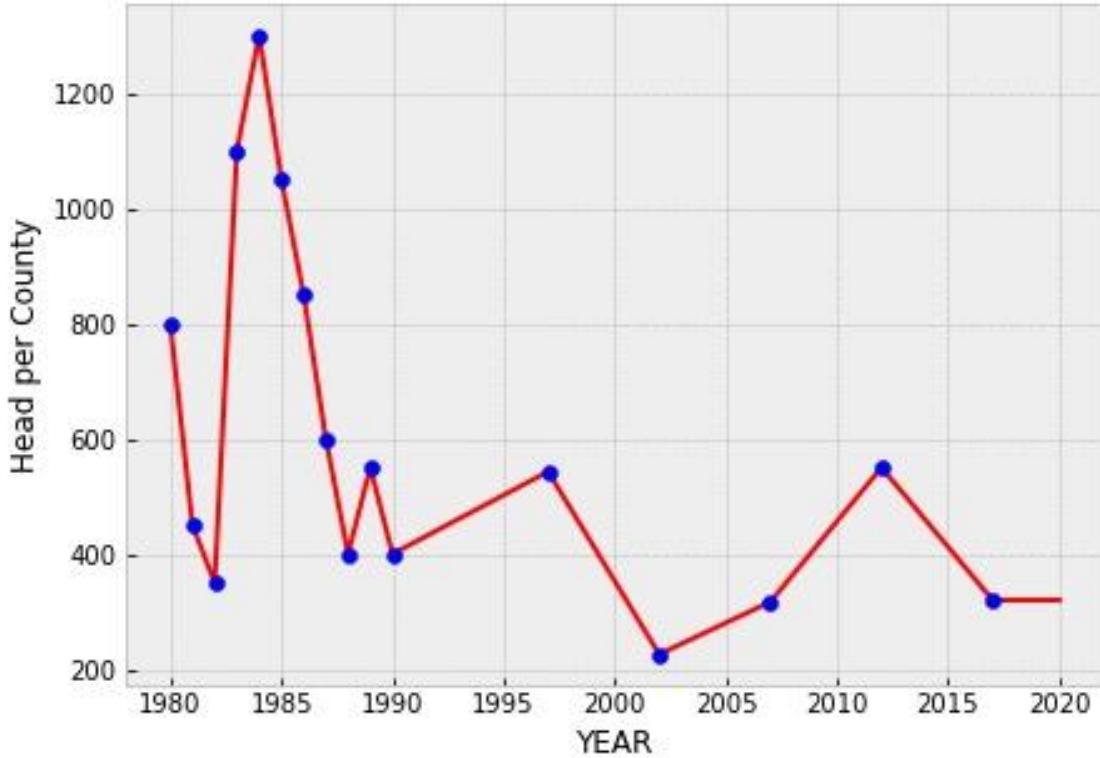
Stable County to State Ratios



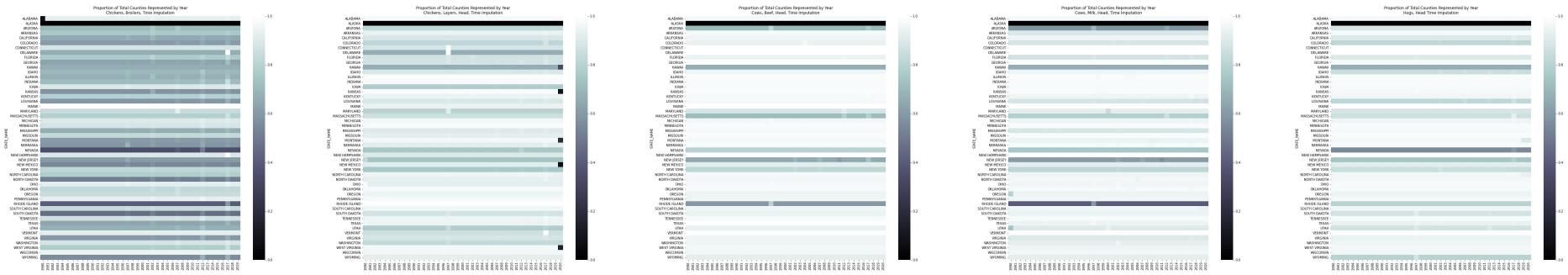
Unstable County to State Ratios



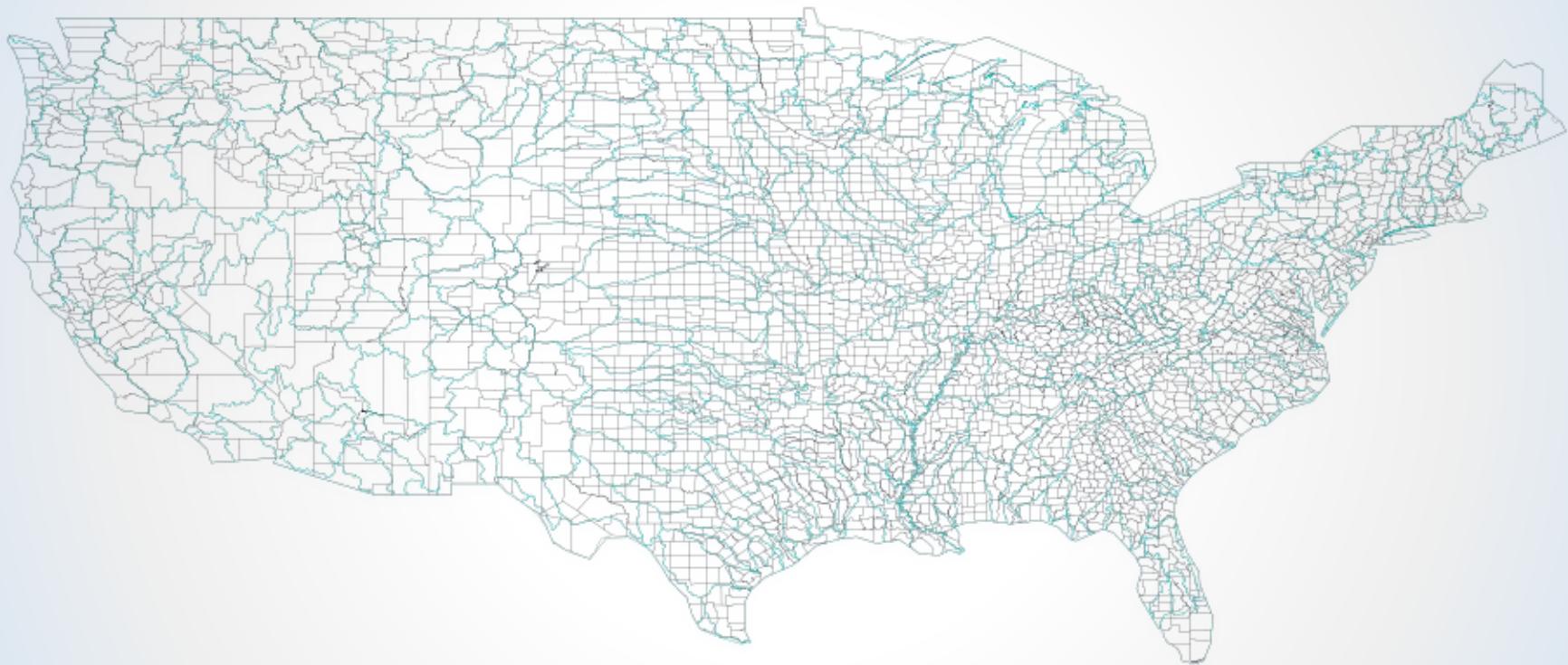
Time Series Interpolation in MONMOUTH, NEW JERSEY



