PREDICTING COUNTY LEVEL POPULATION:

Preparing for Expansion Throughout Montana

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1 Statement of Problem

In collaboration with the Montana Department of Commerce, we have been asked to create a method for predicting populations across the state. The main use for this would be to aid in the creation of open and available resources to aid communities in planning and preparing for change and population mapping. We were asked to make a model that predicts five years into the future, primarily as a means of limiting error and restricting scope. With Montana comprising of a handful of large cities and a slew of smaller cities and towns, prediction is done at the county level to ensure that cities are receiving information that is most pertinent to them whilst still ensuring the model is not over-fitting for each independent community.

Our approach to this problem follows a fairly simple idea: build a base model for the county-level population predictions, and create additional layers to add onto this model that increase accuracy and tell meaningful information. We start with some simple linear models that predict based on prior data, followed by the creation of a multiple regression model that could be expanded upon with future data sets.

1.1 Terms

Throughout this paper, we use numerous terms from the data science and math fields. Following is a glossary/dictionary that defines the variables and the terms that will be used throughout this paper:

- **Baseline Model**: the foundational model for county-level predictions, combining fertility, mortality, and migration predictions
- **Layer**: model comprising of any additional feature or data set outside of the baseline model, added on top of the baseline model
- **Net Migration**: the sum of both immigration (+) and emigration (−)
- **Linear Regression**: model consisting of line of best fit, dealing with linear change across a singular variable alongside a static intercept value
- **Multiple Regression**: model consisting of line of best fit, dealing with linear change across multiple variables alongside a static intercept value
- R^2: statistical measurement that explains the amount of variation in the result that is explained by the formula provided
- $RMSE$: stands for root mean squared error, measurement of error for given model, provided in base units of model (people in the case of population)

2 Data Collection and Preparation

2.1 Baseline Data

In order to build an accurate model, we needed to gather a multitude of data from numerous sources that spanned the past decade so we could get an accurate idea. The main three sets of information needed for the formation of our baseline model are population counts, births and deaths, and migration. Most of our data was sent to us by the Montana Department of Commerce and cleaned and prepared by our team. Our basic population counts were found through the US Census, whilst births and deaths were found through the Montana Department of Public Health and Human Services. Migration was a more difficult issue, as the counts provided by the US Census Bureau were five-year nets, making individual year-by-year predictions difficult. We ended up gathering and preparing data from the IRS, primarily due to their annual migration sets, allowing us to be more accurate on individual yearly predictions.

2.2 Additional Data

In order to make accurate predictions about the population, it is necessary to have a wide array of data that encompasses some of the additional factors that contribute to population change. By creating smaller models that predict these facets, we can layer them on top of our baseline model and improve the accuracy of our model and giving insight about the nature of population change throughout Montana.

The first factor we decided to investigate is housing information, primarily occupancy and available housing units on a per-county basis. This information for every county between the years 2000-2021 is provided by the US Census Bureau. This data required processing and cleaning to better implement it. The housing

occupancy data was grouped into five-year intervals. This average was used for each year within the interval. Therefore, there is some approximation in the data but it provides more steady and reliable data for counties with smaller populations.

The second factor we took into account is personal income, again on a per-county basis. This information was sourced from the Montana Regional Economic Analysis Project (MT-REAP), and information from 1999-2020 was gathered and cleaned. The site provided the total personal income of each county in Montana, as well as what percentage this total was within the sum of personal income across the state.

3 Linear Regression Model

One of the most simple models that can be made is a linear regression model, examining a single, linearly changing value with respect to year. Though simple, this model works to separate the easier to predict counties, those following the linear model closely, from the more difficult to predict counties, those acting differently from the linear model. This allows us to target our more complex model towards increasing accuracy among the more difficult counties, knowing that the easier counties should work with minimal changes to the model. Equation 1 and Figure 1 display the formula and plot for state-level population projection using linear regression, as well as the model's R^2 value. In the equation below, P stands for population and n stands for the year starting at 2006.

$$P_n = 8783.5n - 1.6665 * 10^7, R^2 = 0.996 \tag{1}$$

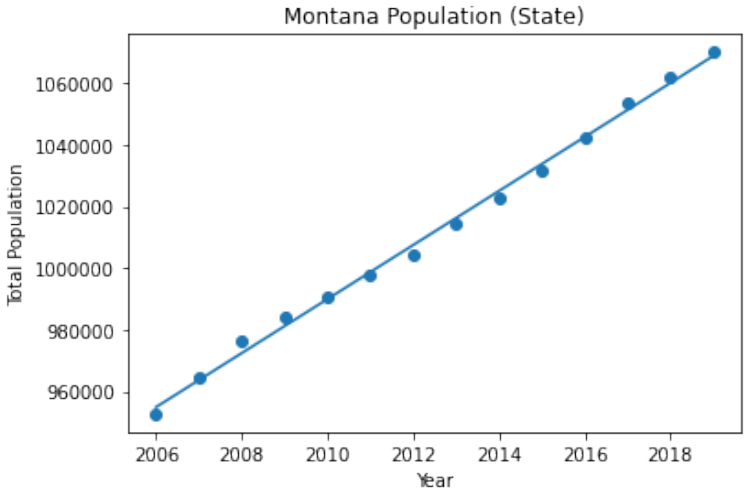

Figure 1: Points represent provided data, and line represents regression. Model built on statewide data from years 2006-2019.

To best picture the change across counties, we created linear models for each county, as well as the state as a whole, and found their R^2 value, showing their similarity to historical data, as well as the provided REMI predictions.

3.1 State Model Summary

To best summarize the results of the linear model strategy, we have focused on showing the influence of this modeling strategy at the state level. Table 1 contains the predictions from the state level model, their respective target values, and the R^2 values that coincide with them. These values were found after creating a linear regression model using data from years 2006-2019 and predicting population out to 2027. The predictions and historical data can also be found in Figure 2, with the orange line representing the predictions, the blue line representing the linear regression of historical data, and the blue points representing the historical data points.

Year	Linear Prediction	REMI Prediction	Carroll Predictions / REMI Predictions
2022	1095532	1102893	0.993
2023	1104315	1112518	0.993
2024	1113099	1121325	0.993
2025	1121882	1130002	0.993
2026	1130666	1139061	0.993
2027	1139449	1147842	0.993

Table 1: State-Level Population Predictions

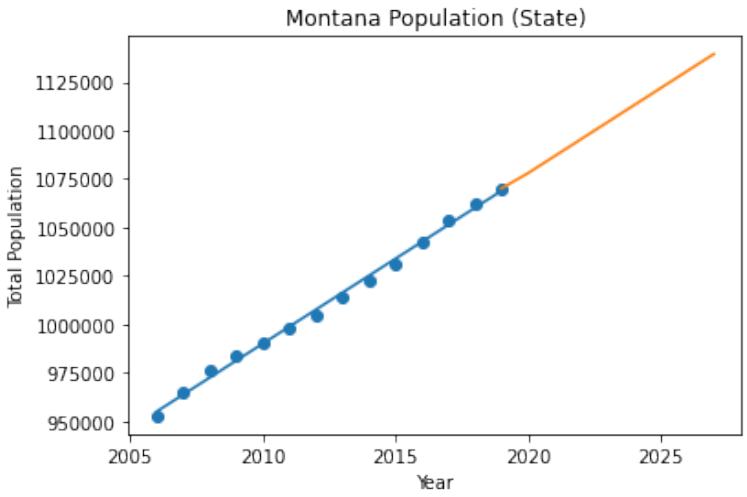

Figure 2: Points represent provided data, blue line represents regression, and orange line represents linear regression predictions. Model built on statewide data from years 2006-2019.

