A Comprehensive Review of the Dog Population in the United States: From 2018 to 2050

Looking beyond the shelter data

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How to Understand Complex Systems with Data

There are two main approaches:

- ✓ direct measurements and estimation.

- Direct measurement lends itself to highly specific studies which have a manageable scope and a high degree of accuracy in the measurement.

- Estimation techniques work well when there is uncertainty in the measurement and it is difficult to obtain sufficient direct measurements, like counting the population in the United States.

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Tenets in the Modeling

Integrated in human demographic, pet ownership and shelter data

Utilized county level of aggregation

Utilized estimation and inferential techniques to predict number of dogs in the community

Centered on "controllable" factors related to animal welfare activities

- Spay/Neuter will reduce stray and unwanted pets over time
- Technology like microchips will improve RTO rates over time
- Promotion of adoptions will increase adoptions over time
- Intervention programs will help reduce relinquishments
- Increasing pet ownership is a good thing

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Predicting the Number of Dogs

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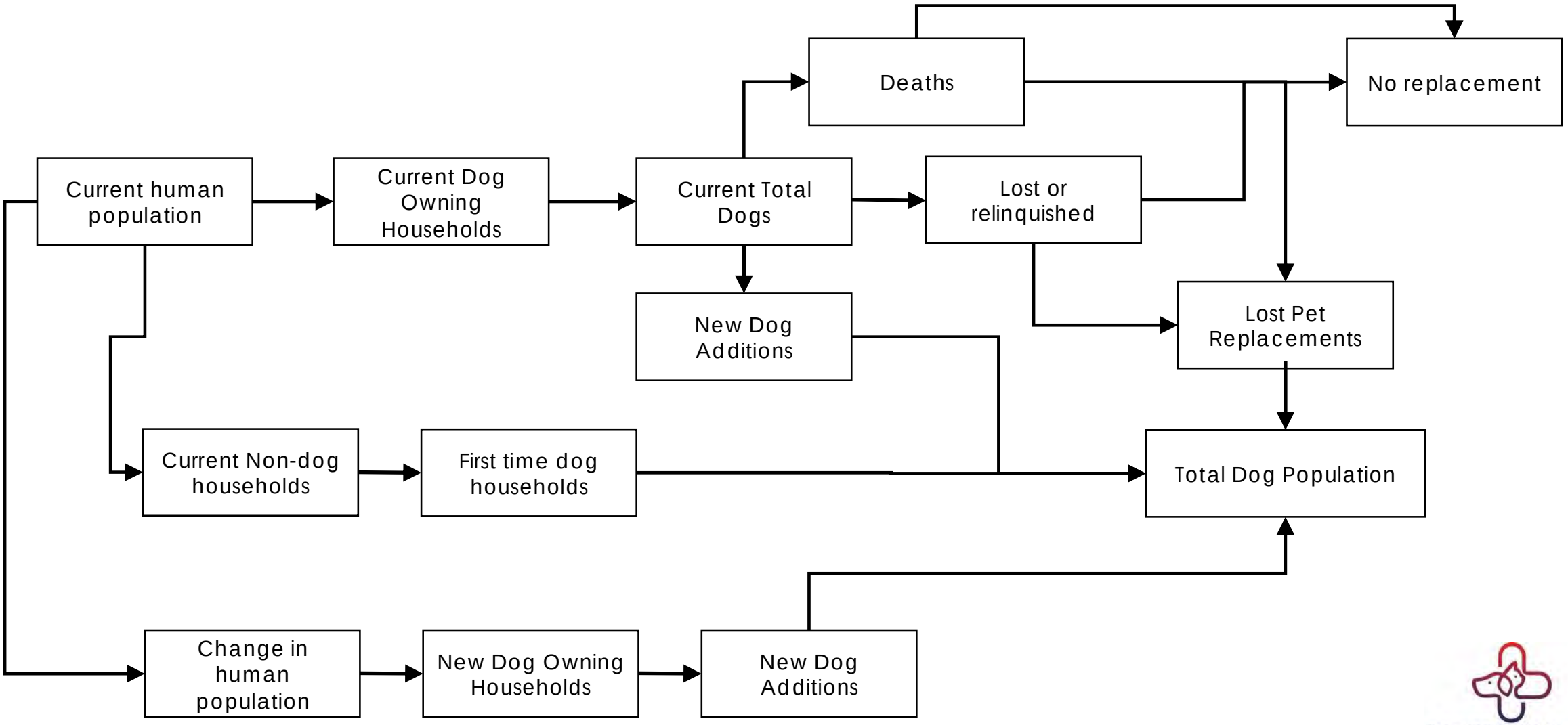
Demand: Dog Population Model Schematic



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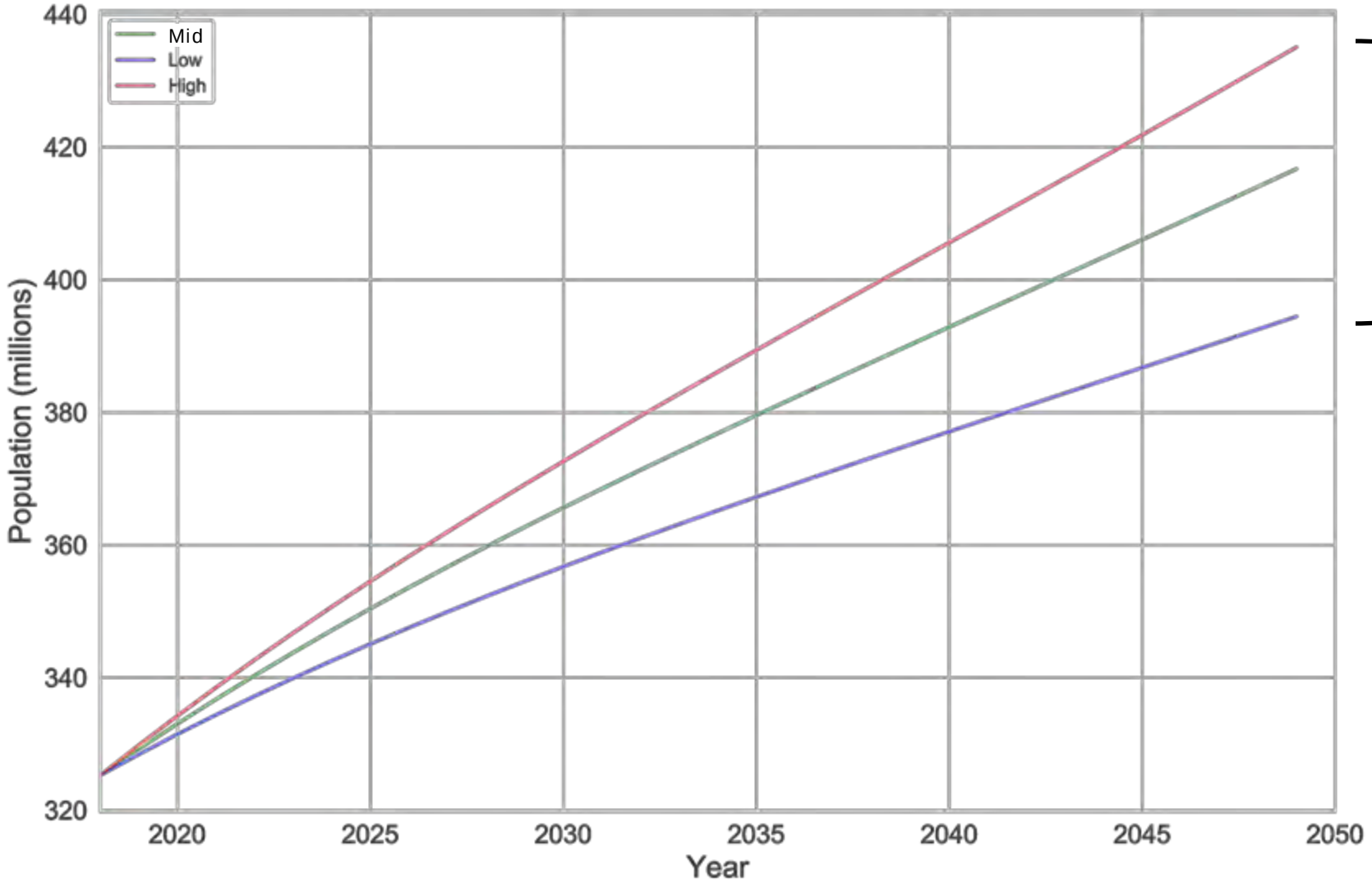
Human Population Estimates



Differences are from the estimated amount of immigration into the US

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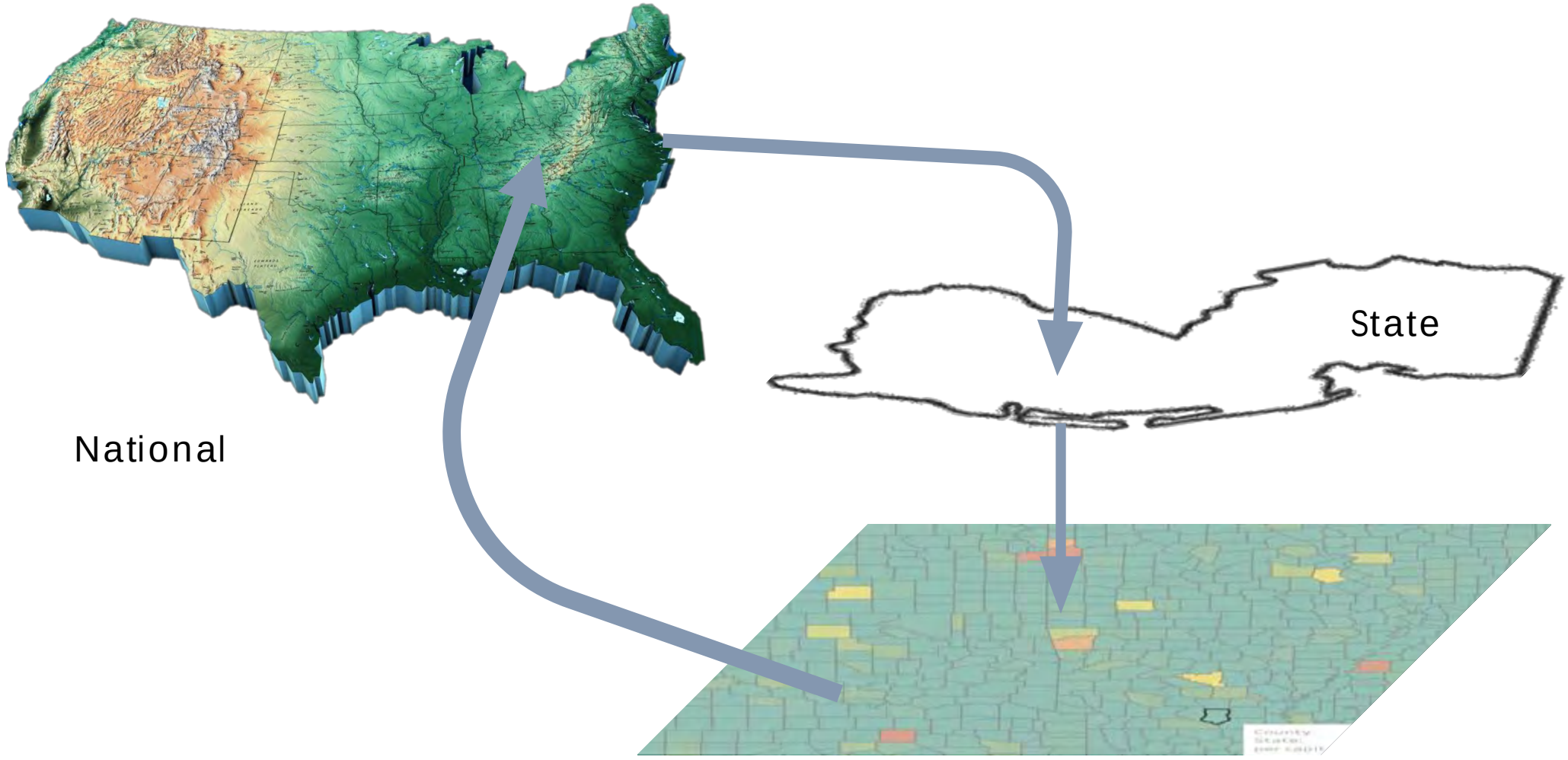
Data Aggregation Level Paradox



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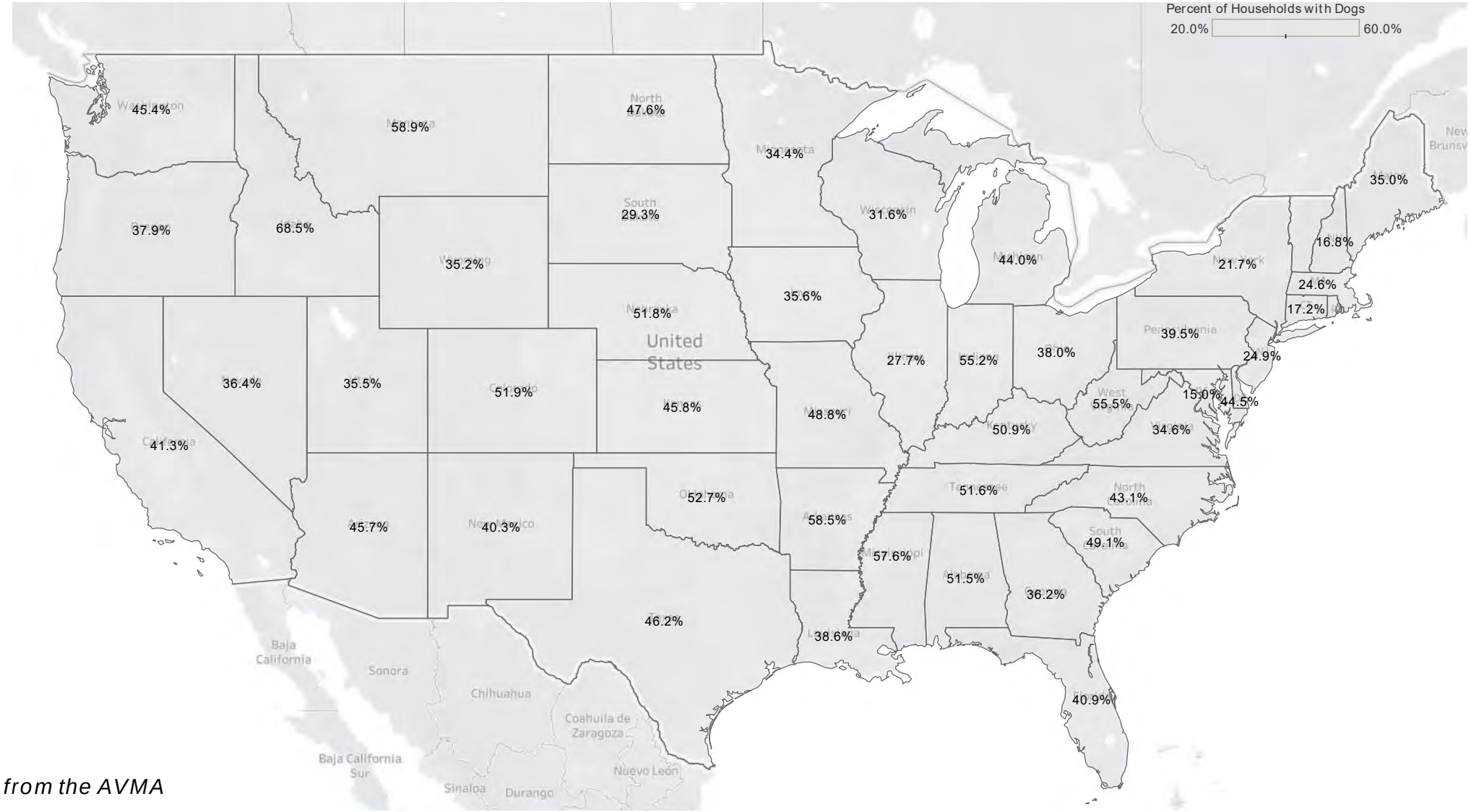
Percent of Households with a Dog



Data from the AVMA

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AVMA Data on Dog Ownership

S3_TAB 17. PERCENT WHO OWNED DOGS BY HOME OWNERSHIP STATUS, 1991–2016

	1991	1996	2001	2006	2011	2016
Home Ownership Status	**%**	**%**	**%**	**%**	**%**	**%**
Own Home	40.7%	36.2%	39.4%	42.1%	45.6%	45.3%
Rent	23.6%	22.2%	23.8%	26.7%	29.9%	32.3%
Other	38.4%	32.3%	39.4%	41.7%	42.1%	36.3%

In 2016, the rates of dog ownership were twice as high among people who lived in mobile homes (53.3%) and houses (47.5%) compared to people in apartments or condominiums (21.2%) (S3_TAB 18).