Time Interpolation

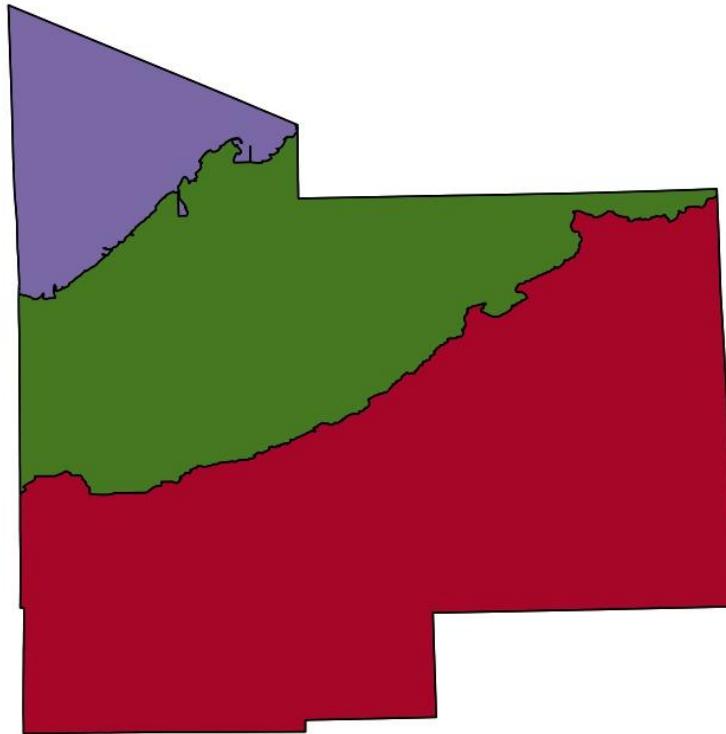




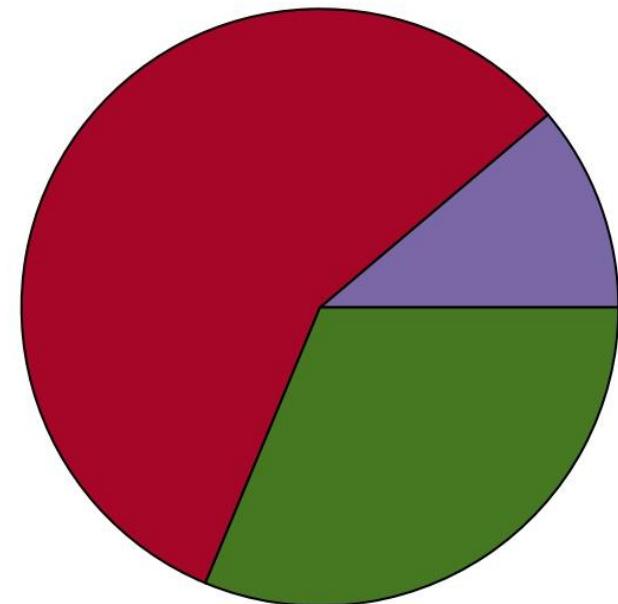


Geographic Ratio Allocation