3.2 County Model Summary

When applying the linear modeling strategy to individual counties, only nine of the 56 counties had R^2 values greater than 0.95, indicating meaningful correlation. Below is a table containing a the counties and their corresponding $RMSE$ values, along with the linear equations.

County	R^2	Equation	RMSE
Carbon	0.962	$P_n = 62.07n - 114599.23$	71.51
Flathead	0.976	$P_n = 1434.64n - 2793327.28$	1322.46
Gallatin	0.980	$P_n = 2352.80n - 4637959.68$	1914.58
Jefferson	0.959	$P_n = 110.00n - 209894.65$	131.08
Lake	0.972	$P_n = 201.00n - 375270.25$	197.26
Lewis and Clark	0.992	$P_n = 760.04n - 1464839.41$	389.043
Missoula	0.993	$P_n = 1240.01n - 2383446.49$	599.88
Stillwater	0.957	$P_n = 73.74n - 139215.13$	89.72
Yellowstone	0.990	$P_n = 1772.45n - 3415548.75$	1012.61
Valley	0.008	$P_n = 1.682n + 4065.68$	107.30
Wheatland	0.003	$P_n = -0.353n + 2832.62$	36.53
Wibaux	0.003	$P_n = -0.404n + 1829.11$	38.83

Table 2: Counties with Linearly Predicted Growth

As seen in the table and linear models in the Appendix (7.2), the linear model only works well on a few counties. However, if the values predicted from this model are compared to the last five years of data (2016 - 2020), it has a resulting RMSE of about 470. This could be due to a wide variety of reasons, such as drastic changes in migration rates or a lack of available resources. Because of this, a more complex model is needed to better encapsulate and predict on the provided data, especially on the greater majority of counties.

4 Baseline Model

In the creation of the baseline model, three components of population change were taken into consideration: birth, death, and net migration. For each of these components, separate models were created to predict the change in population due to that particular component. The baseline model was then created using the combination of these component models.

4.1 Fertility Model

When creating fertility models, resident births - referring to births of residents of the area, whether the child is born in the area or elsewhere - were used in all calculations. Using the available birth data between 2016 and 2020, the number of resident births in each county were predicted using a linear regression of annual county population. This regression, with an R^2 value of 0.979, shows that as the population of a county grows, the number of births also grows. This can be seen in Figure 3, where each point indicates the number of births in a county during a particular year. With 56 counties and 5 years of data for most counties, there are about 280 points on this plot. As the size of county populations grow, the number of births occurring in the county grow at a linear rate. Thus, the number of births for a county in Montana can be modeled as follows, where B is the number of births for the area and P is the population size of the area:

$$B = 0.0107P - 1.23 \tag{2}$$

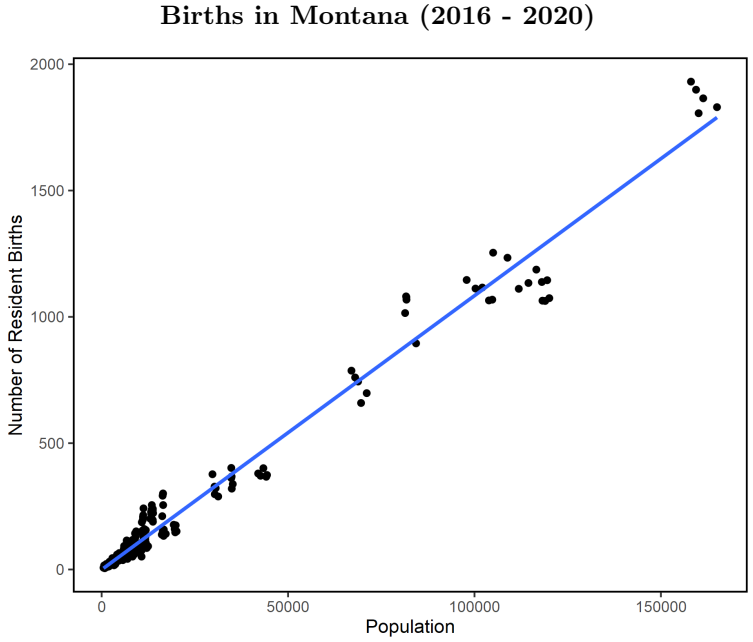

Figure 3: Births vs. Population for All Counties: Data as points, Linear Regression Model as line

In Figure 3, several groups of points are noticeable. These groupings are slightly differing population sizes and number of births in the same county between 2016-2020. For example, in the top right corner of the plot are five points in a cluster by themselves. These points are all from Yellowstone County. Each of these points shows the population size of Yellowstone County for a year between 2016 and 2020.

Using Equation 2, we are able to predict the number of births in a county with a given population. For each year of projection, this model was used to calculate the number of births in the county based off of the previous years' population. Figure 4 shows these projections as dashed lines, in addition to the known data as solid lines. Note that these projections are dependent upon the mortality and migration models, (described in later sections) for all three models are necessary to project the population for future years, upon which these birth projections are based.

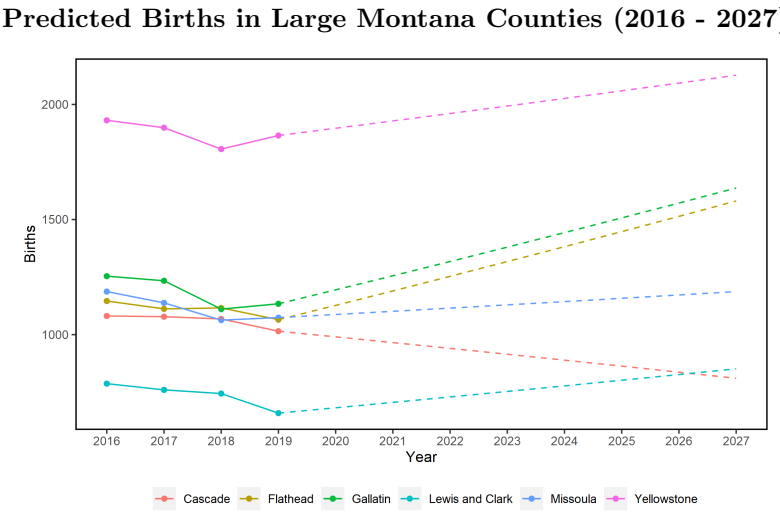

Figure 4: Montana Birth Predictions for Large Counties: Data as solid lines, Projections as dashed lines

4.2 Mortality Model

The mortality model was created in a similar fashion to the fertility/birth model. Data detailing the number of deaths in a given county during a specific year was provided for the years 2016-2020. Shown in Figure 5 is the death count over several years for six Montana counties of medium size. Worth noting is the fact that most of these counties experienced a sharp increase in the number of deaths in 2020, presumably as a result of the COVID-19 pandemic. This increase is seen across almost all counties throughout Montana. For this reason, the death data from 2020 was removed from the creation of the death model to eliminate the effect this anomaly might have.