S3_TAB 18. PERCENT WHO OWNED DOGS BY TYPE OF RESIDENCE, 2001–2016

	2001	2006	2011	2016
Type of residence	**%**	**%**	**%**	**%**
House	40.8%	43.2%	46.8%	47.5%
Apartment/condo	n/a	n/a	21.6%	21.2%
Mobile home	45.4%	50.2%	51.0%	53.3%
Other	24.8%	27.3%	29.0%	26.7%

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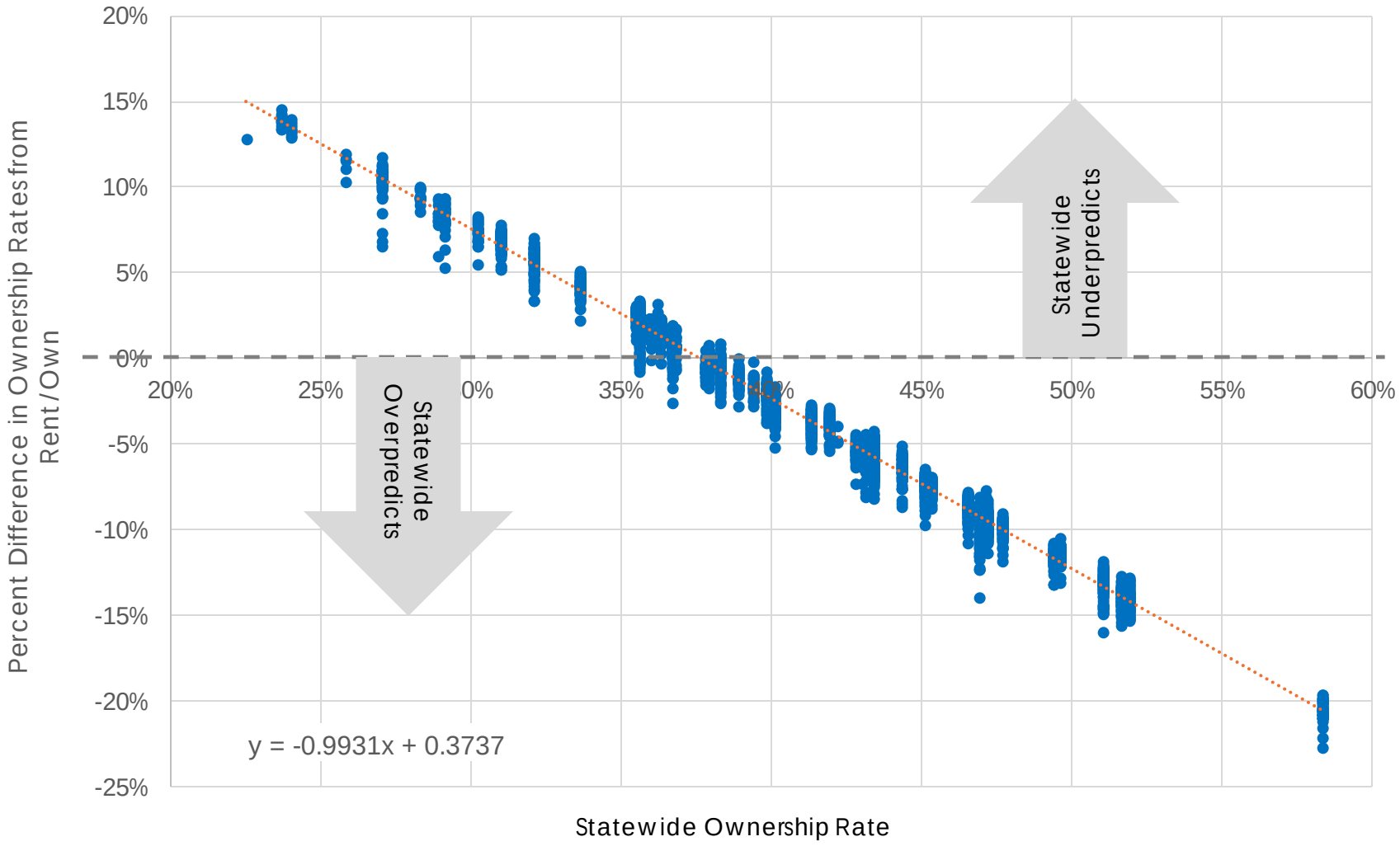
Comparison Total Predicted Ownership rates w/ Dogs



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Estimating the Number of Dog Owning Households

Estimated Dog Ownership Rates and Dog Owning Households in 2018		
Method/Source	Dog Ownership Rates	Dog-Owning Households
AVMA	38.0%	48,225,413
APPA	48.0%	57,129,544
Simmons	38.0%	45,227,555
State-level Method	41.5%	49,448,713
Community-size Method	41.2%	49,135,657
Housing Status Method	40.8%	48,607,596

Outlier

Used this method

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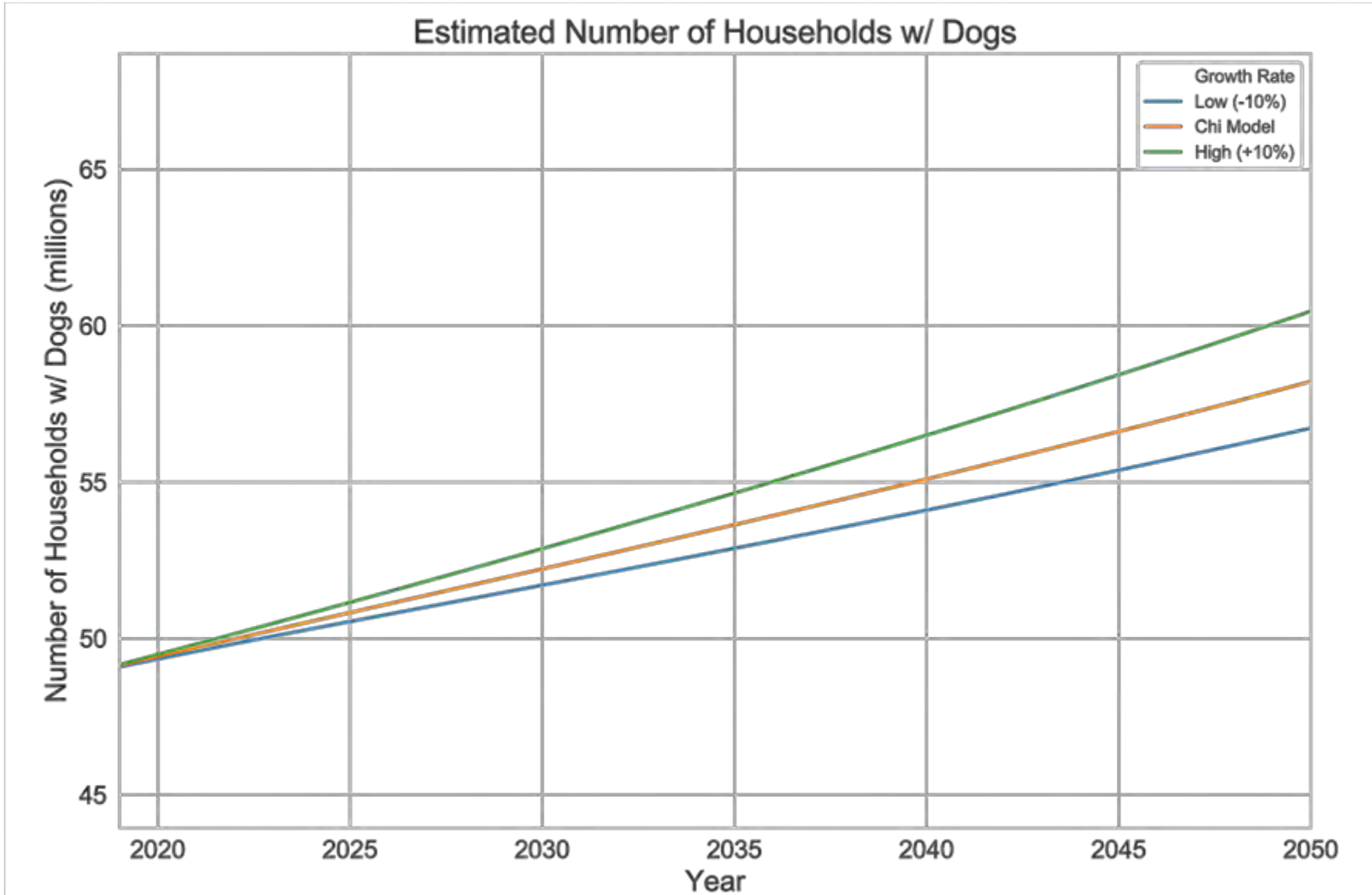
Number of Households with Dogs



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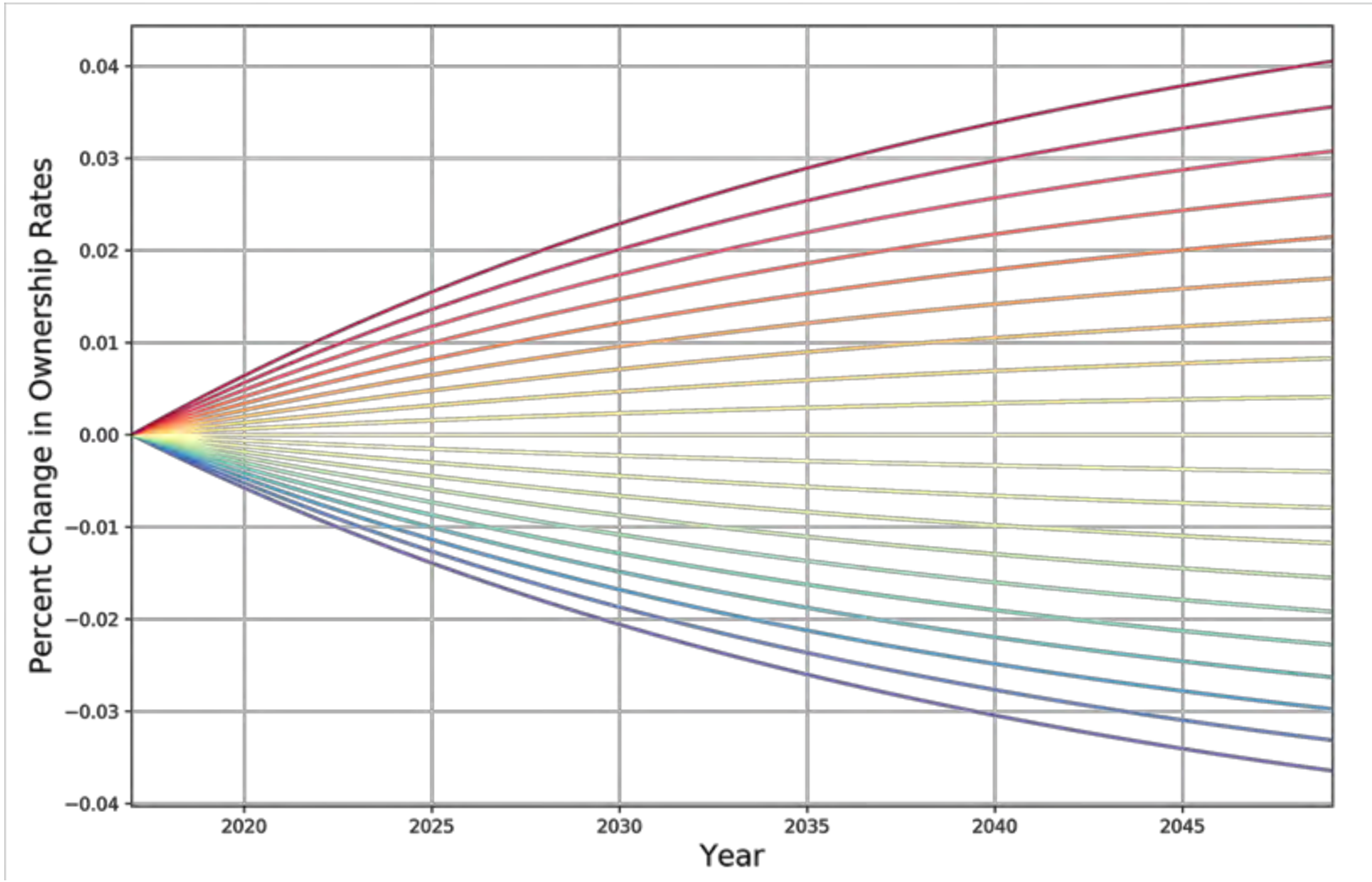
Variability In Ownership Rates



The key controllable variable utilized in testing the sensitivity of the model is dog ownership rates.

This is considered controllable because there are programs that can be executed to try and increase the rate of dog ownership.

A range of ownership rate changes was tested from increasing by 4% to decreasing by 3.8%

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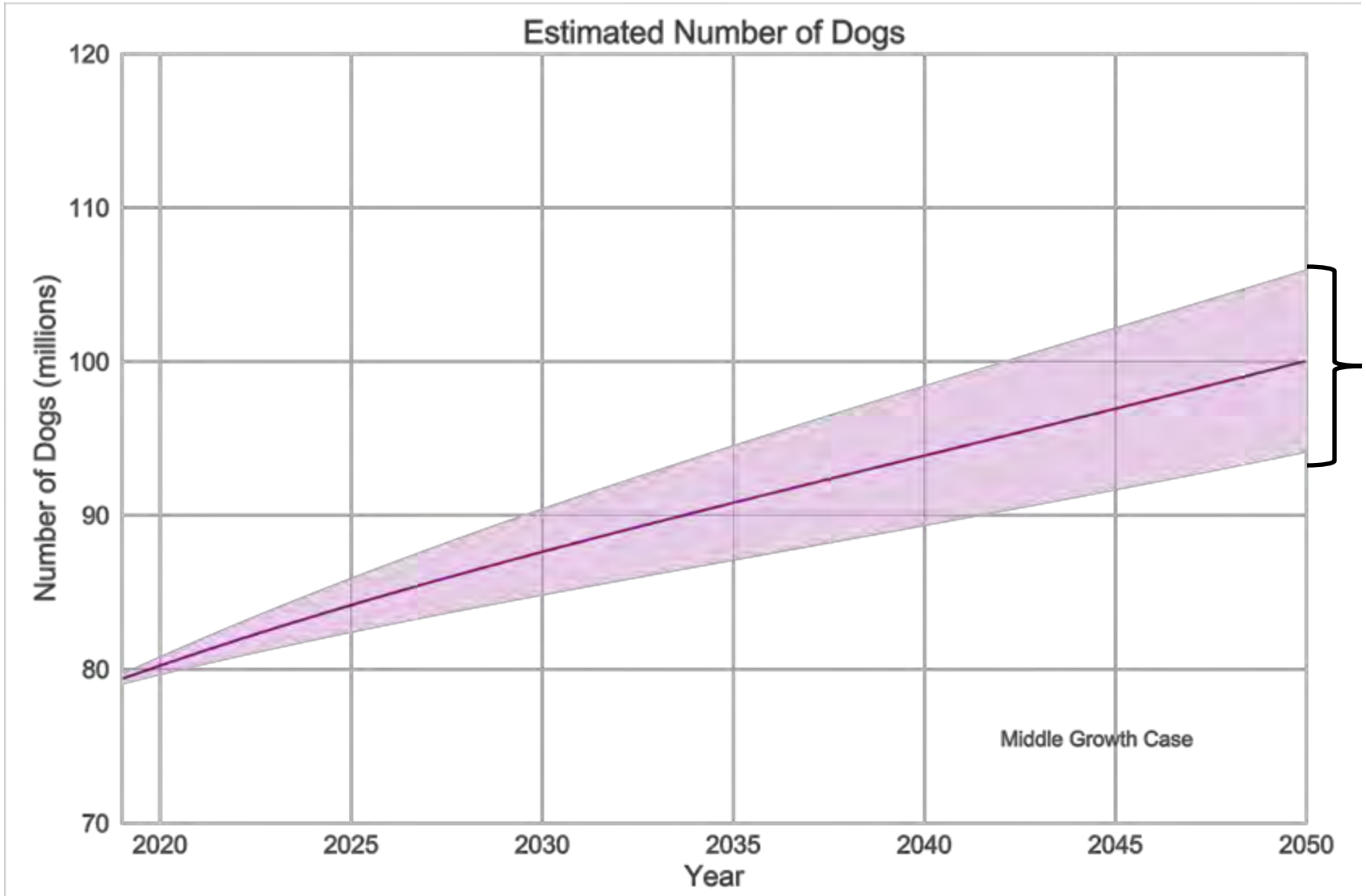
Number of Dogs



Sensitivity of the model to ownership rates. Shaded area is the standard deviation from all the scenarios

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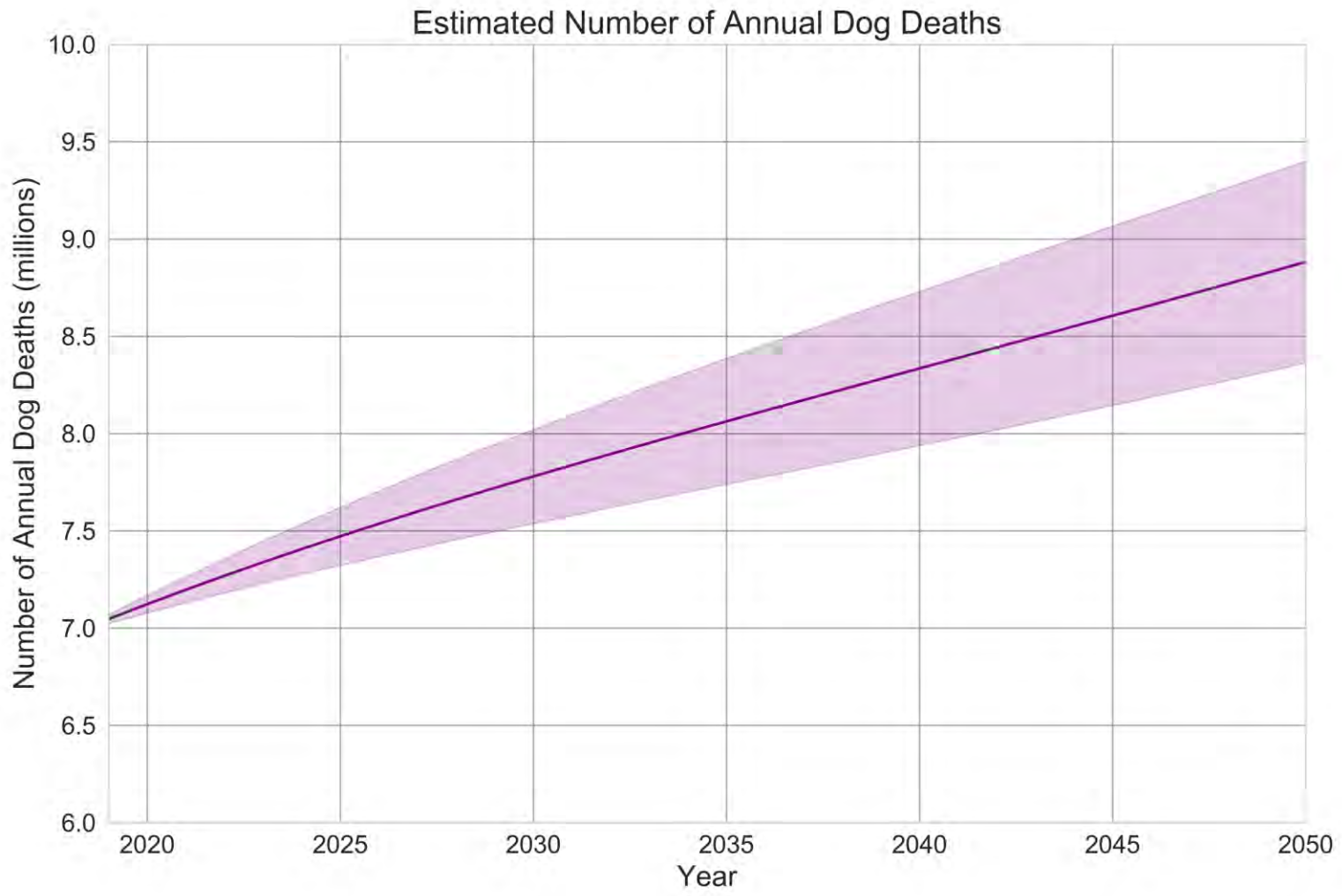
Annual Dog Deaths