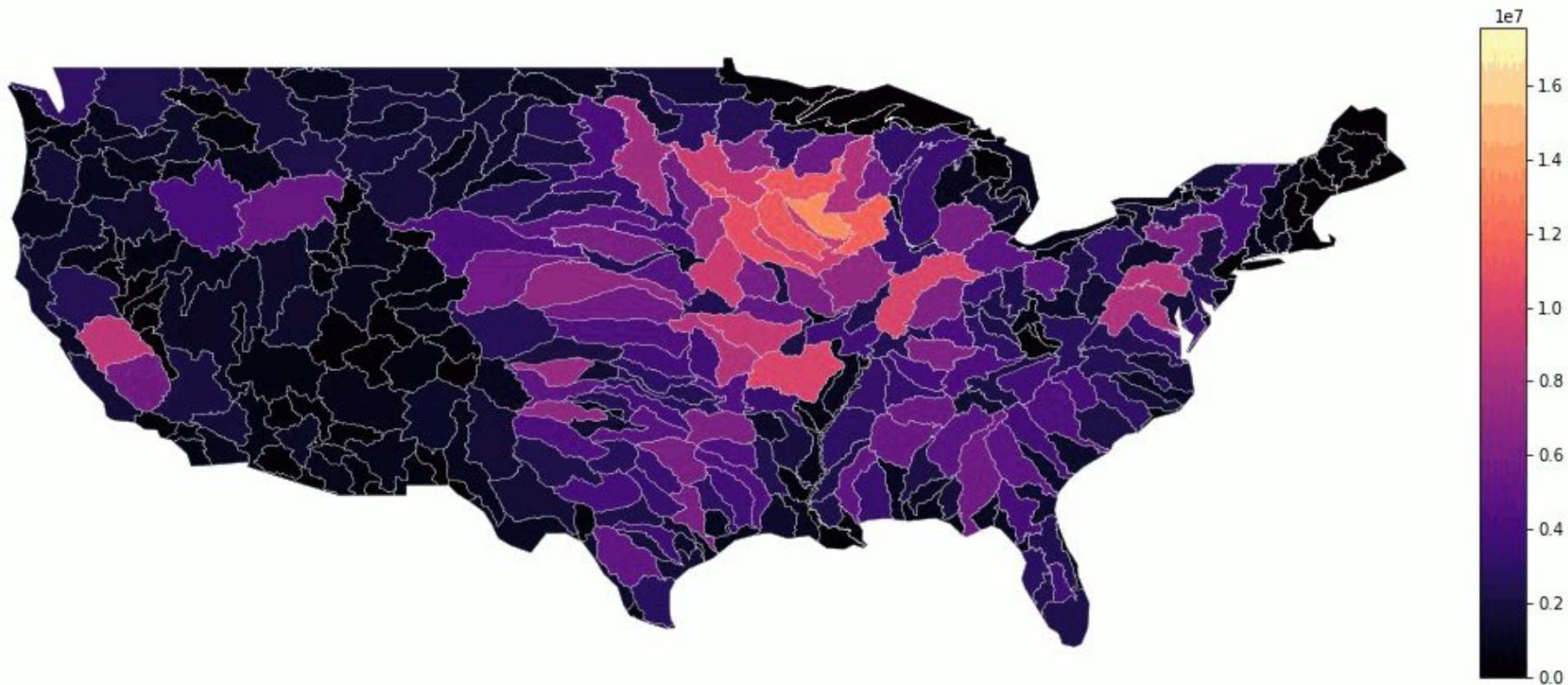
Tuscola County, MI

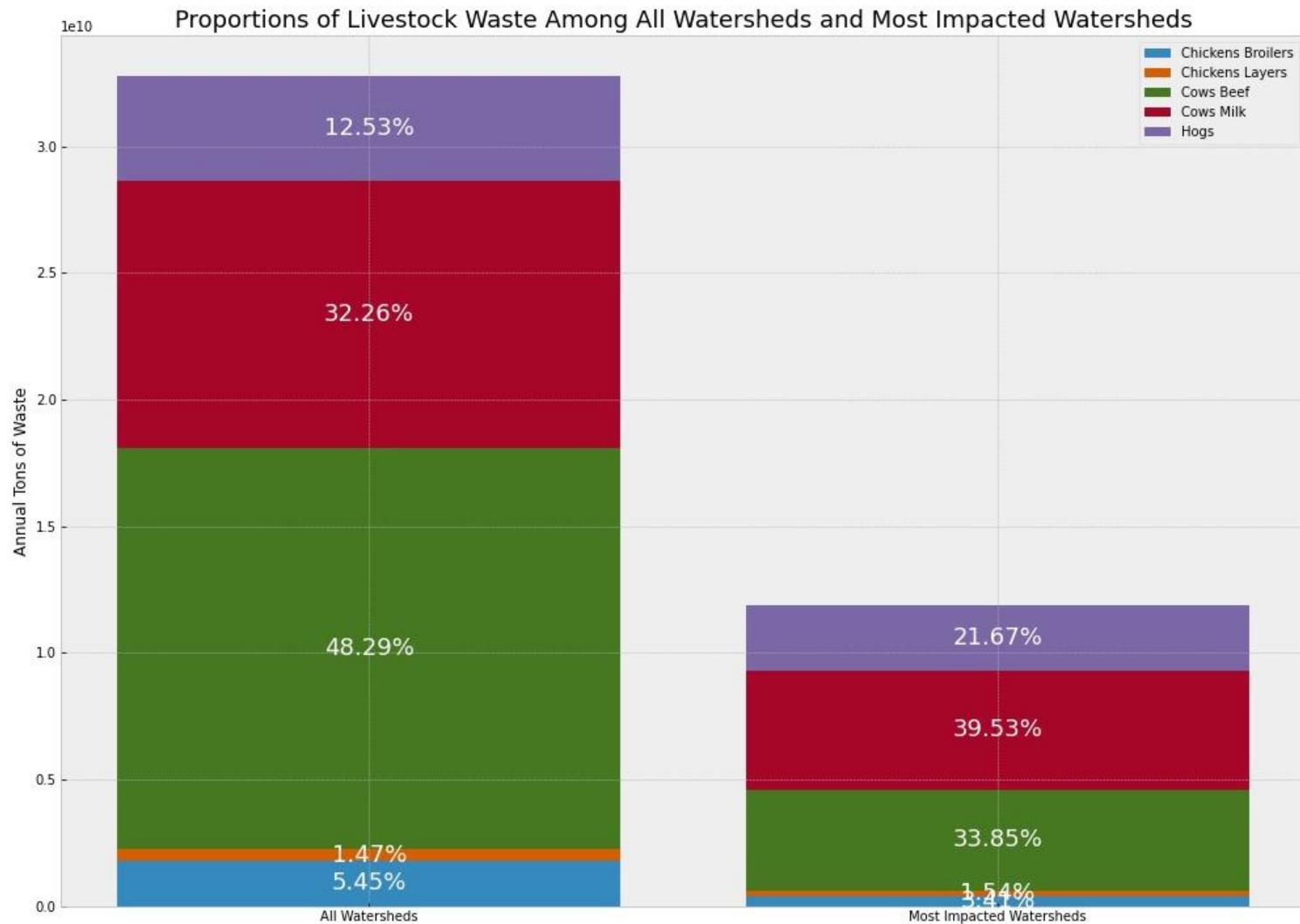


Proportion of Each Watershed Belonging to Tuscola County, MI