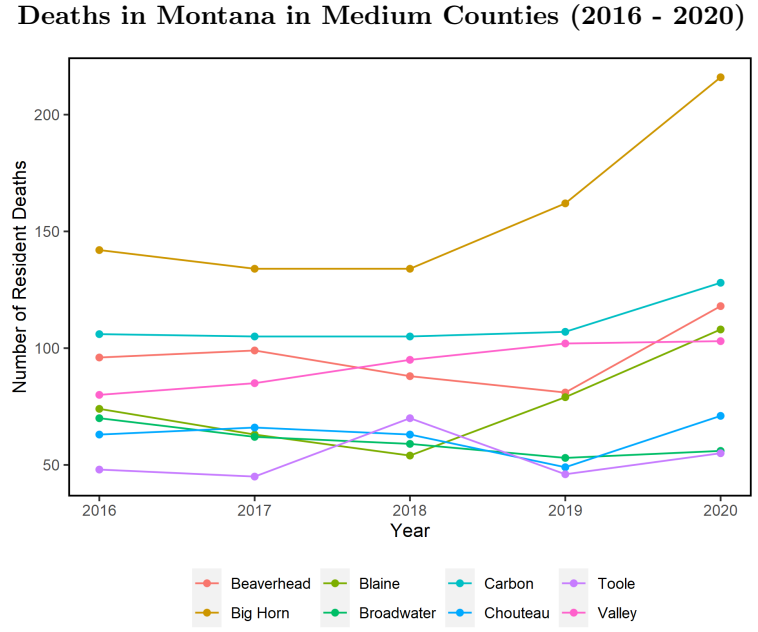

Figure 5: Deaths in Montana, showing results of COVID-19

With the removal of the 2020 data, the death data (4 points per county) can then be more accurately plotted with relation to county population. As can be seen in Figure 6, the number of deaths within most Montana counties can be predicted given the size of the population with a linear regression model. This linear regression has an R^2 value of 0.941. However, there is a group of points that seems to be markedly different from the regression line. These points represent all 4 years of data from a single county: Gallatin County. For unknown reasons, Gallatin County has reported much lower death counts in comparison to its population than other counties throughout Montana.

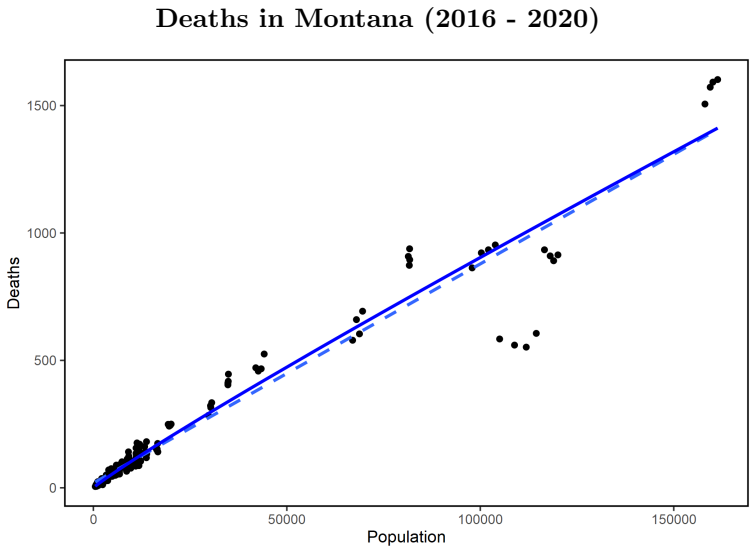

Figure 6: Deaths in Montana showing Non-Linear Regression: Solid line representing regression of logarithm of data shows better accuracy than dashed line representing regression using original data. Each point represents number of deaths for a given county in a year between 2016-2020.

However, almost all counties have populations less than 25,000, with only 8 counties larger than this. Since the populations of the 8 largest counties take up the majority of the range, the logarithm was taken of both the number of resident deaths and the population. This data is shown in Figure 7. Notice that the data appears more evenly distributed. As such, a linear model fitted to the logarithm of the data is a better fit, with an R^2 value of 0.967. This model is compared to the original data and linear regression in Figure 6, where the original regression is represented by a dashed line and the newer regression of the logarithm of the data is represented by a solid line. Our mortality model was created using the logarithm of the mortality data.

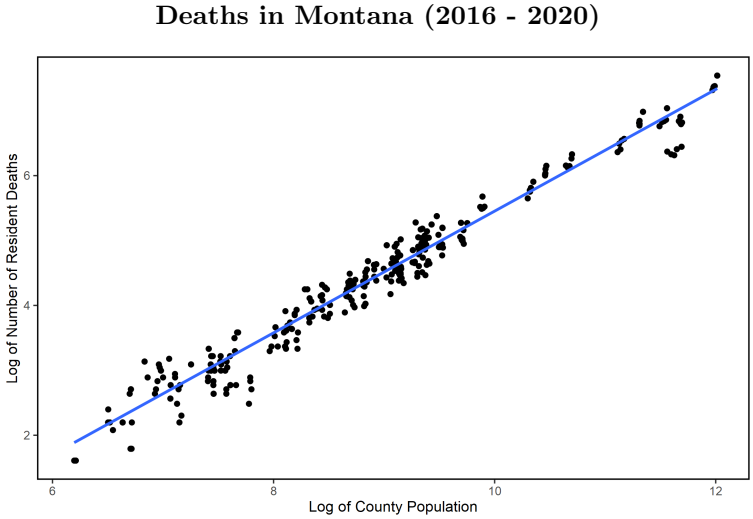

Figure 7: Logarithm of Deaths in Montana showing Linear Regression

According to this model, with every population increase of 1000 persons, the number of deaths in the county increases by about 12 persons. This model can be written as follows, where D is the number of deaths occurring among residents of the county and P is the population of the county:

$$D = 0.0198P^{0.932} \tag{3}$$

Using Equation 3, death predictions were then created in the same manner as described in Section 5.1. The number of deaths for a given year was calculated based upon the model described above and the previous year's population. Figure 8 shows the results of these calculations for the same counties shown in Figure 4. Solid lines represent the actual data, while dotted lines represent our projections.

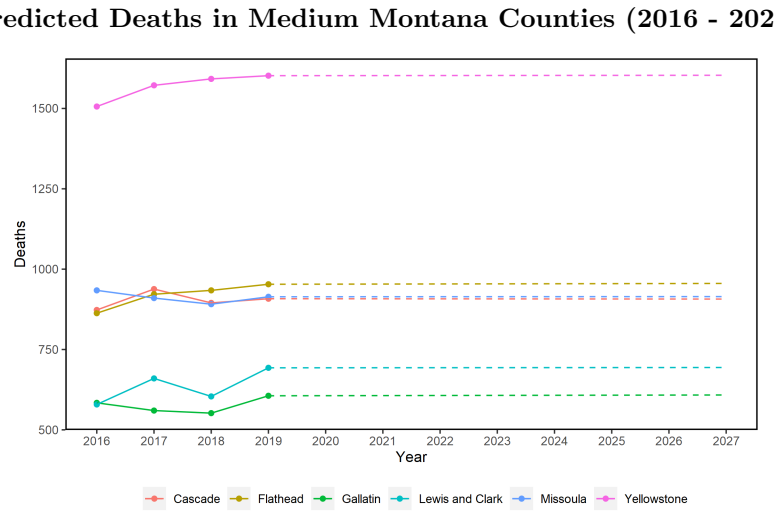

Figure 8: Predicted Deaths in Montana based on Population Data: Solid lines represent data, Dashed lines represent model

4.3 Migration Model

As can be seen in the following two graphs, migration numbers are much more difficult to predict than either fertility or mortality numbers. Migration is neither constant over time nor predictable by the size of the population. Figure 9 shows the net migration of several smaller Montana counties between 2001-2020, while Figure 10 contains shows net migration of every county in the state over the same time period. A single point represents the net migration in a single county during a single year. As such, each plot contains 1120 data points.