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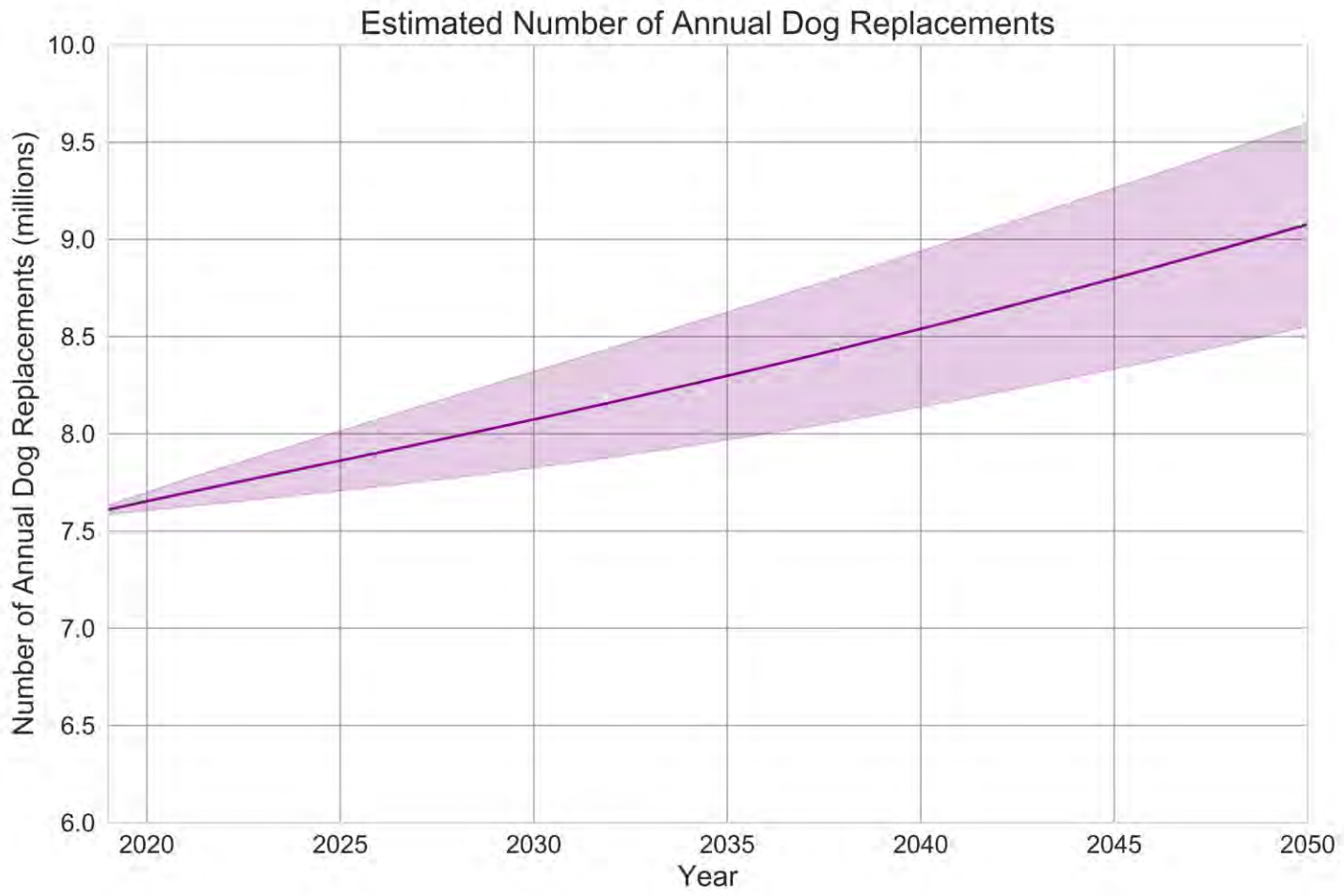
Annual Dog Replacements/Acquisitions



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Estimating Future Shelter Populations

Integrating Shelter and Demographic Data to Predict Homeless Dogs

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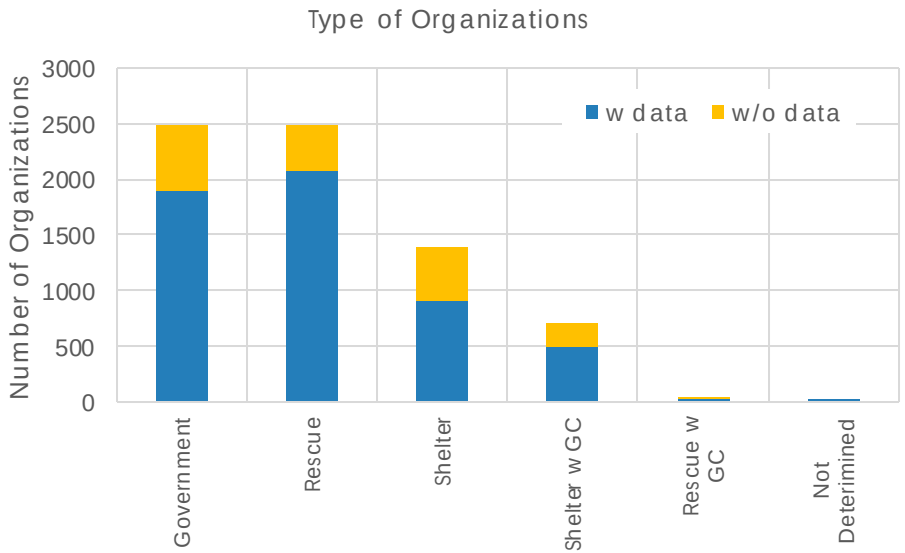
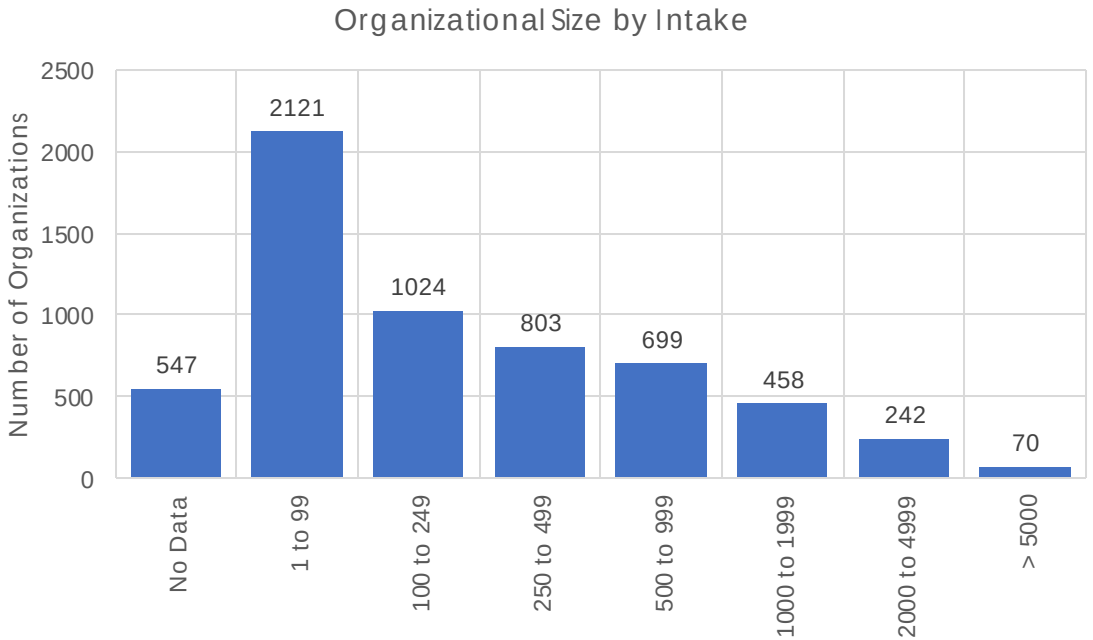
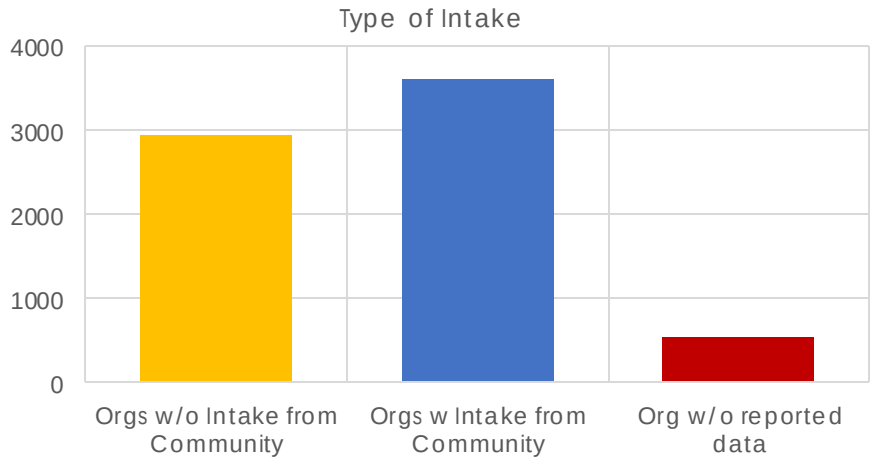
Summary of Data Sources







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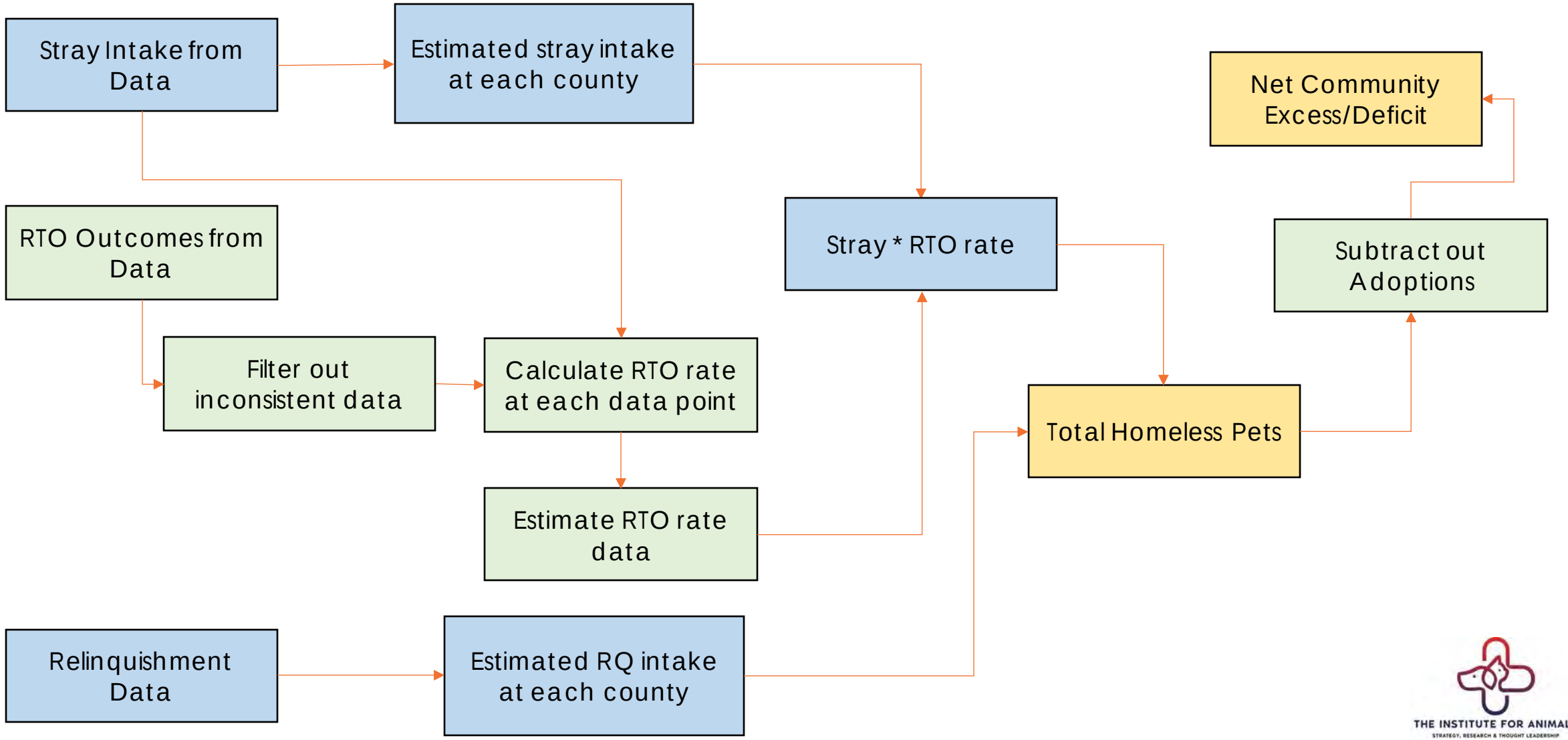
Estimating the Total Homelessness in the Community



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Types of Data Challenges

- Non-random sampling of the population
  - the data suffers from both spatial, type and temporal sampling errors that complicate the analysis and interpretation.
- Dominantly self-reported
  - data suffers from input errors, miscoding, and incomplete reporting that can be difficult to unravel.
- The intake and outcome data are often geographically disassociated
  - where an animal comes in is not necessarily where the animal goes out.
- A shelter does not represent a point in space but rather a sphere of influence
  - in general, the size and scope of that sphere of influence is unknown.
- Internal shelter policies create data distortion

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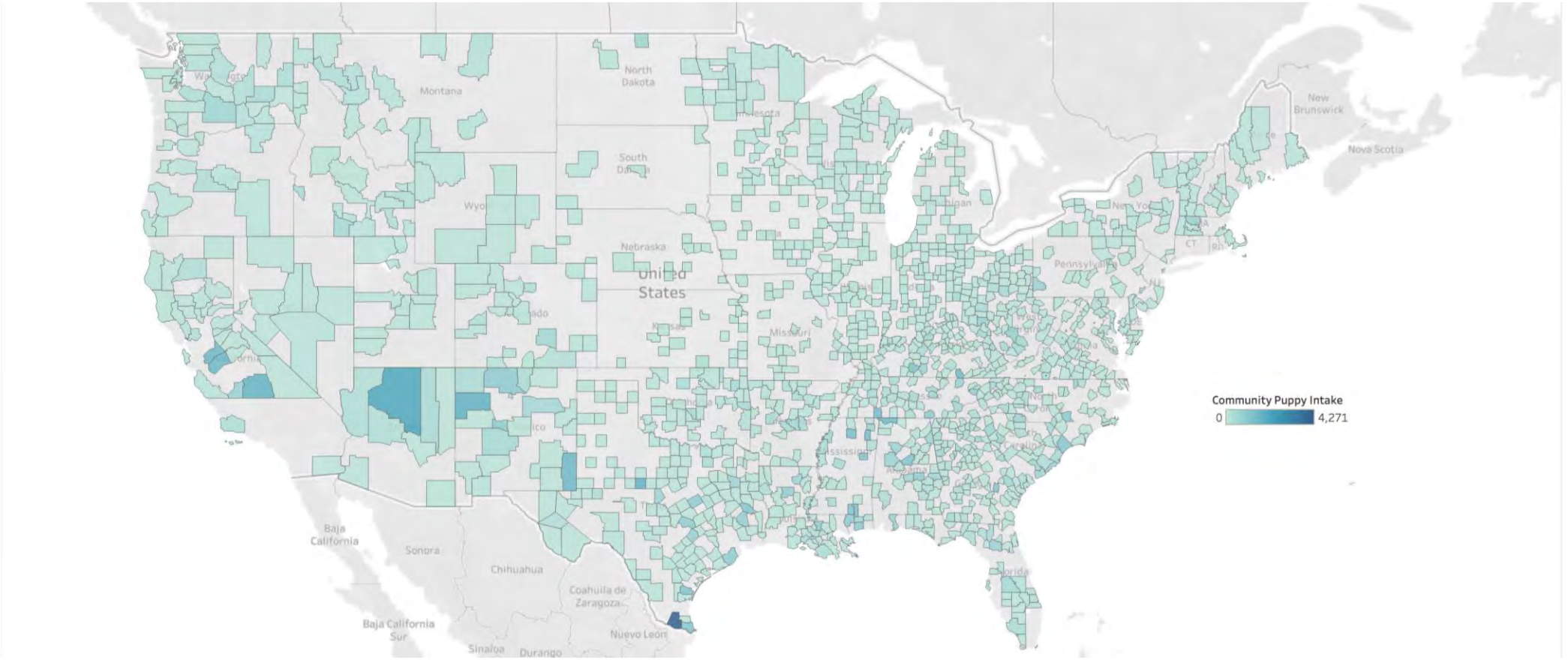
Sparse Data