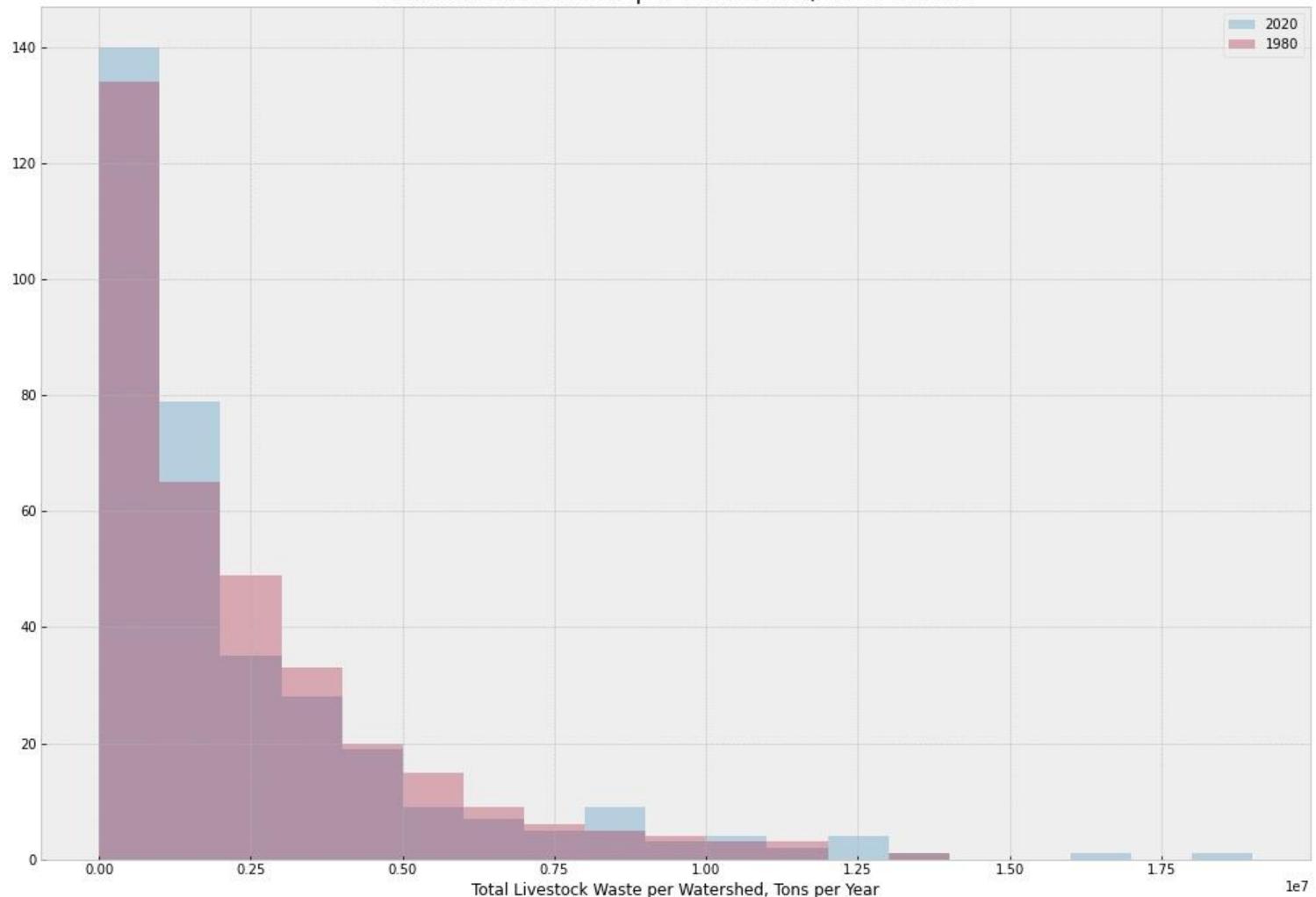


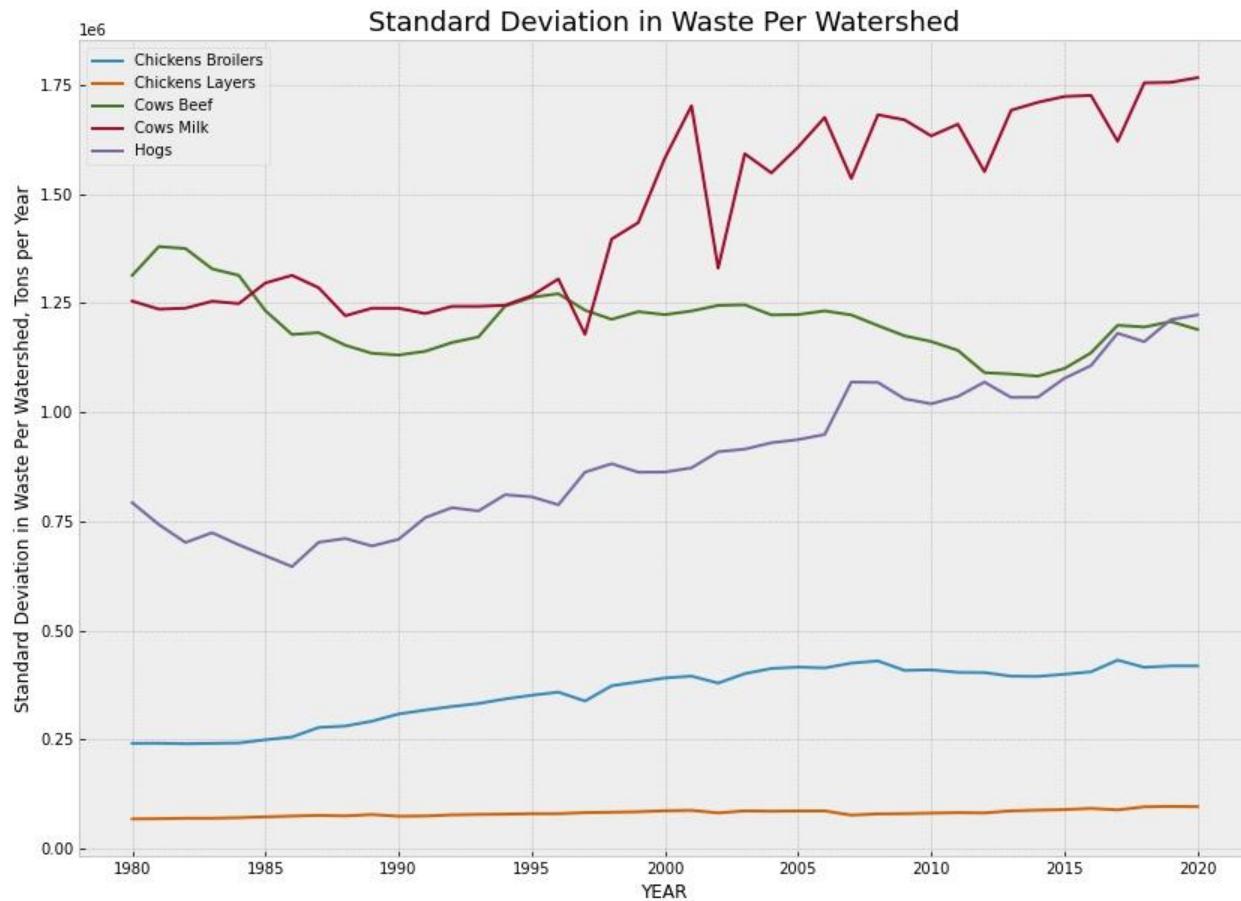
Total Livestock Waste, Tons per Year, by Watershed, 1980