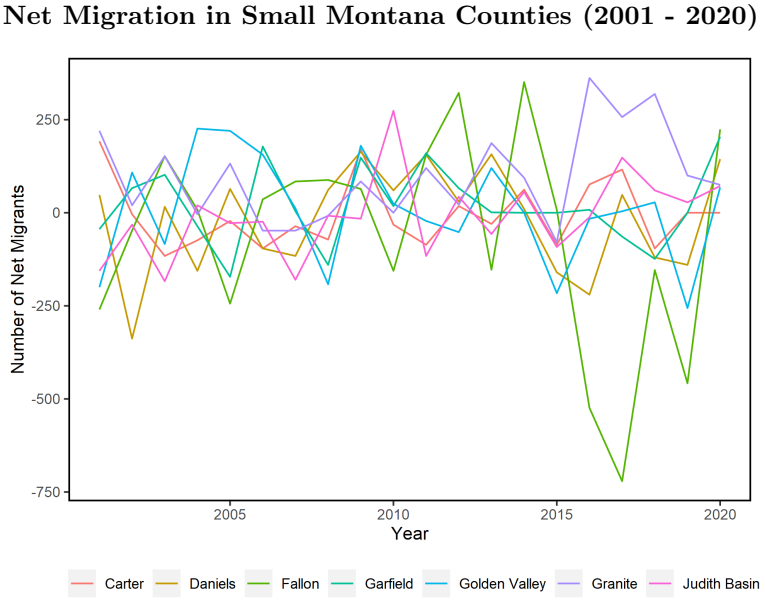

Figure 9: Net migration shows no clear patterns over time

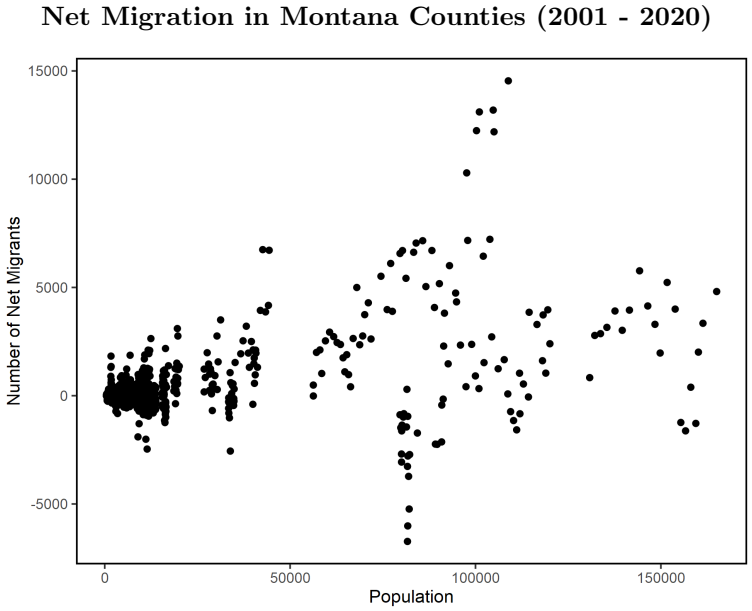

Figure 10: Net migration shows no clear patterns with population size

Due to the unpredictability of these migration numbers, current migration models are simply an average of the annual net migration between 2001-2020 for each county. As can be seen in Figure 9, the net migration in these counties cannot be predicted simply by looking for patterns over time. Migration neither follows a clear linear pattern, nor remains constant enough for accurate prediction. The net migration for these smaller counties, with relatively small populations, contain a large range of -750-300, accounting for up to 10% of the population.

Additionally, net migration has no ability to be predicted by the size of the population. The average net migration of a Montana county between 2001-2020 is about 360. However, there is a massive range around this mean, ranging from -7000 to 15000. This large range makes it difficult to project migration numbers into the future.

4.4 Combined Model

Using the above three models, a baseline model was build by combining them together. The population for the next year was calculated using Equation 4, where P is the predicted population of the county, B is the predicted number of births for the county, D is the predicted number of deaths in the county, M is the average annual net migration for the county, and n is the year:

$$P_{n+1} = P_n + B - D + M \tag{4}$$

If Equations 2 and 3 are plugged into Equation 4, the population of a county can be modeled with Equation 5.

$$P_{n+1} = P_n + (0.0107P_n - 1.23) - (0.0198P_n^{0.938}) + M \tag{5}$$

Using this combined baseline model, Figures 11, 12, and 13 show a comparison between our predictions and REMI predictions for a sampling of various-sized counties throughout Montana. Our predictions are shown with solid lines, while REMI predictions are shown with dotted lines.

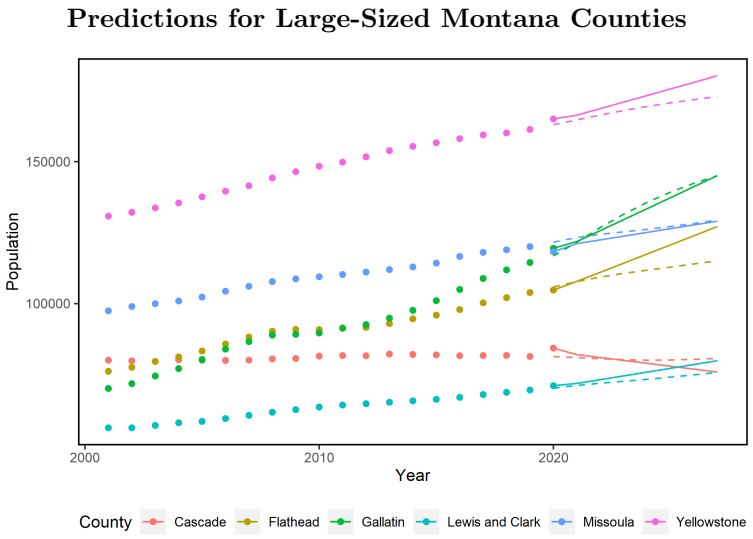

Figure 11: Comparison between Carroll Predictions as solid lines and REMI Predictions as dashed lines for Larger Counties within Montana

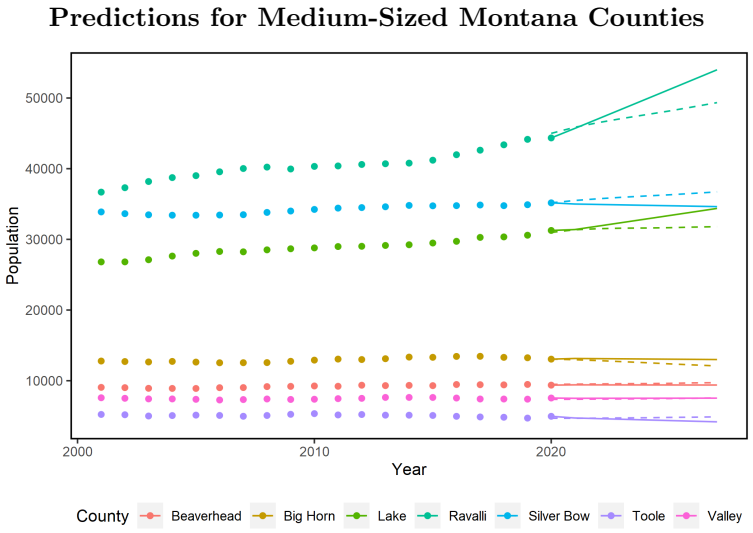

Figure 12: Comparison between Carroll Predictions as solid lines and REMI Predictions as dashed lines for Medium-Sized Counties within Montana