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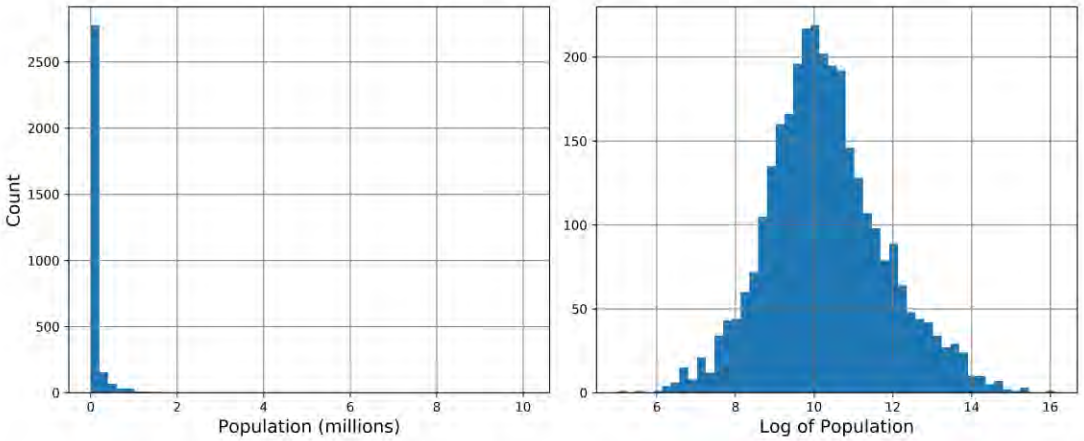
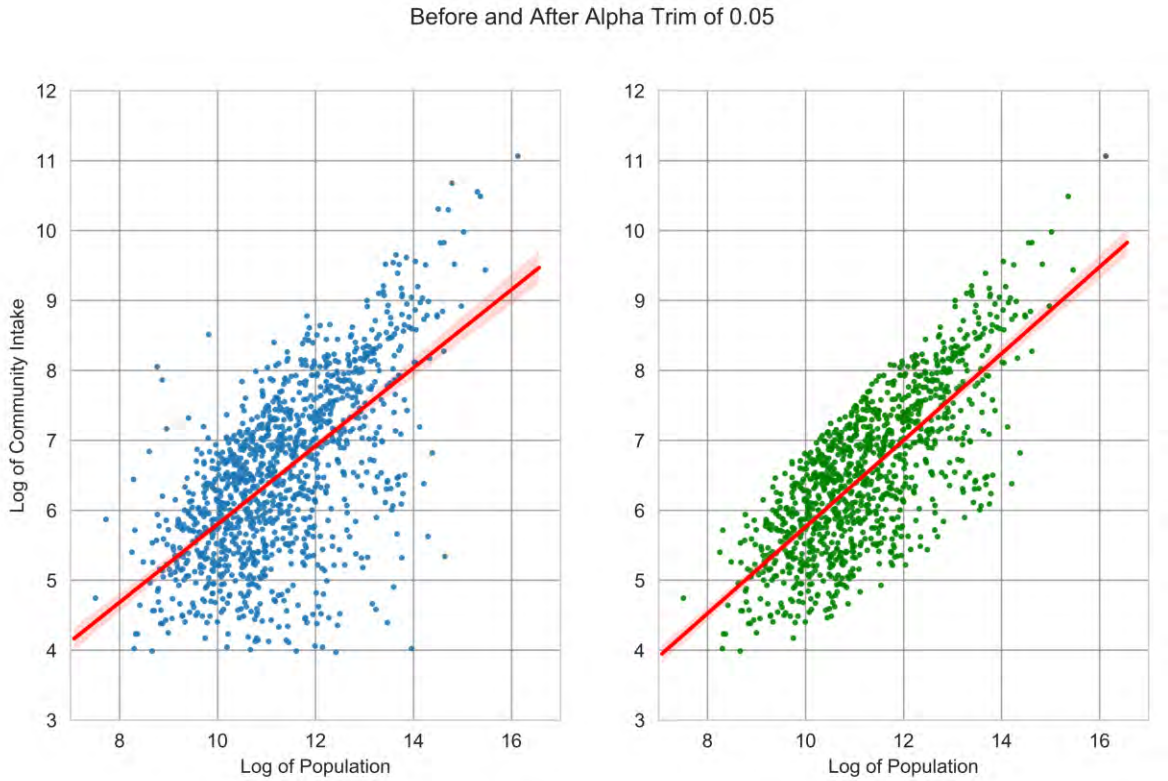
Data Conditioning Required

Domain Transformation





Outlier Removal

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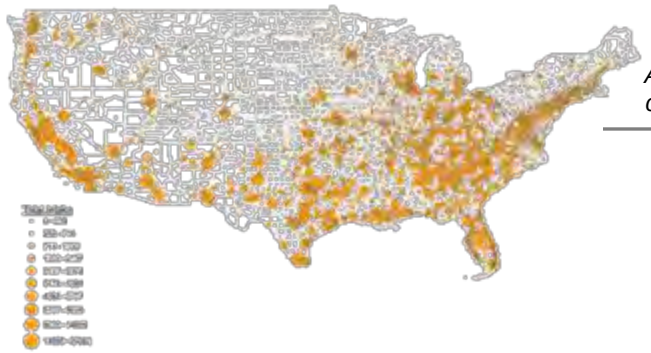
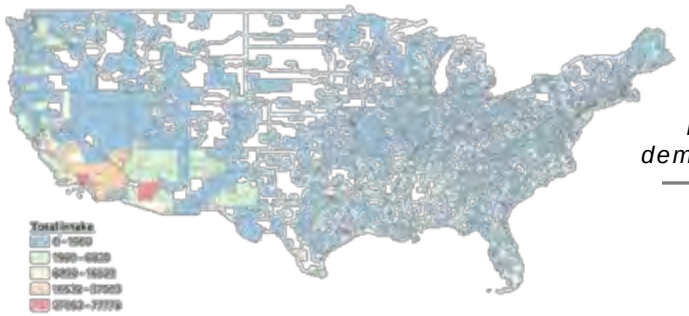
Interpolating Using Random Forest Regression

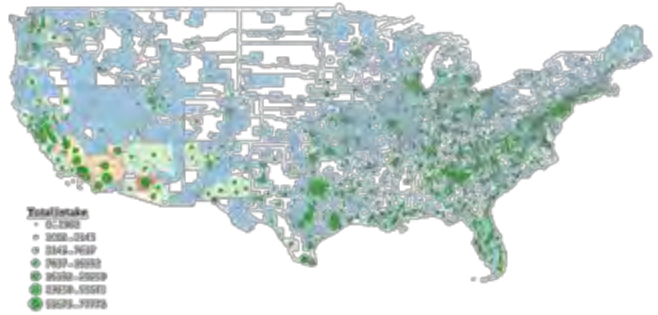
Known Shelter Attribute



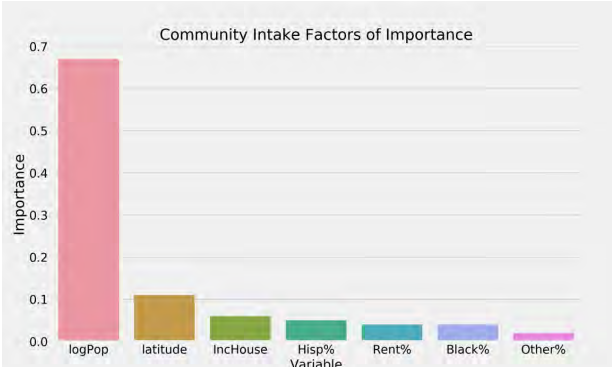
Aggregate to county level



Merge with demographic data

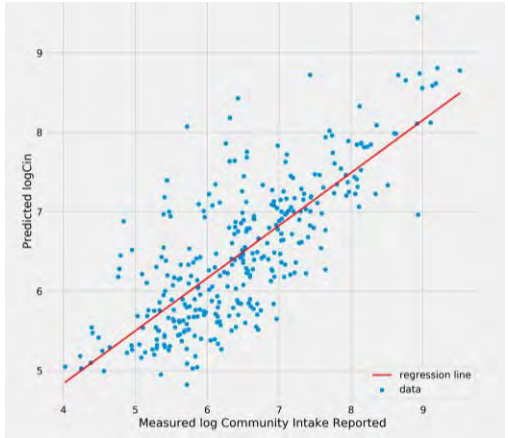


Develop a predictive model with demographic and shelter data for each county



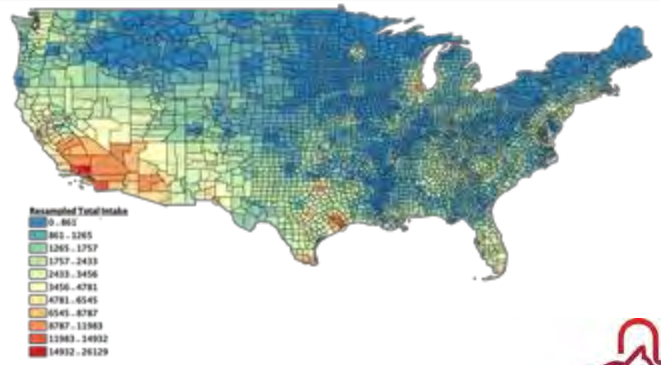
Validate the model on test data

Predicted vs. Actual



Populate the predictions

Continuous estimate for every county



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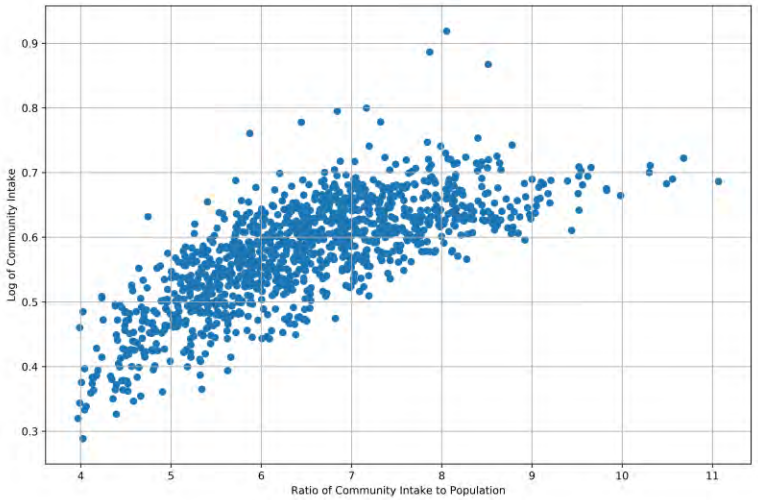
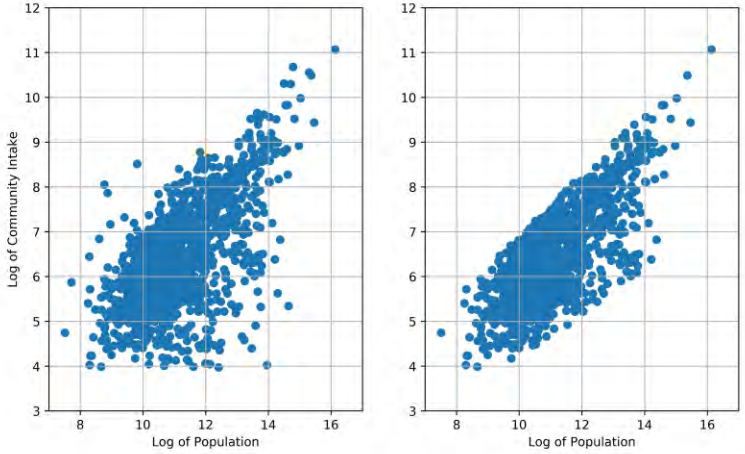
Community Intake Prediction

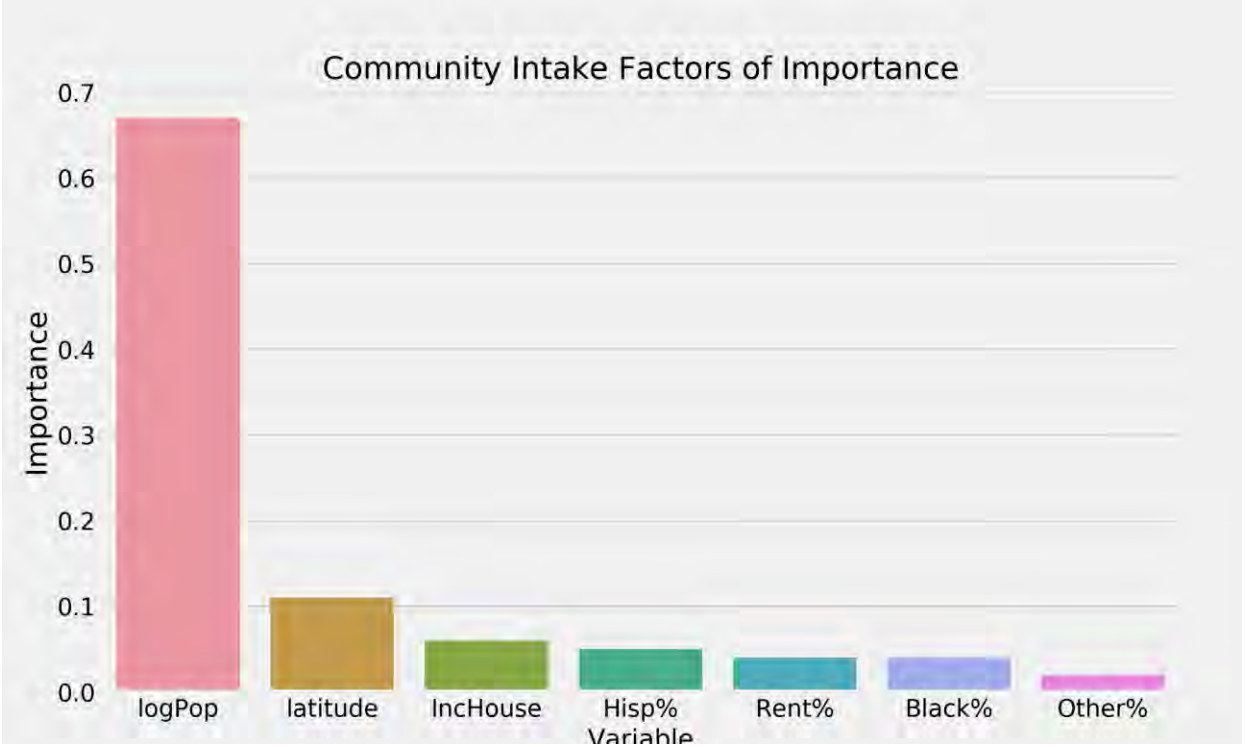
Data Conditioning



Before and After Alpha Trim of 0.05



Random Forest Regression for Interpolation



Community Intake = Stray + Relinquishment + Other

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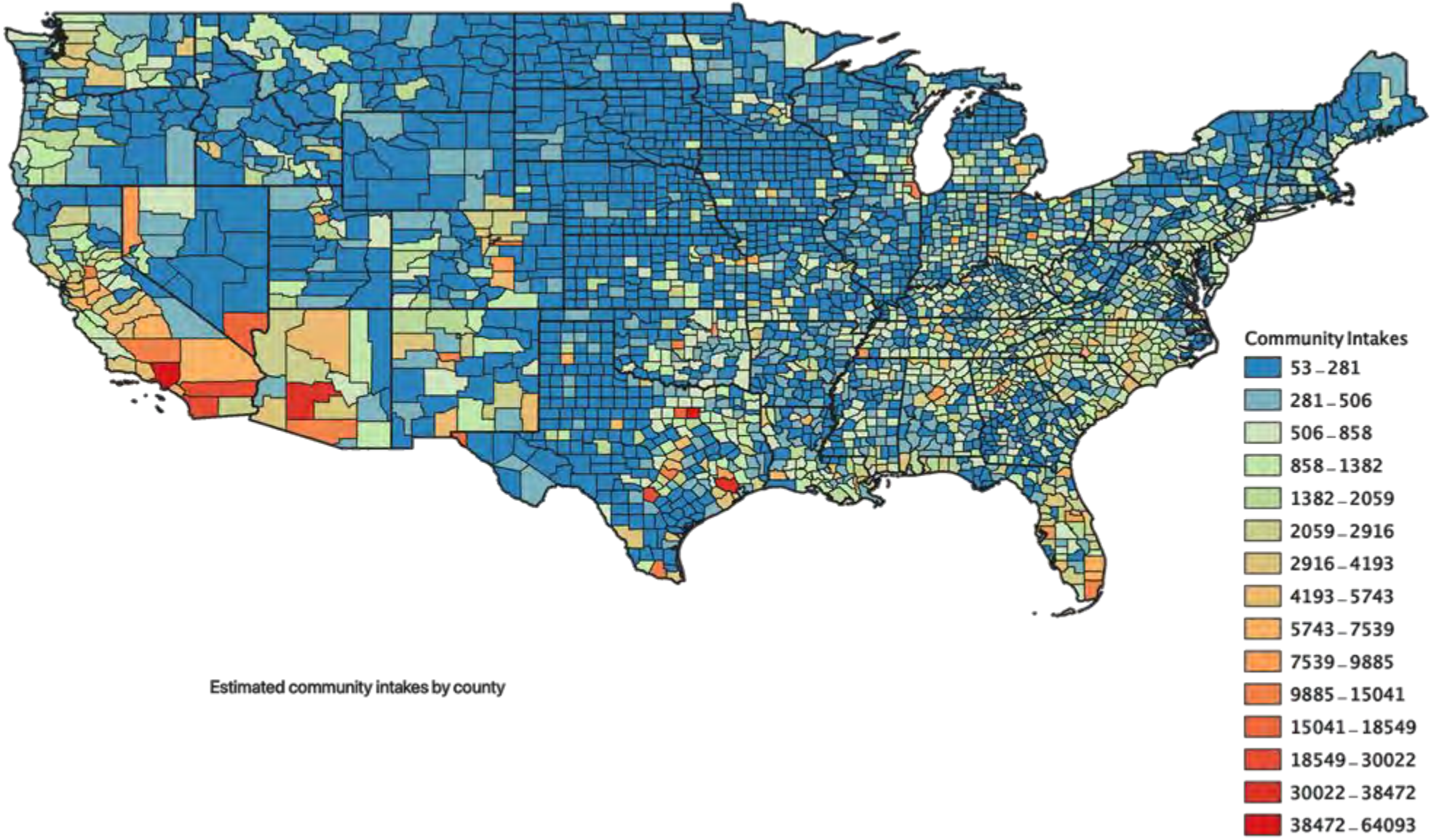
Interpolated Community Intakes