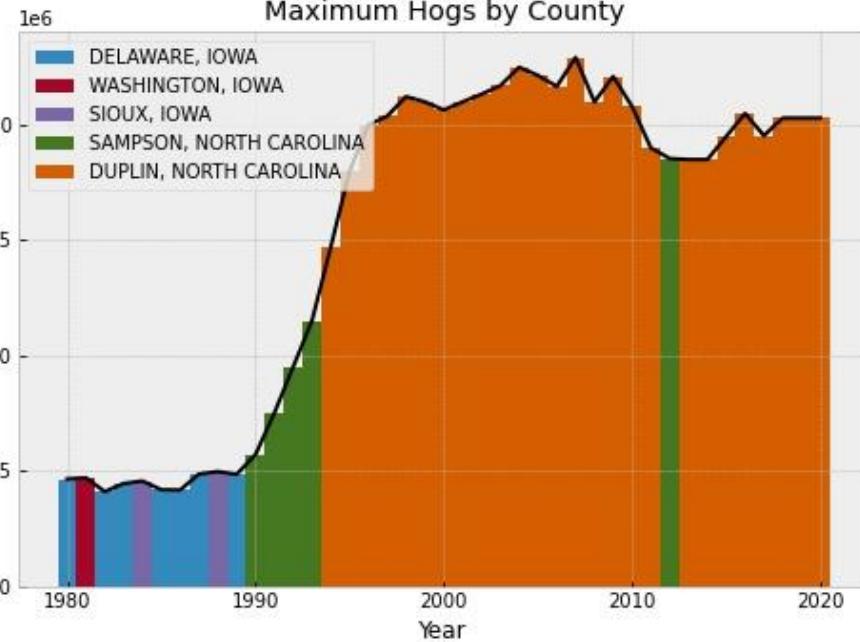


Total Livestock Waste per Watershed, 1980 & 2020

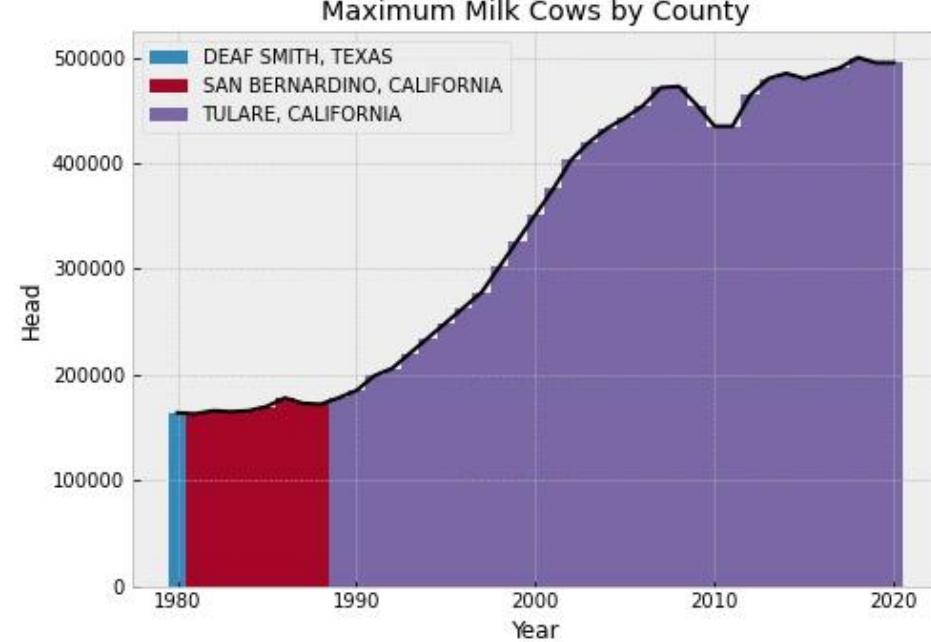




Maximum Hogs by County

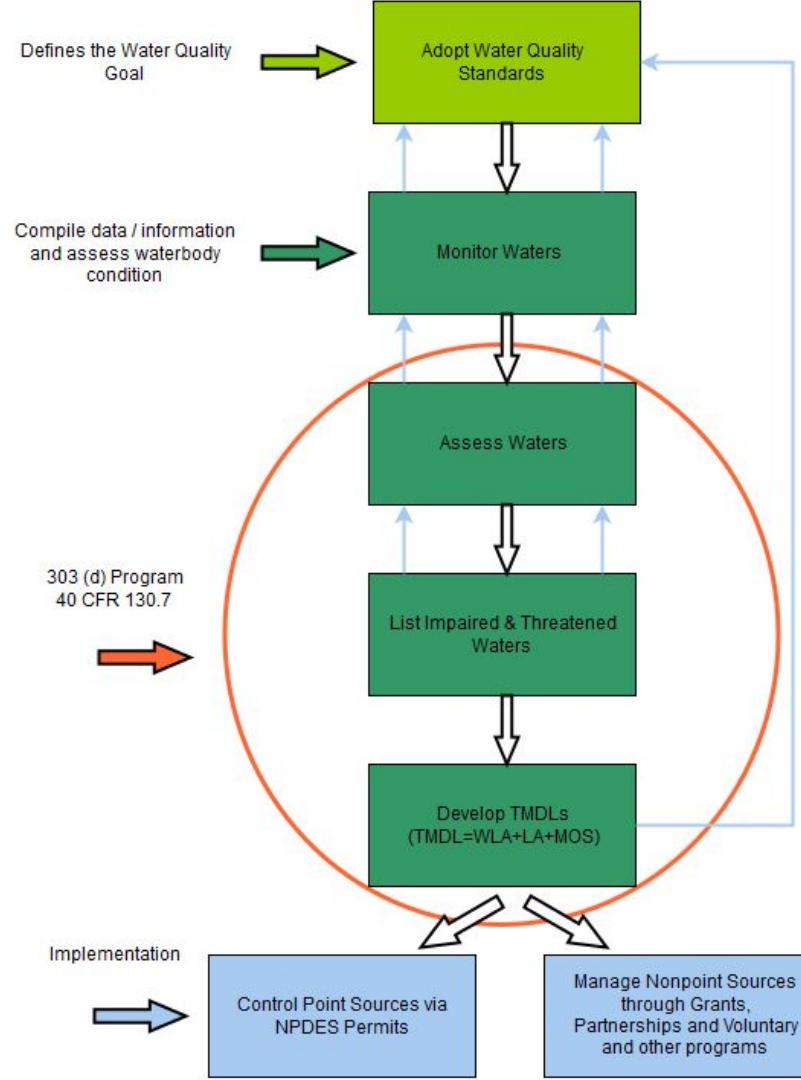


Maximum Milk Cows by County



EPA Impaired Waters

Section 303(d) of the Clean Water Act authorizes EPA to assist states, territories and authorized tribes in listing impaired waters and developing Total Maximum Daily Loads (TMDLs) for these waterbodies. A TMDL establishes the maximum amount of a pollutant allowed in a waterbody and serves as the starting point or planning tool for restoring water quality.



Hypothesis Test