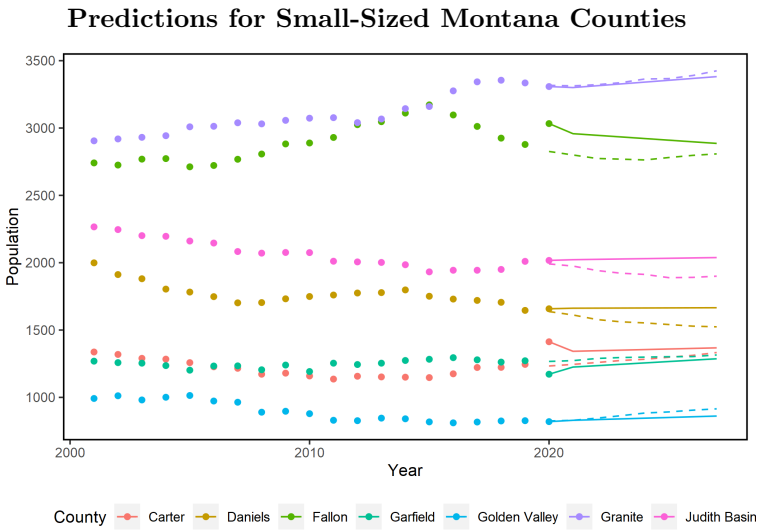

Figure 13: Comparison between Carroll Predictions as solid lines and REMI Predictions as dashed lines for Smaller Counties within Montana

Table 3 details the first and final year of predictions for a select subset of counties. Due to the issues with predicting migration, the baseline model seems to predict numerous counties declining in population over time. Though realistic for some smaller counties, larger counties, such as Cascade County, should continue increasing as their respective cities grow. Logically, and in accordance with the REMI predictions, we see small counties, like Judith Basin and Granite, decline in population.

County	**Year**	**Linear Prediction**	**Baseline Prediction**	**REMI Prediction**
Gallatin	2022	121052	130740	126792
Gallatin	2027	135513	159080	145055
Cascade	2022	79369	79440	80582
Cascade	2027	79046	67126	80723
Big Horn	2022	13257	12858	12846
Big Horn	2027	13389	12373	12093
Ravalli	2022	44080	49524	46523
Ravalli	2027	46353	62543	49344
Judith Basin	2022	1886	2002	1942
Judith Basin	2027	1851	1966	1900
Granite	2022	3322	3500	3322
Granite	2027	3480	3981	3425

Table 3: Population Prediction Comparison for Sample Counties, 2022 & 2027

In order to test the performance of the baseline model with the linear models from Section 4, predictions were made for that last five years of data (2016 - 2020). When the actual populations are compared to these predictions, the baseline model has an RMSE of about 2135.

5 Layered Models

In order to increase the accuracy and reliability of our model, additional features need to be taken into account. The following models act as layers, adding to the preexisting baseline model in order to show additional information and improve predictions of population. Though the differences between the models' predictions may not be drastic, the differences tell important stories about the conditions in Montana and the various factors that can impact population or be of note. The layers used within this project are only a few of many that can be added. We decided to go with two features that we believe to have an interesting impact on population: housing and income.

5.1 Housing Model

Housing data was used in the creation of the first model to be layered over the baseline model. As shown in Figure 14, the number of occupied houses in a county is understandably heavily correlated with the population of the same county. As the total population rises in a given county, the number of houses needed to sustain that population also increases, causing a rise in the number of houses.

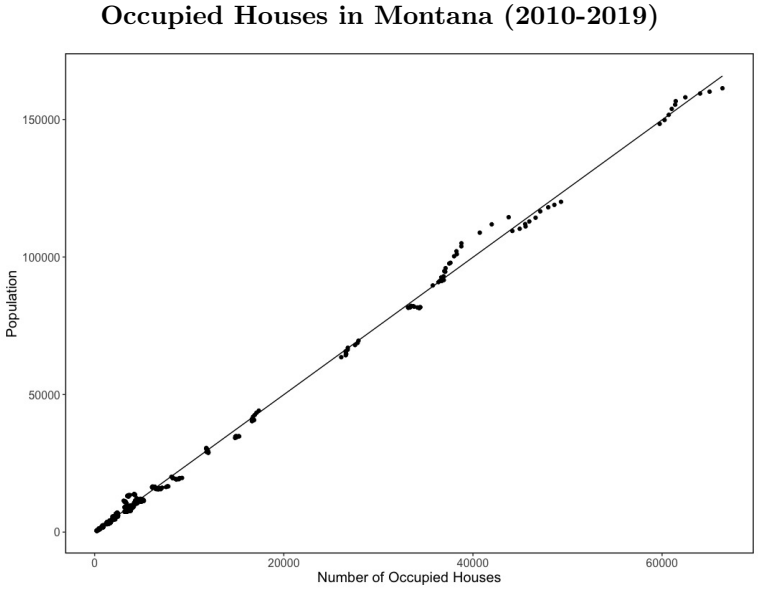

Figure 14: Number of Occupied Houses in Montana, showing Linear Regression with R^2 of 0.997

This housing model is as follows, where P is the population of the county and H is the number of occupied houses in the county:

$$P = 2.50H + 12.0. \tag{6}$$

Using this model, the population of a county can be predicted given the number of occupied houses in the county. As such, if the number of occupied houses can be projected for each county into the future, the population of the county can be projected as well. Figure 15 shows that the growth in the number of occupied houses is fairly linear between 2010-2019. Due to this linear growth, linear regression models were created for each county to predict the number of occupied houses in the county through 2027. These projections can be seen along with the data in Figure 15, where the solid lines represent the actual data and the dashed lines represent our projections.

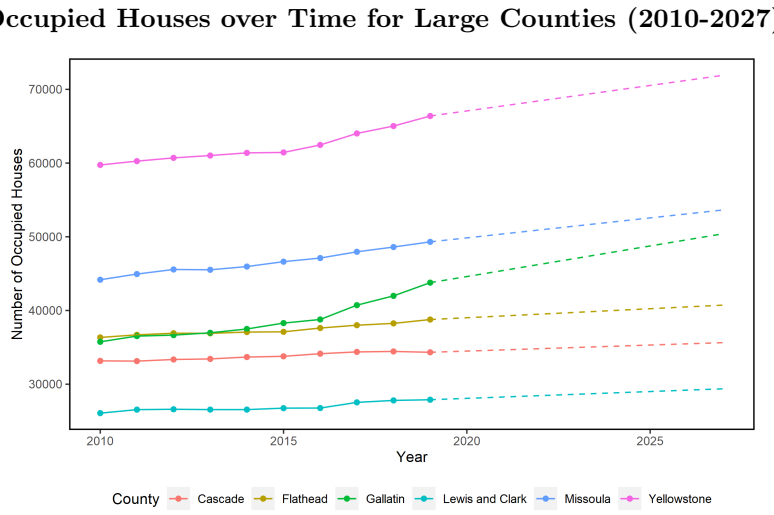

Figure 15: Occupied Housing Data and Projections - Solid lines represent data, Dotted lines represent projections

These housing projections can then be used to project the population in these counties, using the model shown in Equation 6. Figure 16 shows our population projections using these housing projections. Once again, the solid lines represent actual data and the dashed lines represent our projections. If this model is used to predict the last five years of available housing data (2016-2020) and then compared to the actual populations from these years, the model gives an RMSE of about 1767. During this set of years, this housing model has a much smaller error than the baseline model.