Estimated community intakes by county

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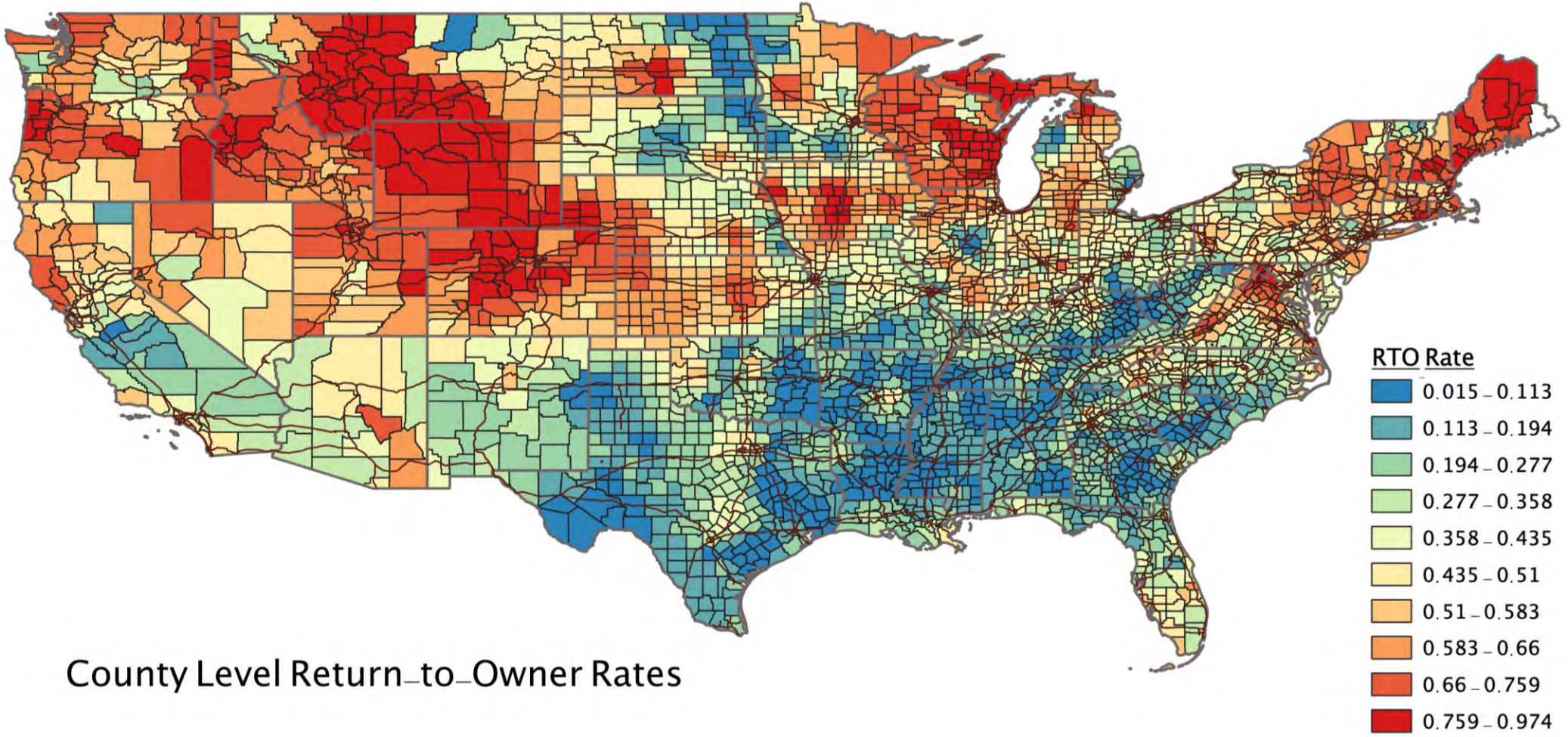
Return-to-Owner Rates



County Level Return_to_Owner Rates

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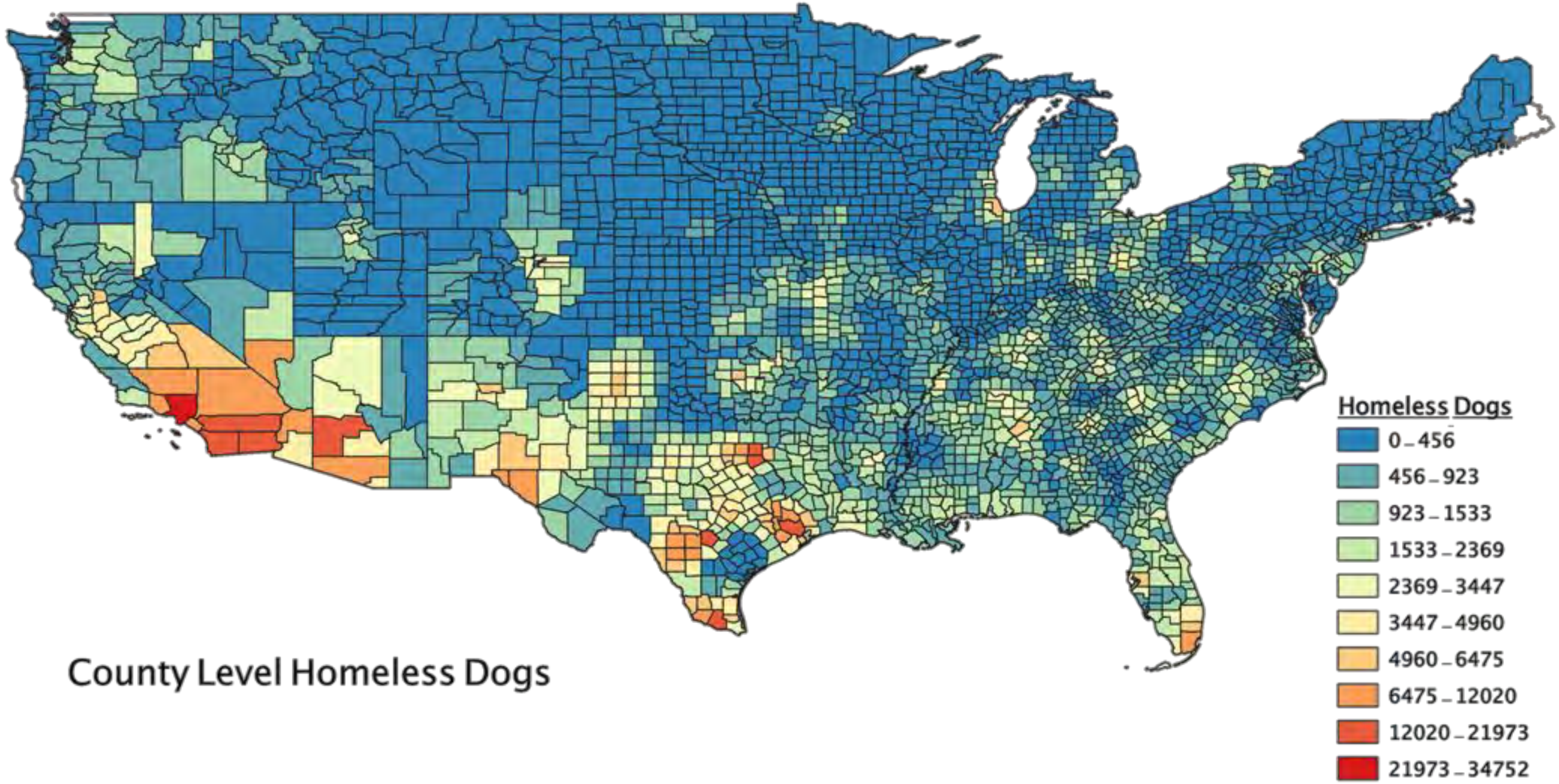
Homeless Dogs



County Level Homeless Dogs

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Modeling Intake Decline

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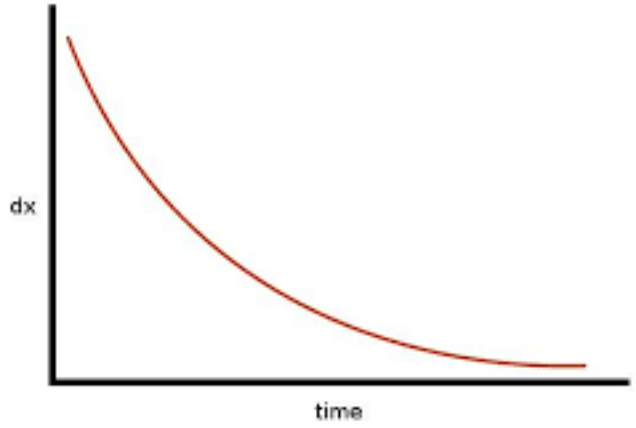
Estimating Intake Decline

- Assumed decline will follow an exponential decay curve
- Need to estimate:
  - Initial rate of decline
  - Decay parameter for shape of decline curve over time



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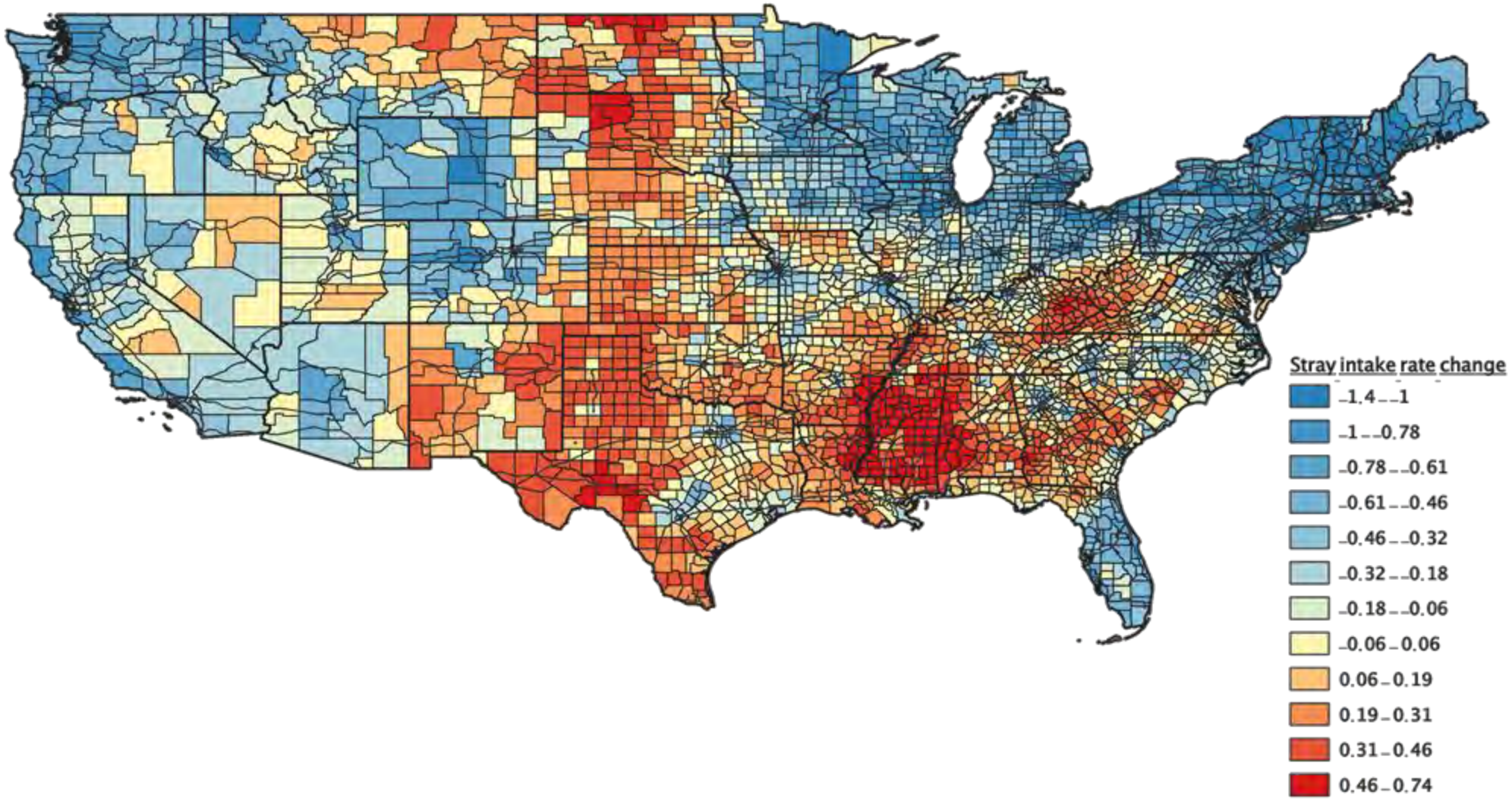
Current Intake Decline Rate



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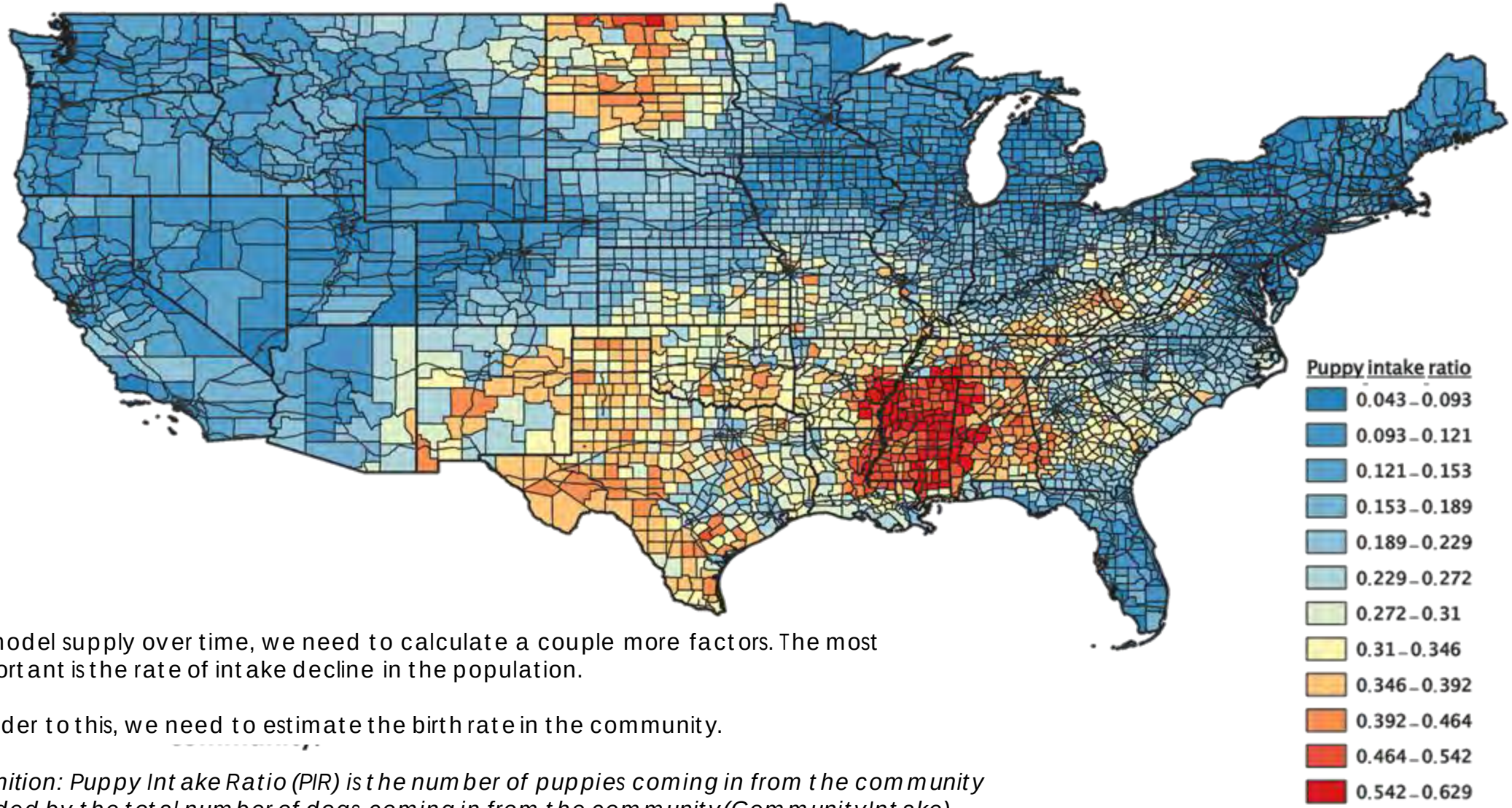
Estimating Decay Rate: Puppy Intake Ratio



To model supply over time, we need to calculate a couple more factors. The most important is the rate of intake decline in the population.

In order to this, we need to estimate the birth rate in the community.