- Does the 303(d) classification of impaired waters relate to the amount of livestock waste in that watershed?

$$H_0: \mu_1 = \mu_2$$

$$H_1: \mu_1 \neq \mu_2$$

Livestock Type	<i>p</i> -value
Broiler Chickens	0.159
Layer Chickens	0.007
Beef Cows	0.703
Milk Cows	0.086
Hogs	0.033

Hypothesis Test

- Does the 303(d) classification of impaired waters relate to the amount of livestock waste in that watershed?

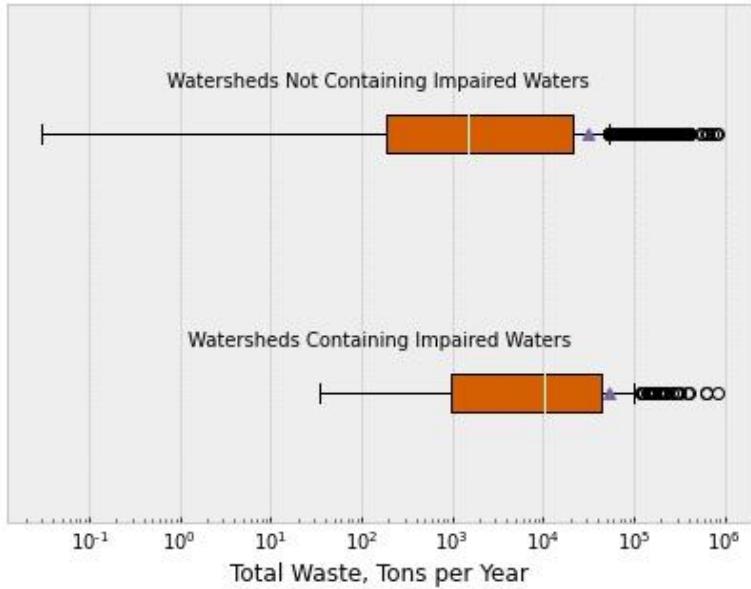
$$H_0: \mu_1 = \mu_2$$

$$H_1: \mu_1 \neq \mu_2$$

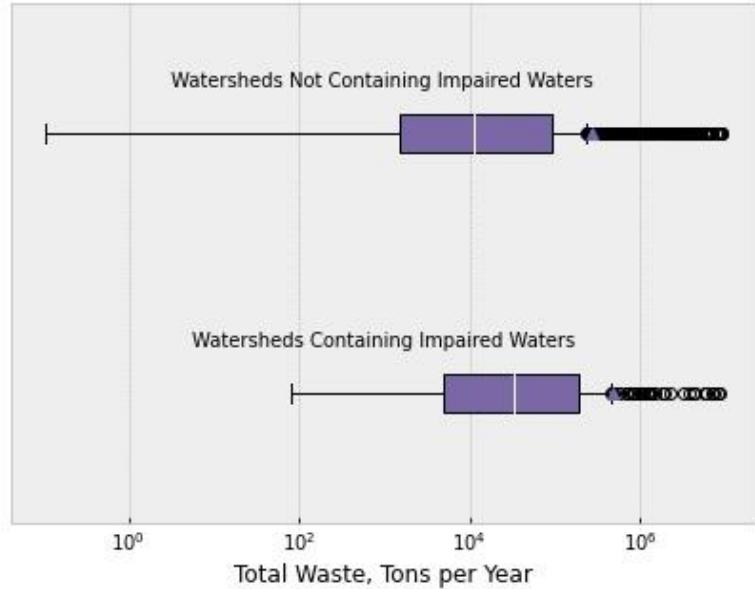
Livestock Type	p-value
Broiler Chickens	0.159
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Hypothesis Test