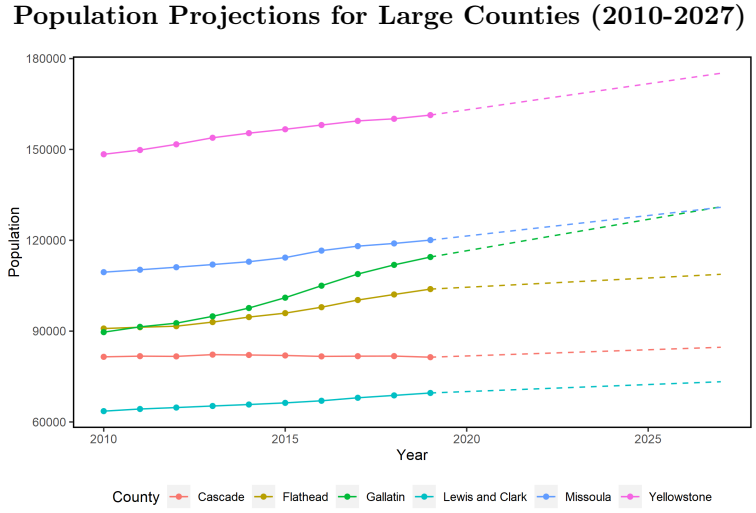

Figure 16: Population Projections using the Housing Model - Solid lines represent data, Dotted lines represent projections

5.2 Income Model

The next set of data we examined is sum personal income, again split by county and years. We hope that by looking at the population as a factor of wealth, we can predict the populations of counties with greater paying jobs (large businesses) and more businesses. We were able to create a linear model that displays the statewide income represented by I where y is the year:

$$I(y) = (1.07 * 10^6)y - (2.13 * 10^9) \tag{7}$$

Equation 7 has an R^2 of 0.977 on the data used from 2007-2019. Figures 17 and 18 supports that income in Montana is growing and can be used as a factor in multiple linear regression.

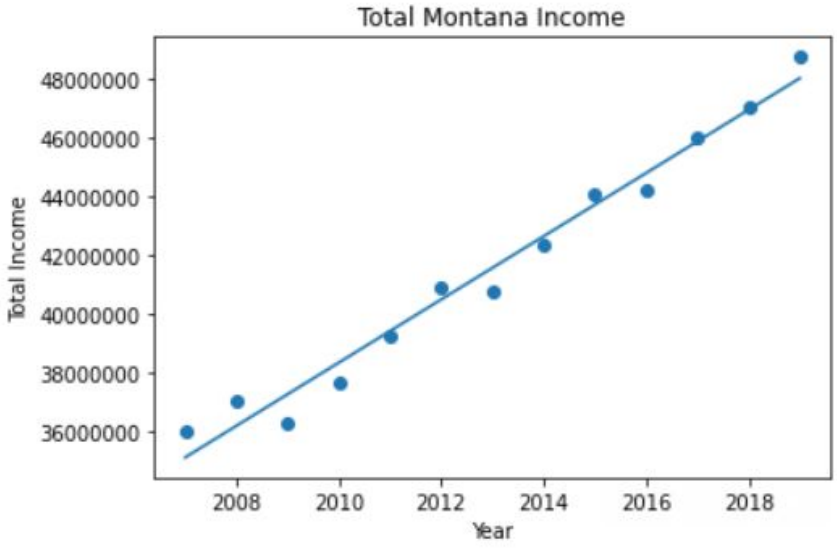

Figure 17: Total Montana Income Across Provided Data, 2007-2019

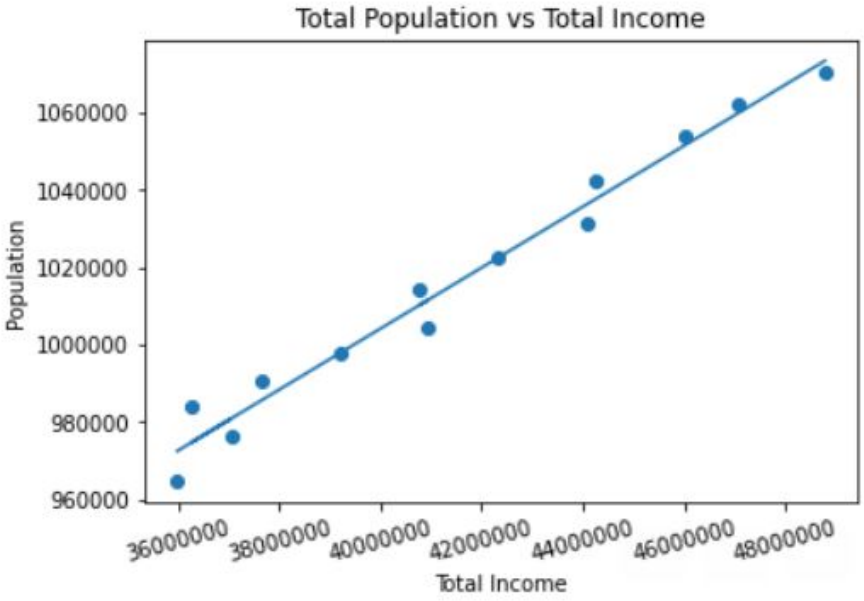

Figure 18: State Population and State Income Across Provided Data, $R^2 = 0.997$

Table 4 displays a select number of counties that responded well to this layer, displaying the equation and R^2 value. In the equation, i is the income for the provided year, either gathered through real data or predictions made on the county level. Predictions for every counties income will be provided in CSV format, as well as the models and the population predictions given the total income of the county. The resulting RMSE, using data from 2016 - 2020, from this model is about 719. This error is higher than the linear models from Section 4, but still significantly lower than the error from the baseline model.