Definition: Puppy Intake Ratio (PIR) is the number of puppies coming in from the community divided by the total number of dogs coming in from the community (Community Intake)

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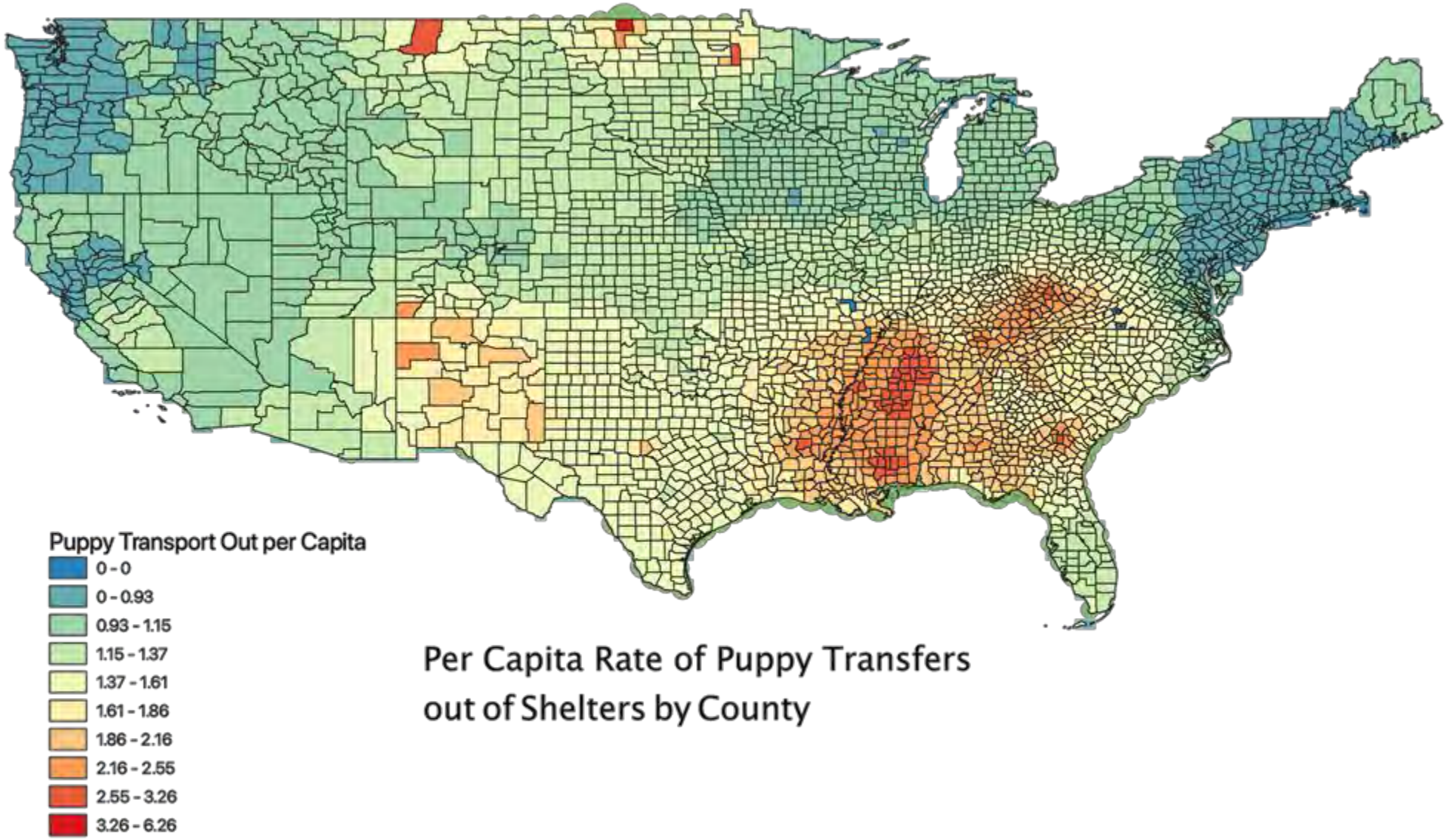
Per Capita Puppy Transport Out



Per Capita Rate of Puppy Transfers out of Shelters by County

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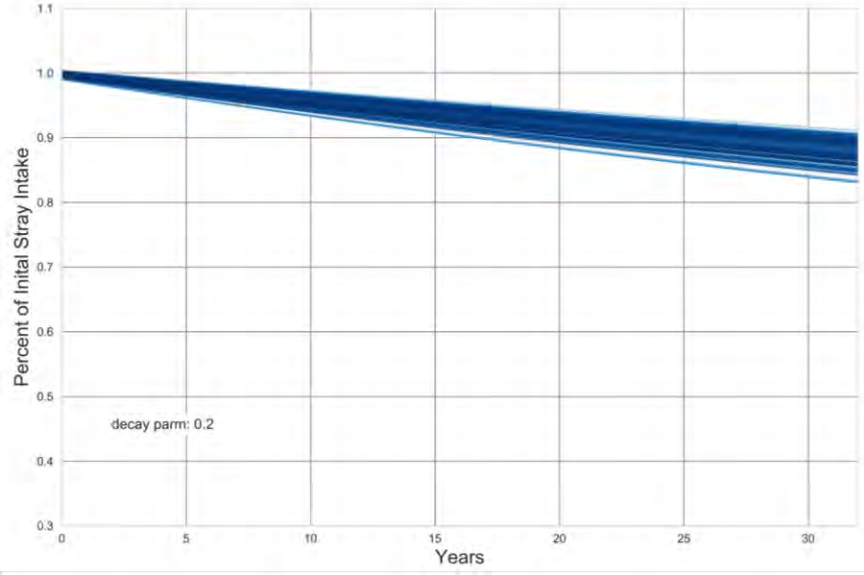
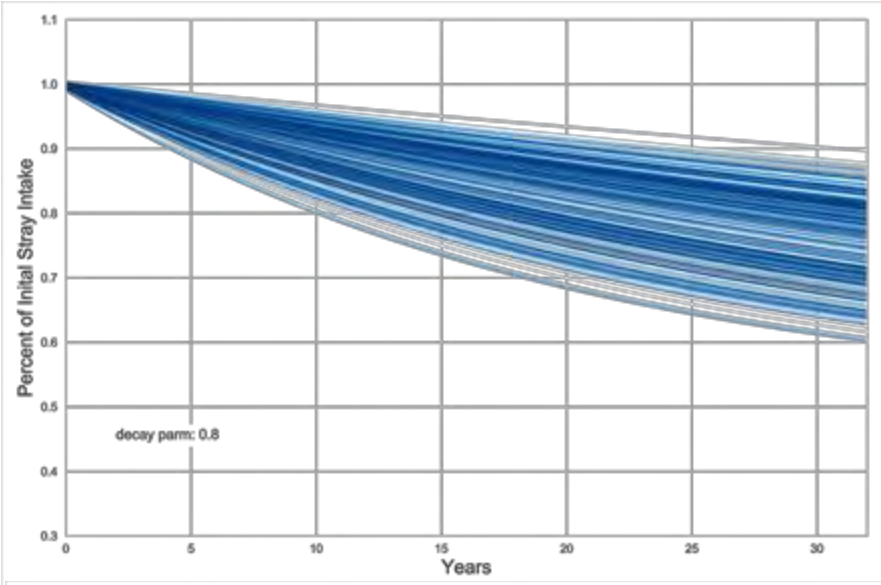
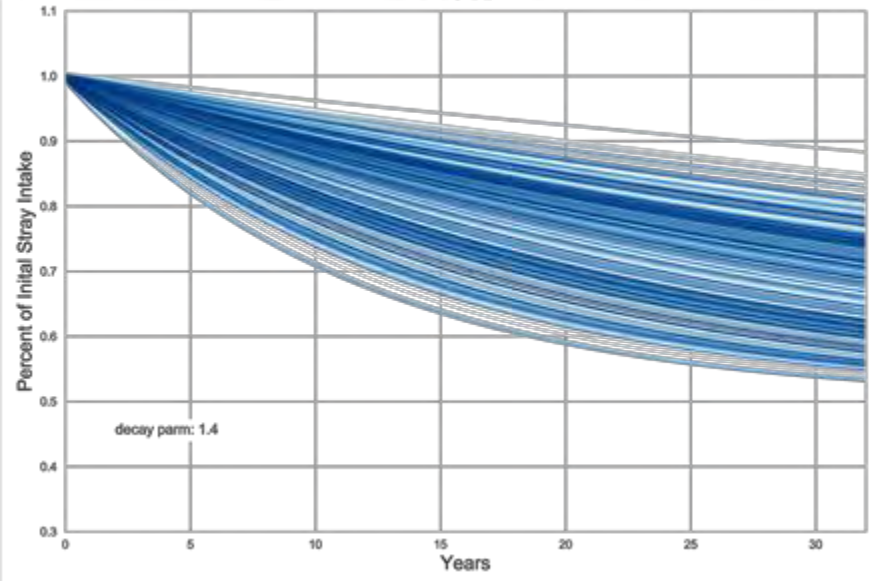
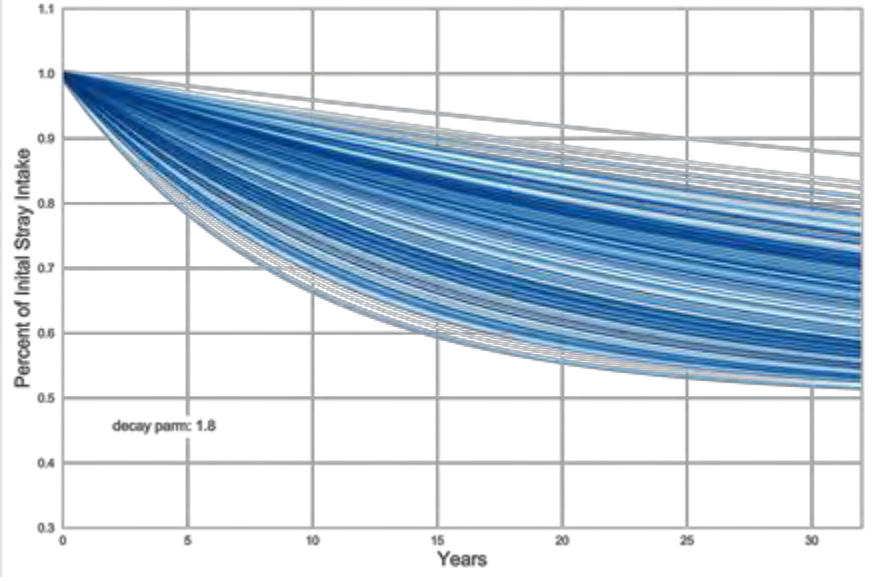
Stray Decline Scenarios for Model









To develop the decline curves over time, it was assumed that the decline followed and exponential function over time.

A decline rate for each county was calculated based on the PIR and the inferred current decline rate

A family of decline scenarios was used to test the sensitivity of the model to the decline assumptions

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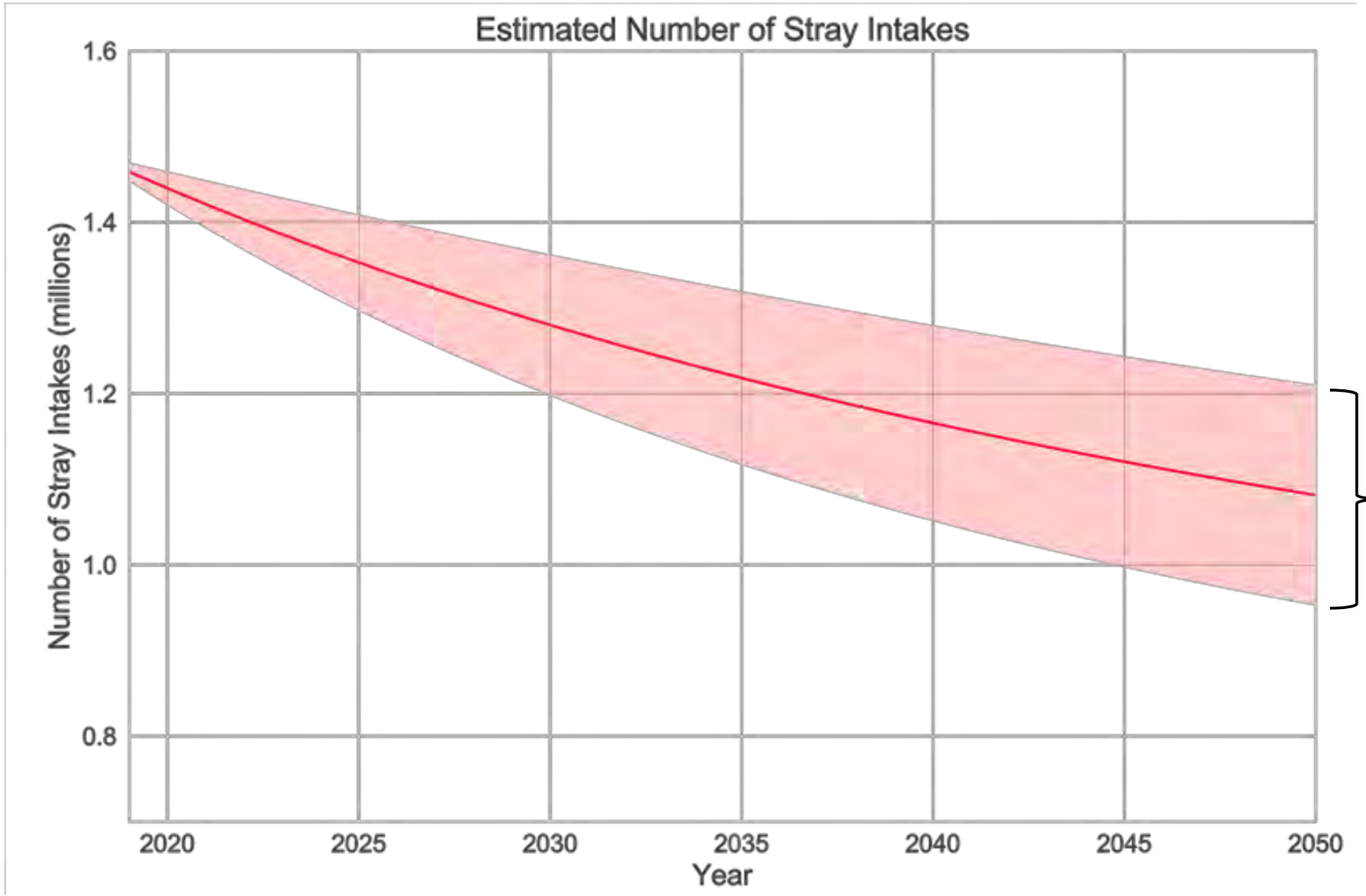
Stray Intake over Time



Standard deviation from range of decline scenarios

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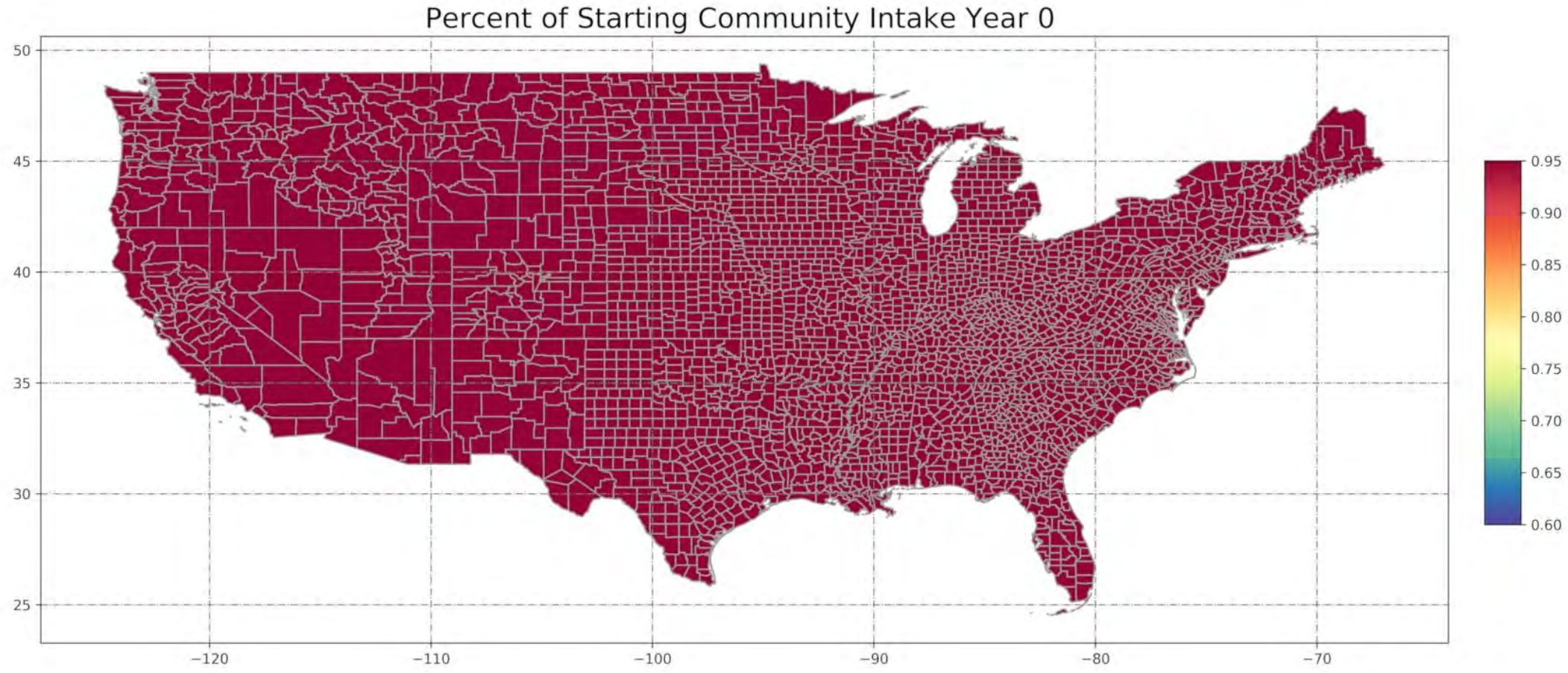
Community Intakes Over Time