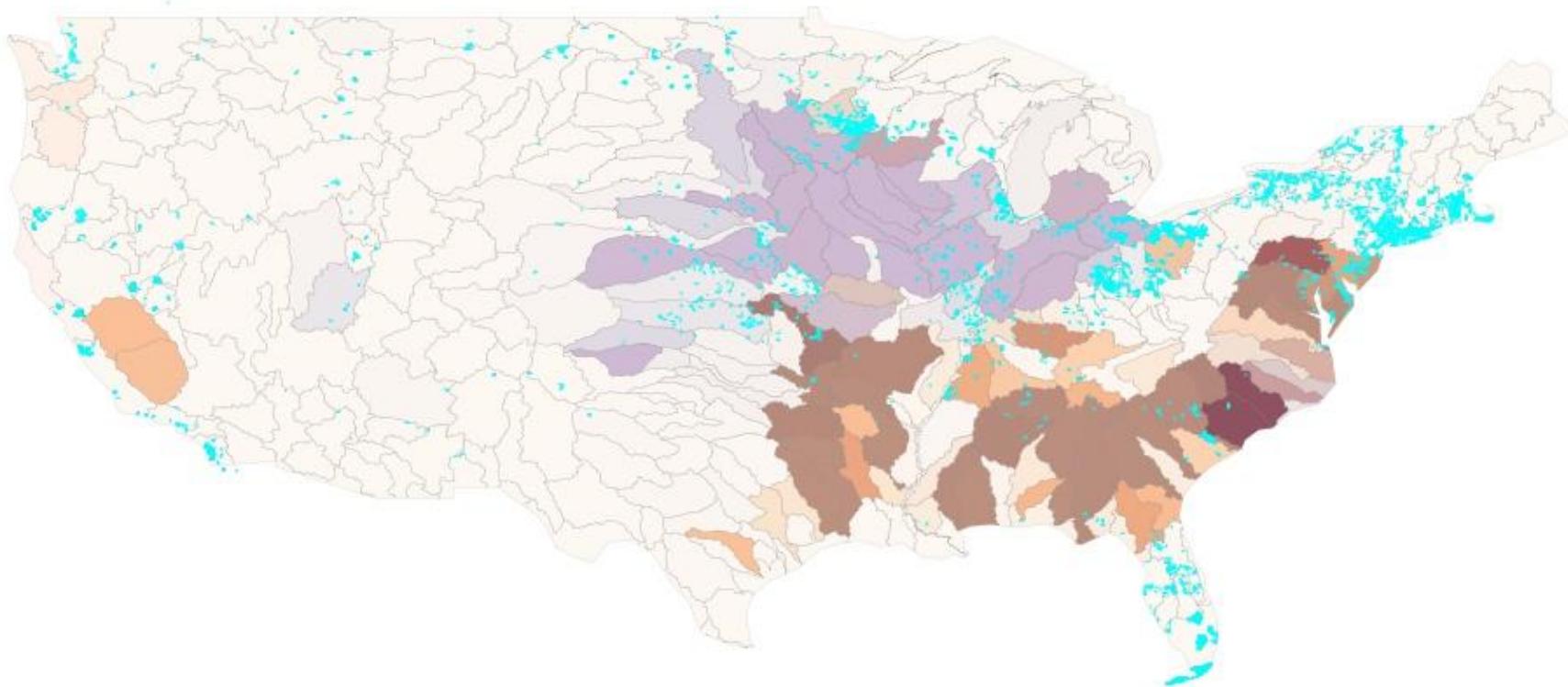
Total Chickens Layers Waste in Watersheds



Total Hogs Waste in Watersheds



Hog- and Layer Chicken- Impacted Watersheds and 301(d) Listed Waters, 2002-2012



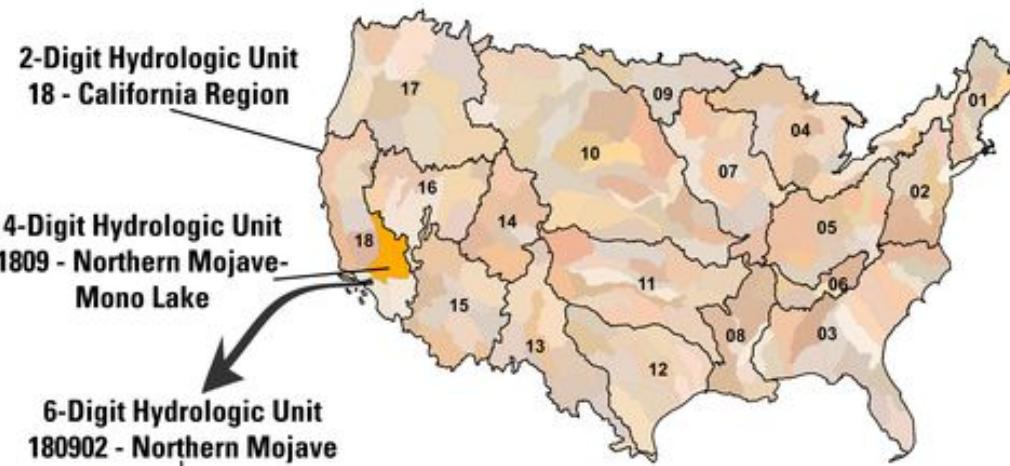
Conclusions

- Animal agriculture has become increasingly more concentrated since 1980
- The dairy and hog industries have experienced the most extreme geographic concentration
- The egg and hog industries have a measurable impact on watersheds listing on US 303(d) Impaired Waters List
- Has animal agriculture reached its saturation point? Will trends continue or reverse in the future?