County	Model	R^2	RMSE
Flathead	$P_{Flathead}(i) = 0.0114i + 50201.89$	0.964	1579.37
Gallatin	$P_{Gallatin}(i) = 0.0106i + 48893.85$	0.981	1879.85
Lewis and Clark	$P_{LewisAndClark}(i) = 0.009774i + 36900.00$	0.913	1295.32
Missoula	$P_{Missoula}(i) = 0.00856i + 72464.40$	0.964	1355.26
Yellowstone	$P_{Yellowstone}(i) = 0.00866i + 93102.15$	0.987	1188.98

Table 4: County-Level Population Predictions Using Year and Income

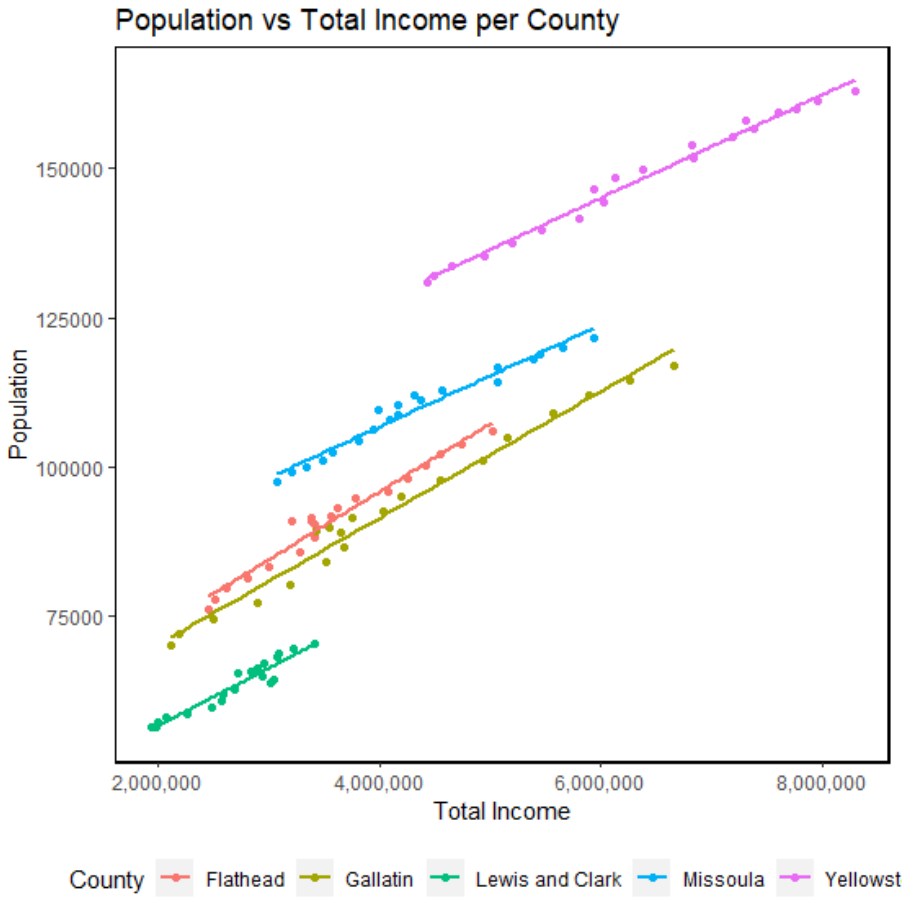

Figure 19: Model Projections Using Income

5.3 Weighted Average Model

These layered models, both housing and income, can be combined with the linear and baseline models from Sections 4 and 5, respectively. This combined model takes 40% of from the linear model projection, 30% from the economic model projection, 20% from the housing model, and 10% from the baseline model projection. Figures 20, 21, and 22 illustrate these combined projections for a sampling of different-sized counties throughout Montana. Using this combination, we are able to make more accurate population projections. This combined model has an $RMSE$ of 504 when tested against the data from 2016 - 2020.

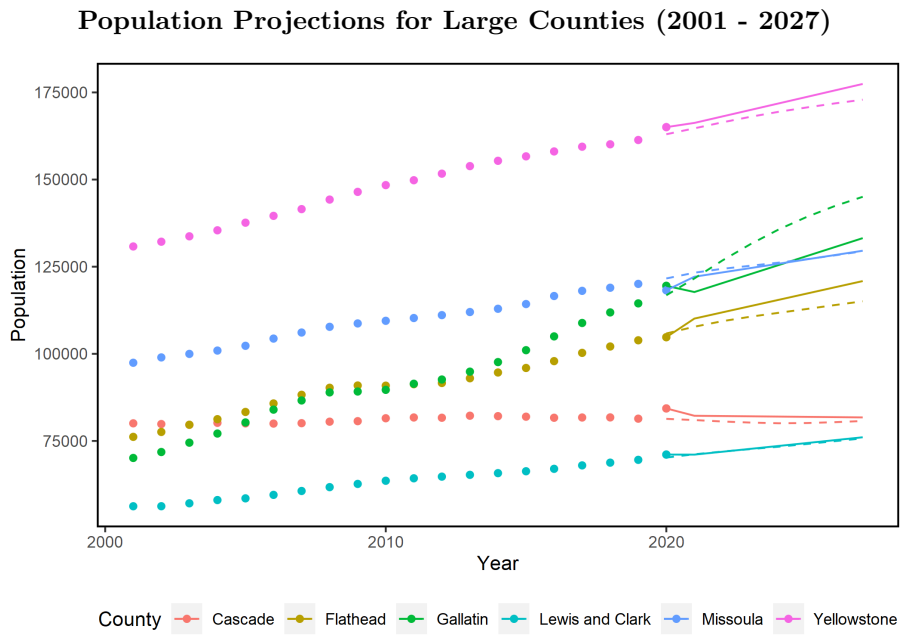

Figure 20: Combined Model Projections for Large-Sized Counties - Solid lines represent Combined Model and Dashed lines represent REMI projections

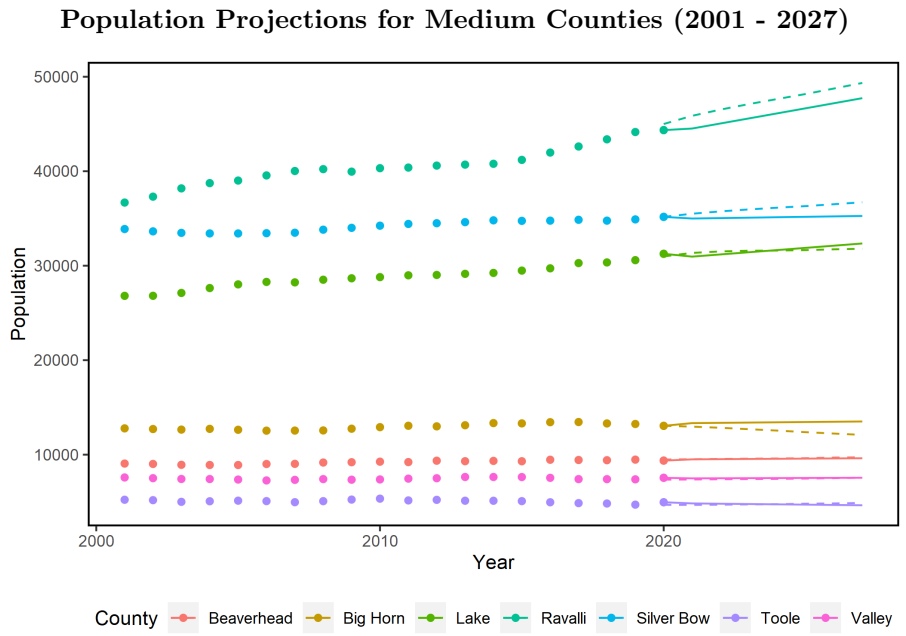

Figure 21: Combined Model Projections for Medium-Sized Counties - Solid lines represent Combined Model and Dashed lines represent REMI projections