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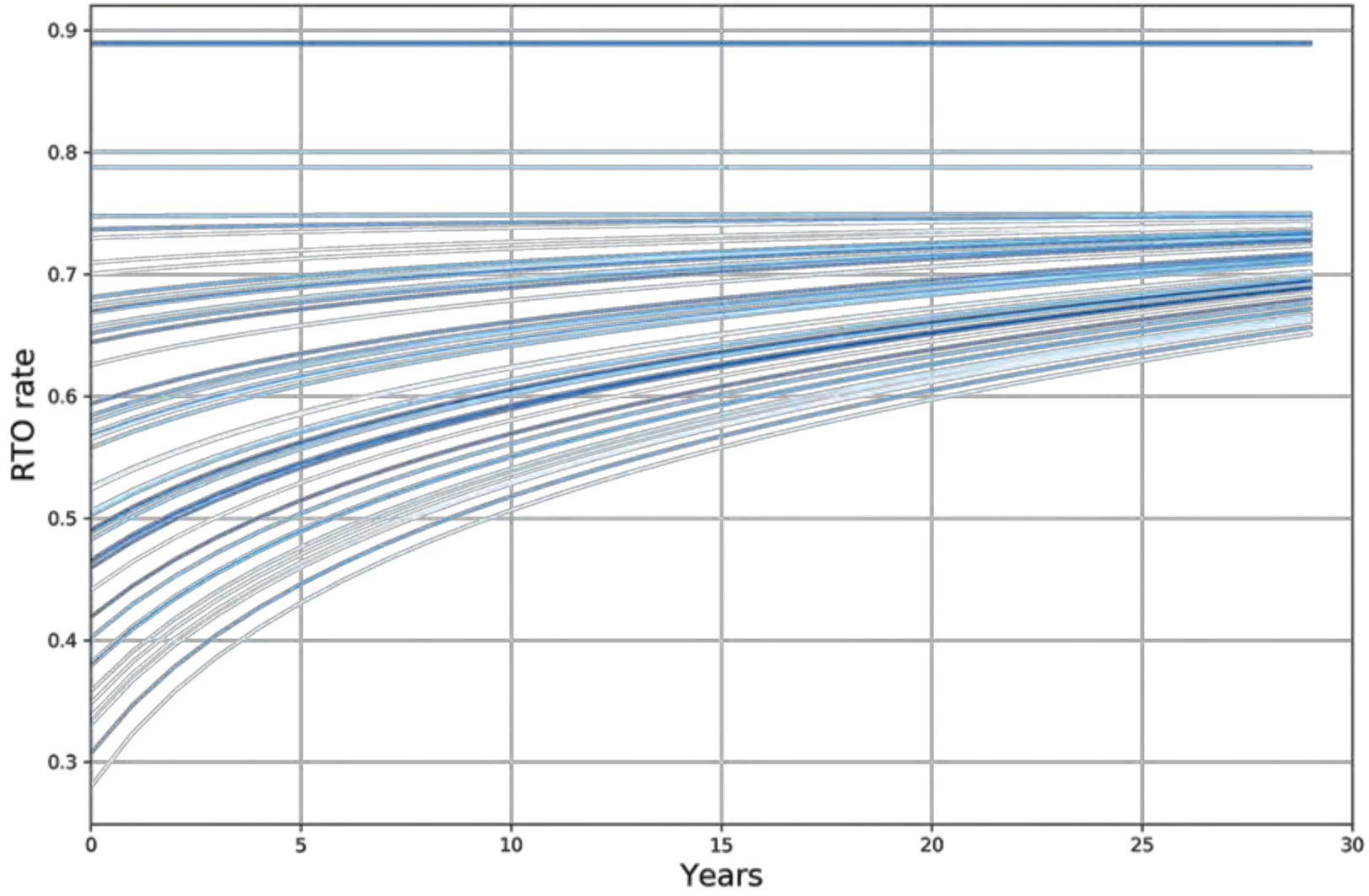
RTO Rate



It was assumed that over time RTOs would improve up to a threshold around 70%

It was also assumed that areas that had the lowest RTO rates would improve more quickly

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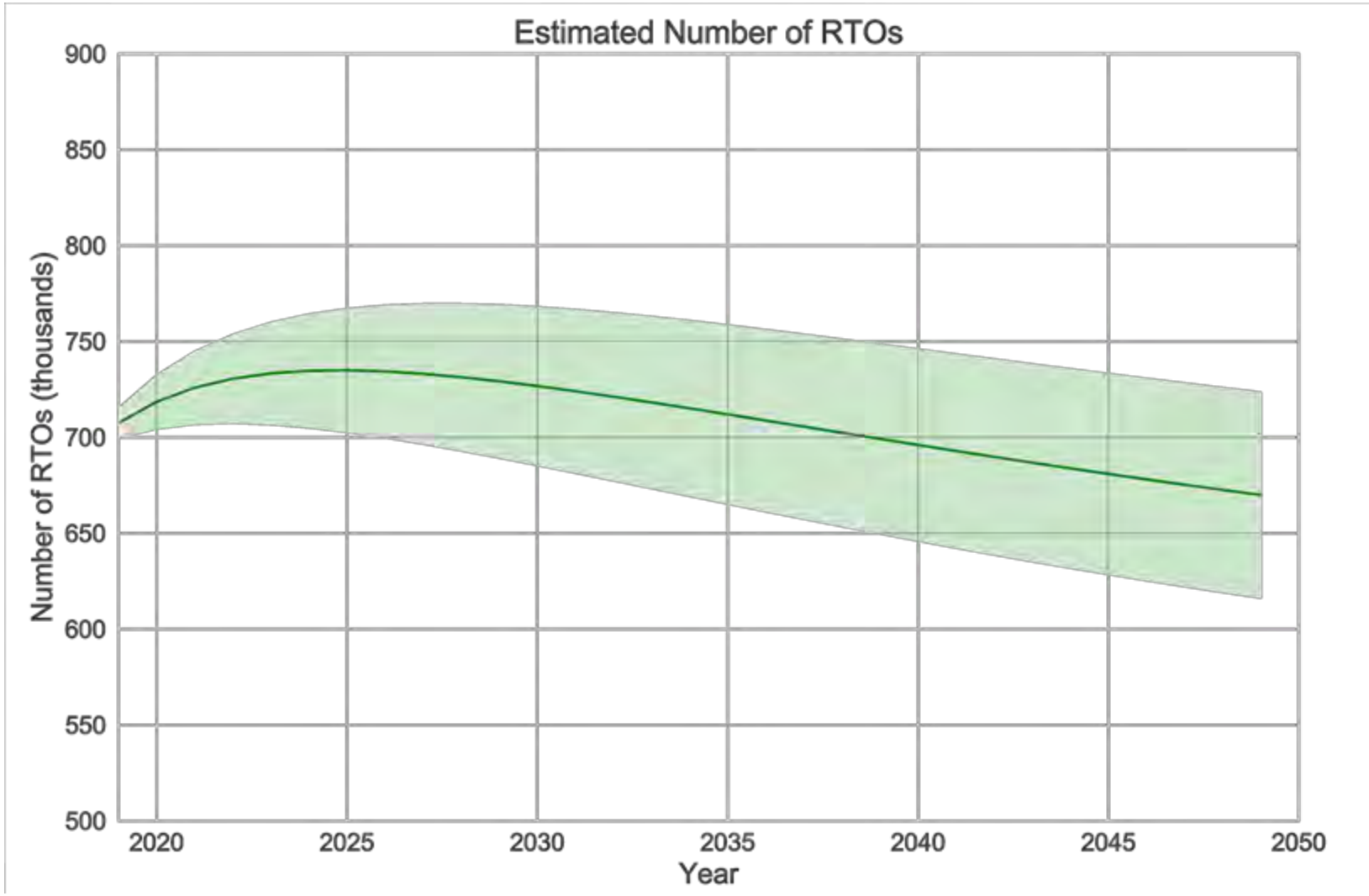
RTOs over Time



The RTOs initially climb with improving ability to get dogs back to their families, but it then starts to decline in later years as the total number of stray animals coming into the shelter starts to drop

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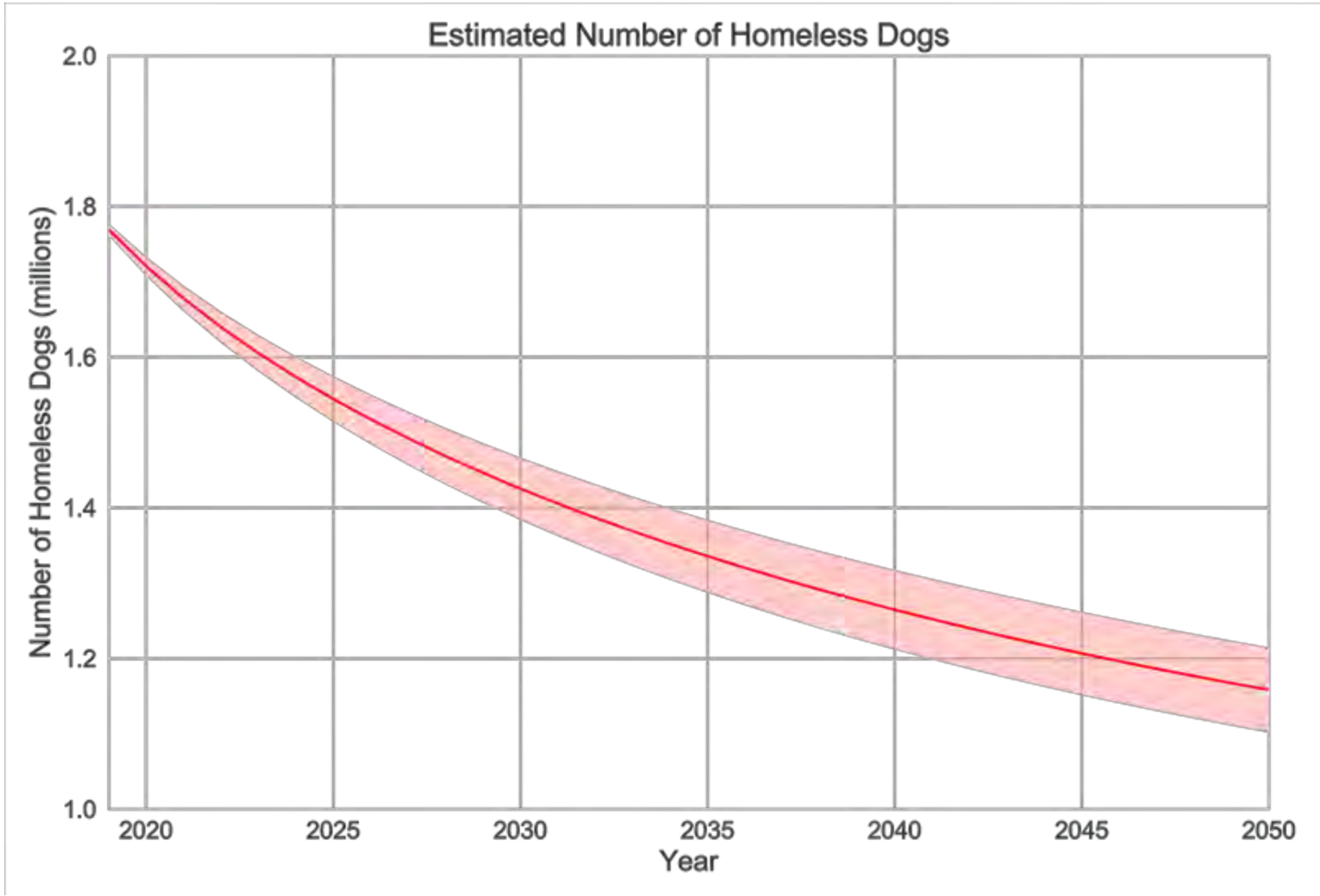
Total Homeless Dogs over Time



Homeless is defined as:
stray + relinquishment + seizures - RTOs

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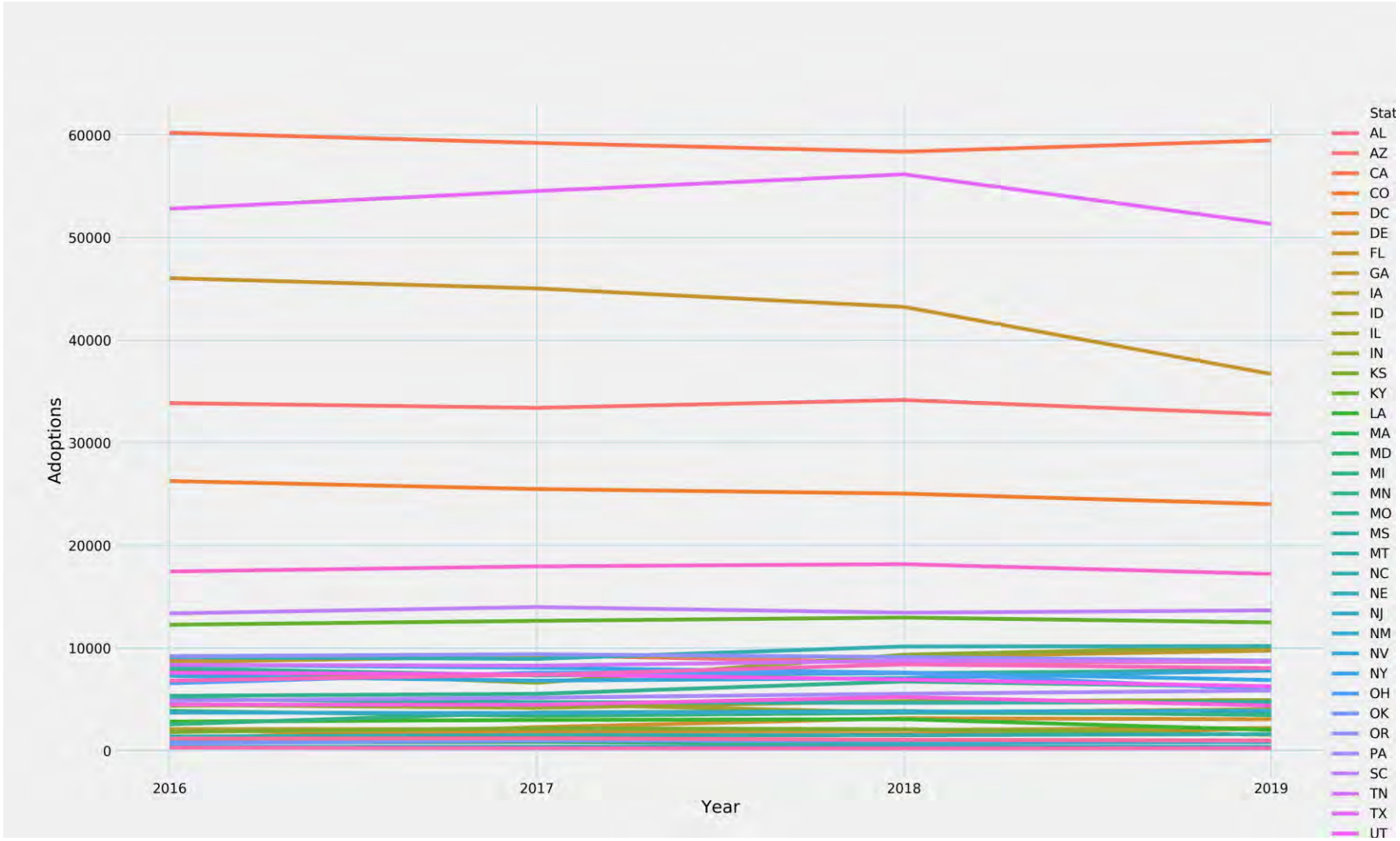
Adoptions by State



Adoptions have been relatively flat in the last 4 years.

This data represented about 1/3 of all adoptions in the country.