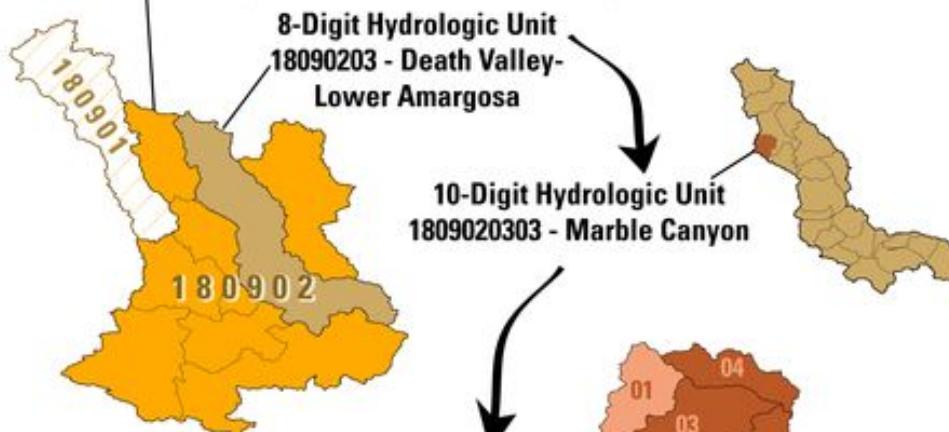
Thank You!

Appendix



4-Digit Hydrologic Unit
1809 - Northern Mojave-Mono Lake

6-Digit Hydrologic Unit
180902 - Northern Mojave



10-Digit Hydrologic Unit
1809020303 - Marble Canyon

12-Digit Hydrologic Unit
180902030303 - Upper Marble Canyon



Table A-1. The number of animal units (AU) and associated manure generation per animal type as defined by USDA's NRCS.

Animal Type	Animals per AU	Manure Generation per AU (tons)
Beef Cattle	1	11.5
Dairy Cows	0.74	15.24
Heifers & Dairy Calves	1.82	12.05
Steers, Calves, & Bulls	1.64	10.59
Swine, Breeders	2.67	6.11
Swine, Market	9.09	14.69
Chickens, Layers	250	11.45
Chickens, Broilers	455	14.97
Turkeys for Slaughter	67	8.18
Turkeys Hens for Breeding	50	8.18

Kellogg et al. 2000, Gollehon et al. 2001.

What is the Annual County Data Program?

The end-of-season December survey is supplemented with a mailing to a county sample of about 300,000 farm operators (~15 percent of the 2.19 million farms) to collect information to support the County Data program. The responses from this supplemental sample are combined with those from the December Quarterly Survey and aggregated to a County Summary.

The county data are "assembled" starting from the State estimate and working back to the county and are published by each NASS Field Office and loaded to the On-Line-Database (Published Estimates or Quick Stats Data Base). The following is a brief outline of the process to produce the annual county data, using corn for grain as an example. The State Corn for Grain estimate, published in the Crop Production Summary each January, is the total to which the counties must add. The County Summary, in combination with administrative data from various sources (other USDA agencies, cotton ginners, etc.), is the basis for the annual county data for crop acreage, yield and production, and livestock inventories. Agricultural Statistics Districts are defined groupings of counties in each State, by geography, climate, and cropping practices. Agricultural Statistics District (ASD) totals are set first because the greatest data accuracy occurs with a larger number of reports. The sum of the ASD's must equal the State estimate. After the ASD's are set, the county values in each district are set. The counties in each district must sum to the district total.

NASS Cattle Survey Methodology

The reference dates for the surveys are January 1 and July 1 with data collection periods of 15 and 14 days respectively beginning at the reference date. A considerable amount of time and effort is expended to tailor the data collection to the operation as well as coordinate the data collection with other surveys underway. Mail out/mail back data collection is used and emphasized as a cost effective and less burdensome method of data collection. Web-based reporting is also offered. However, the primary method of collecting data is phone enumeration. A limited number of personal interviews are reserved for large cattle operations or operators who request that method.

Phone enumerators utilize Computer Assisted Telephone Interviewing (CATI), a sophisticated software which allows them to verbally maintain a conversation with the respondent while following the instrument flow and question text. Reported data are entered directly into an electronic format and the software performs simple consistency checks which drastically reduces the need to make follow up contacts to the respondent.

NASS Chickens and Eggs Survey Methodology

NASS maintains a list of chicken and egg contractors and independent producers in every state. Operations with an expected inventory of 30,000 chickens or more table egg layers, flocks of hatchery supply layers, or pullet only operations with at least 500 pullets are surveyed monthly with a reference date of the first. Operations less than 30,000 are only surveyed in December. Imputation methods are employed for operations not reporting using historical data and current data relationships for similar size operations. Reports received too late to be summarized for the current month are still processed for the next month and revised estimates may be published based on these data. Data for broiler hatchery estimates are collected weekly from all broiler-type hatcheries that hatch at least one million chicks a year, with smaller broiler-type ones and egg-type hatcheries contacted monthly. Data for hatcheries not reporting are estimated based on prior reports, capacity, seasonal changes, and changes shown for hatcheries reporting.

NASS Hogs Survey Methodology

For the quarterly hog surveys, nearly 7,000 hog owners are contacted for inventory as of the first of the month for (1) sows and gilts for breeding, (2) sows and gilts expected to farrow for the next six months, (3) boars and young males used for breeding, (4) weight groups of market hogs and pigs (under 50 pounds, 50 to 119 pounds, 120 to 179 pounds, and 180 pounds and over), (5) sows and gilts that farrowed during the previous three months and the resulting pig crop whether the hog operation still owned, sold, or slaughtered the pigs, and (6) information on contractor/contractees. The quarterly hog sample is drawn from the list of known hog owners on the NASS list frame. Owners are stratified by size of total inventory. Information for the quarterly hog surveys is collected by electronic data reporting, mail, telephone interview, and face-to-face personal interviews.