Although, there may be growth in adoptions that are not reporting into the SAC, the consistency of the trend suggests that adoptions are not growing quickly

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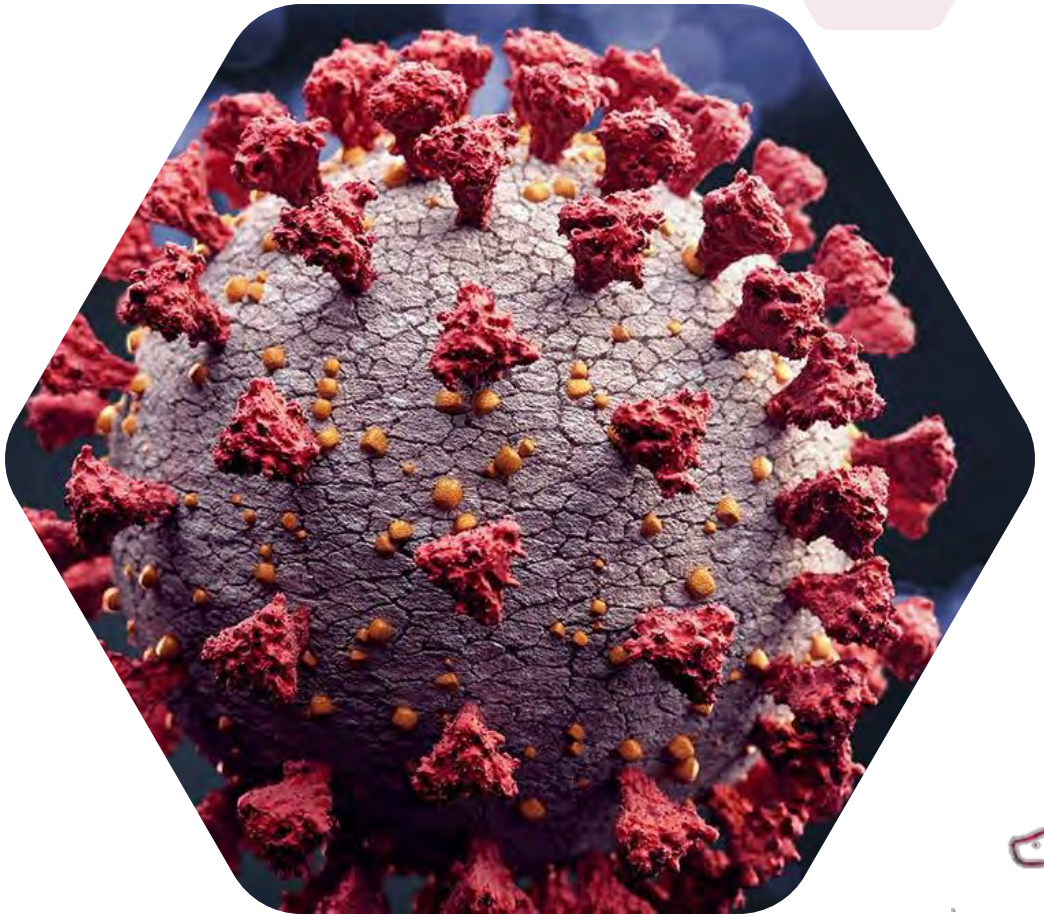
The Impact of COVID



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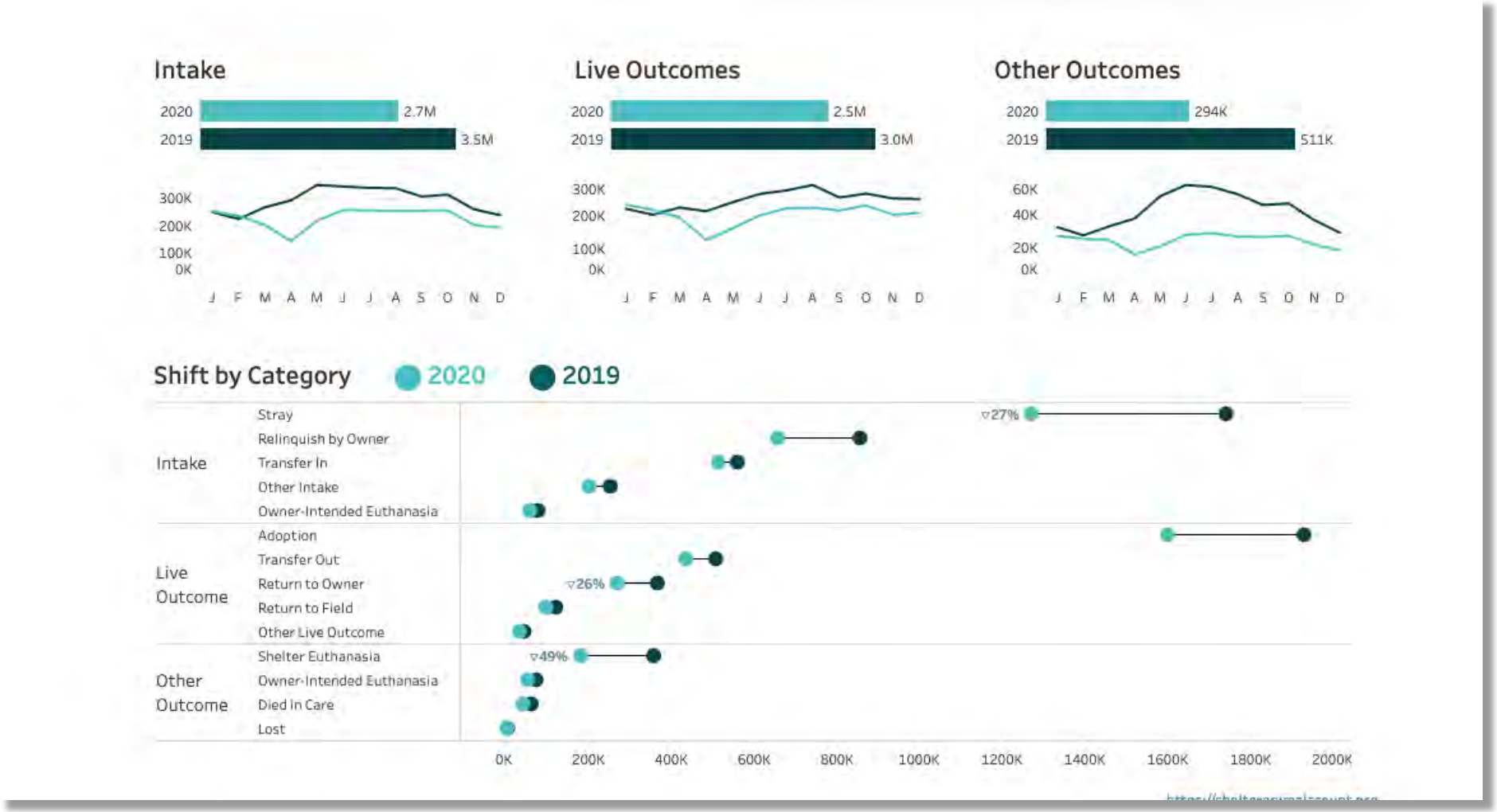
Covid Impact



Data from Shelter Animals Count

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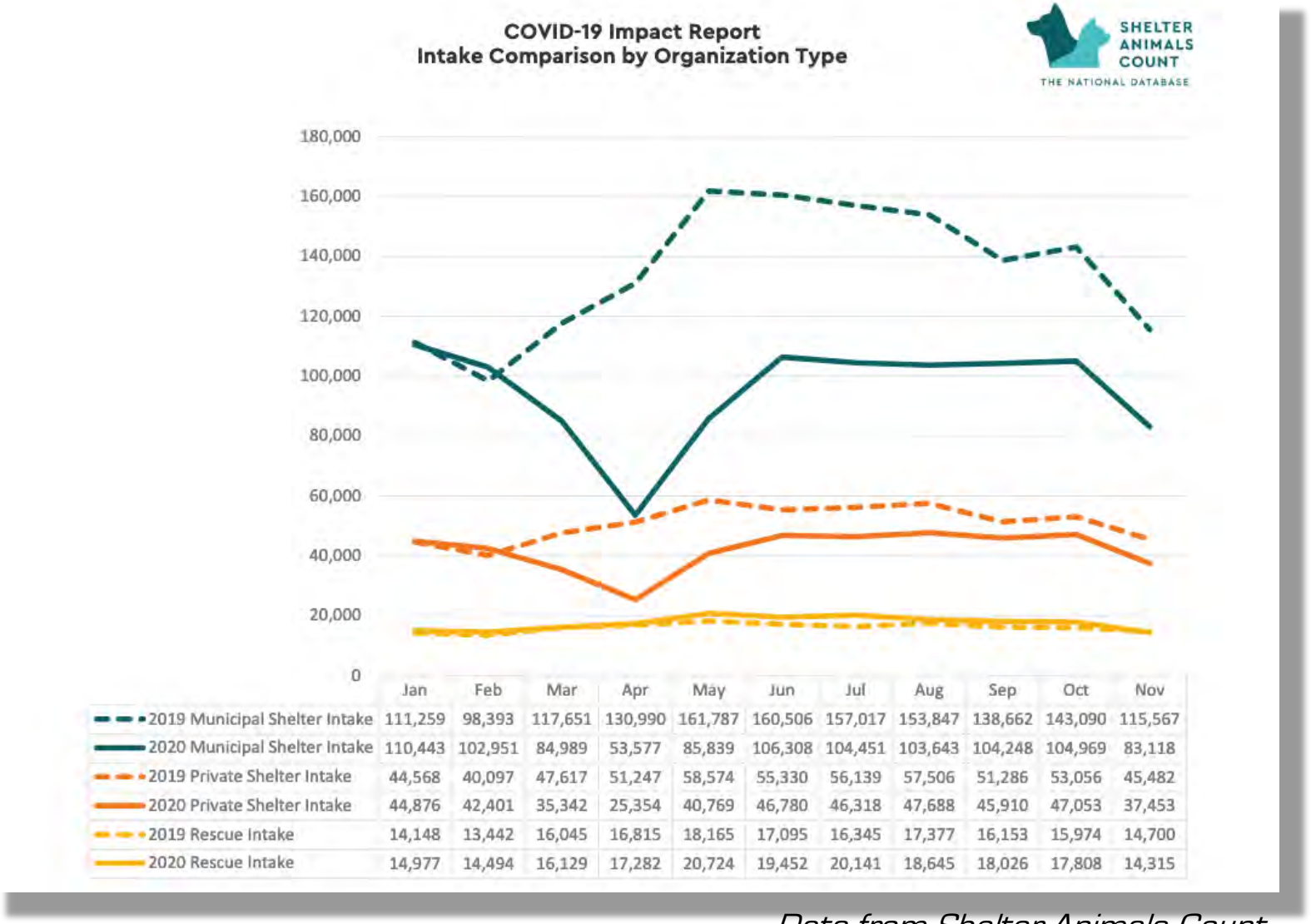
Intake Impact by Organization Type



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
2019 Municipal Shelter Intake	111,259	98,393	117,651	130,990	161,787	160,506	157,017	153,847	138,662	143,090	115,567
2020 Municipal Shelter Intake	110,443	102,951	84,989	53,577	85,839	106,308	104,451	103,643	104,248	104,969	83,118
2019 Private Shelter Intake	44,568	40,097	47,617	51,247	58,574	55,330	56,139	57,506	51,286	53,056	45,482
2020 Private Shelter Intake	44,876	42,401	35,342	25,354	40,769	46,780	46,318	47,688	45,910	47,053	37,453
2019 Rescue Intake	14,148	13,442	16,045	16,815	18,165	17,095	16,345	17,377	16,153	15,974	14,700
2020 Rescue Intake	14,977	14,494	16,129	17,282	20,724	19,452	20,141	18,645	18,026	17,808	14,315

Data from Shelter Animals Count

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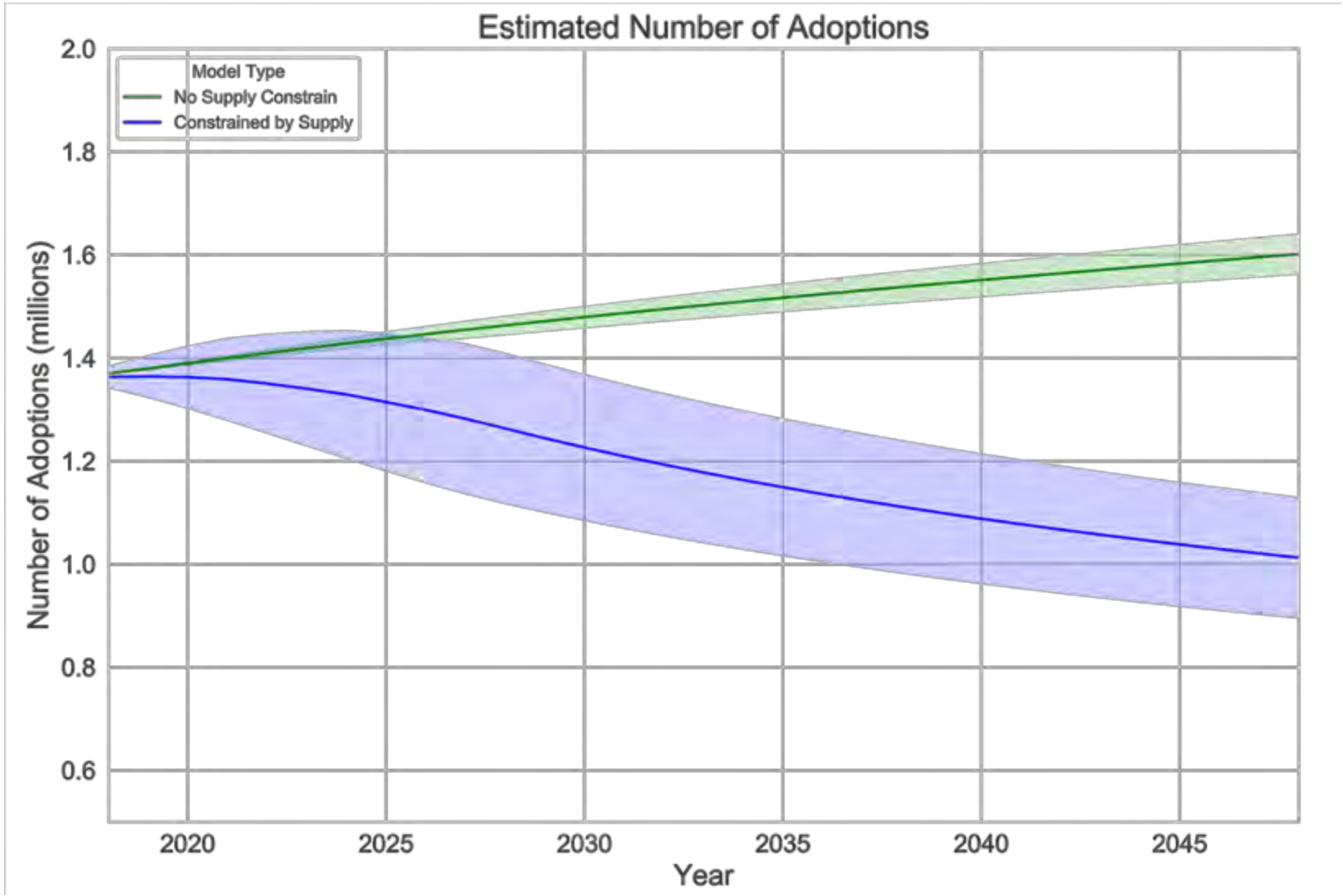
Adoptions over Time



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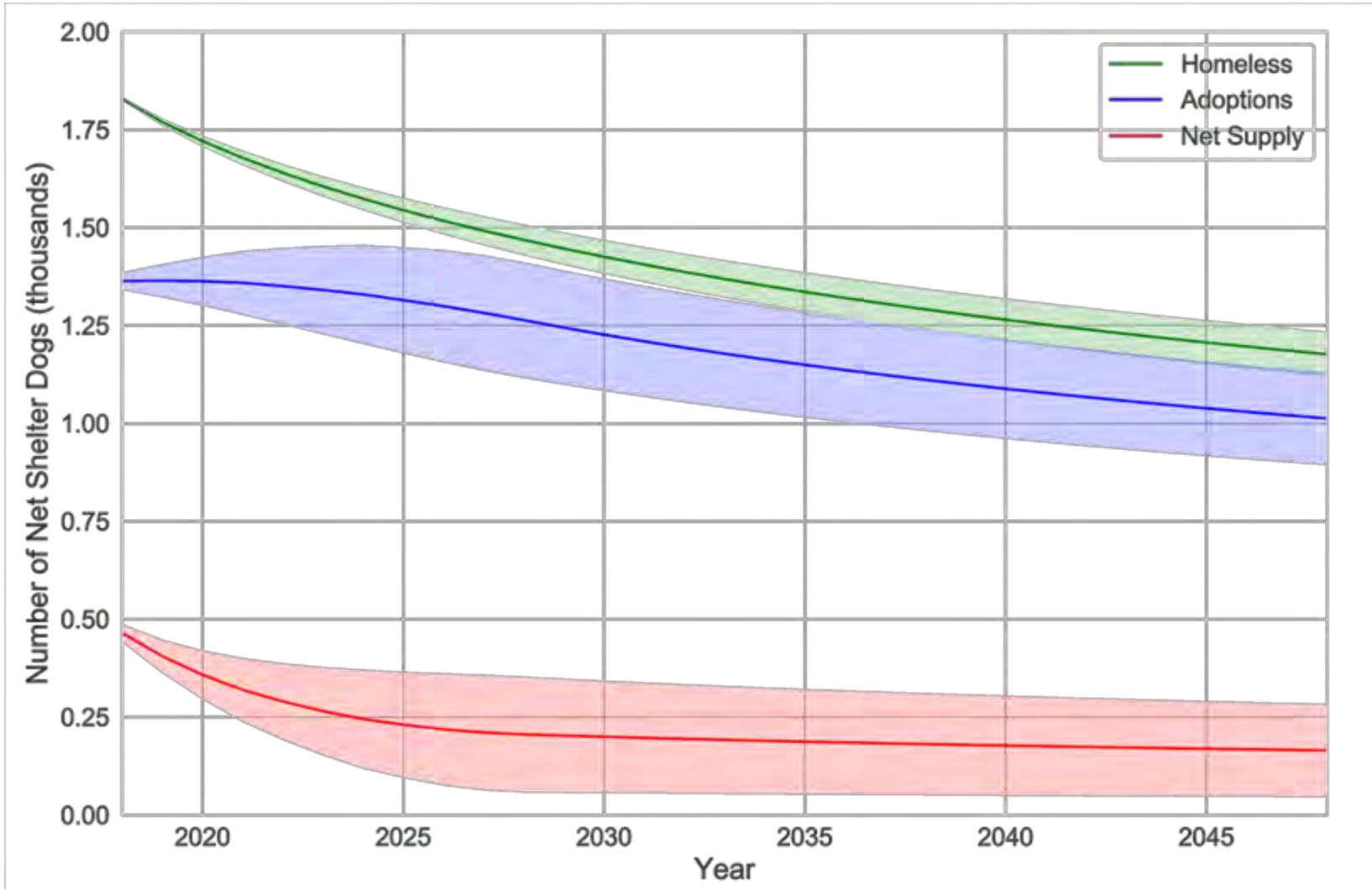
Inflow, Outflow and Net



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Summary

- The demand for dogs will continue to increase in the country
- Shelter intake will continue to decline if we continue the fundamental work of reducing overpopulation and keeping pets in homes through relinquishment prevention programs and improved RTO
- Under most assumptions, we will hit a stasis point on number of dogs in the shelters sometime by 2028 to 2030
- Adoptions will decline along with intake

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Questions?

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