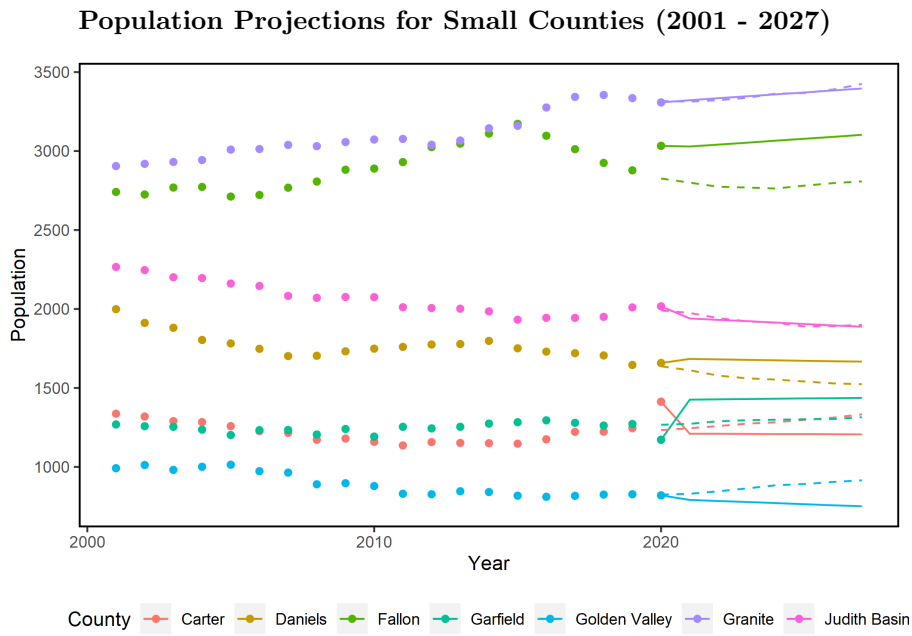

Figure 22: Combined Model Projections for Small-Sized Counties - Solid lines represent Combined Model and Dashed lines represent REMI projections

5.4 Further Exploration

When trying to add layers to the layered model we explored a number of different data sets. Of the data that we found and attempted to use in our layered model births and net migration did not prove useful for a multiple linear regression model as the births and net migration data was not linear.

6 Conclusion and Closing Remarks

Our baseline model projects population in Montana counties based upon the core tenets of population change: births, deaths, and migration. Although births and deaths are fairly predictable, migration is so unpredictable that the projections from this model are thrown from their likely values in counties with larger variations in migration numbers. Our layered income model often project similar population numbers as the linear models. In larger counties, both of these models project more gradual change in population compared to the baseline model. Thus, when the three models are combined, the linear and income models level out the baseline model projections, making the combined projection more realistic. Overall, the combined model makes projections that are likely to be much more accurate than any one model on its own. Due to the simplicity with which these three models were combined, adding additional models in the future would be easily accomplished, and the method allows for county-specific data sets and layers to be added to better benefit individual communities.

7 Appendix

7.1 References

[1] Population Research Center, Methods and Data for Developing Coordinated Population Forecasts, *Portland State University,* https://www.pdx.edu/population-research/population-forecasts, June 2022

[2] Washington State County Population Projections For Growth Management, *Washington State Office of Financial Management,* https://ofm.wa.gov/washington-data-research/population-demographics/population-forecasts-and-projections/growth-management-act-county-projections, January 2002

[3] County-to-County Migration Data, *Internal Revenue Service,* https://www.irs.gov/statistics/soi-tax-stats-migration-data, May 24, 2022

[4] Data on housing, fertility, mortality, and additional migration information was provided by the Montana Department of Commerce.

[5] Data on personal income for Montana Counties was gathered from the Regional Economic Analysis Project (https://montana.reaproject.org/).

7.2 Linear Model Predictions

7.2.1 Good Linear Regression

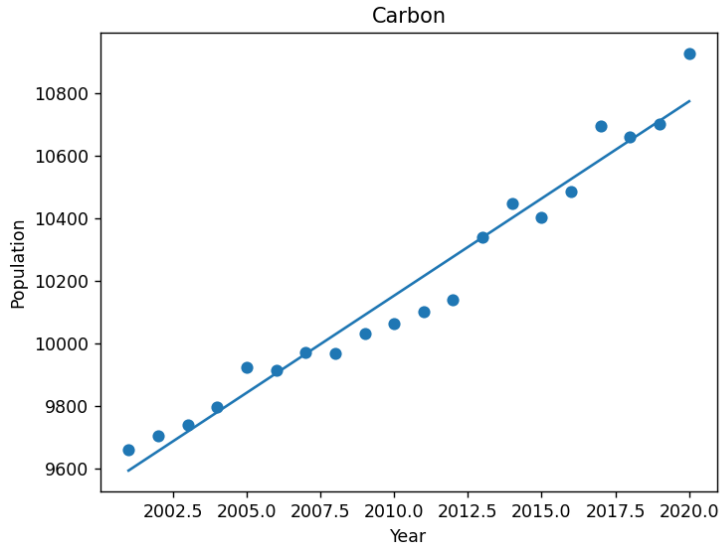

Figure 23: Linear Regression For Carbon County

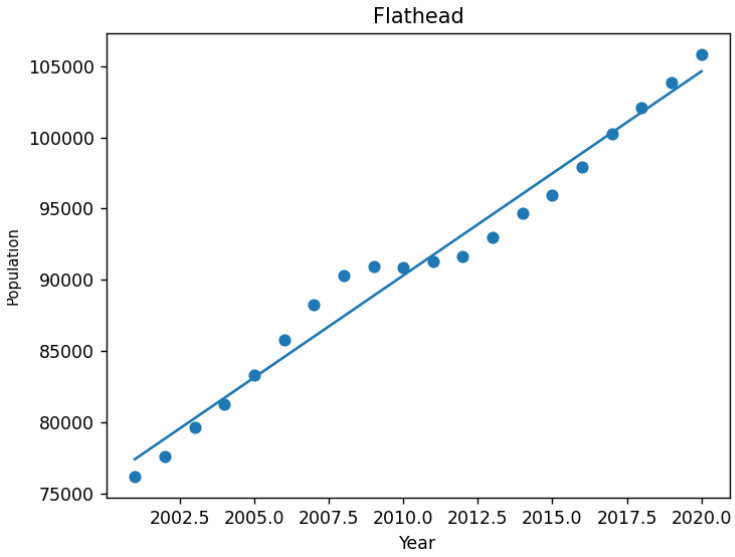

Figure 24: Linear Regression For Flathead County

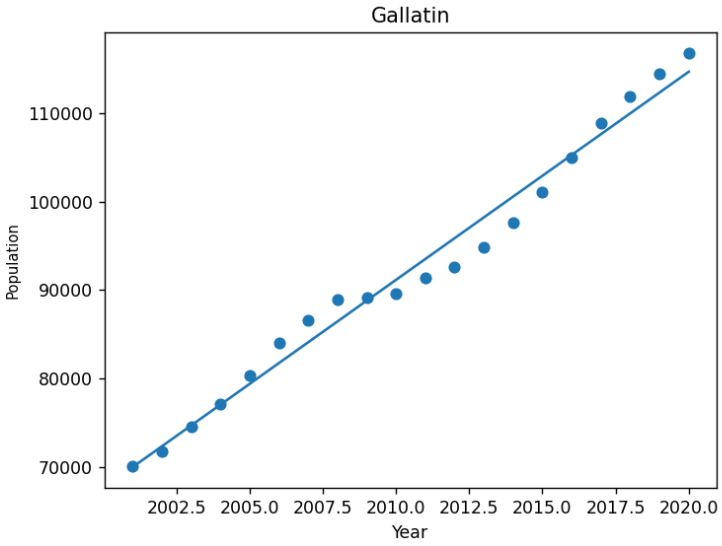

Figure 25: Linear Regression For Gallatin County

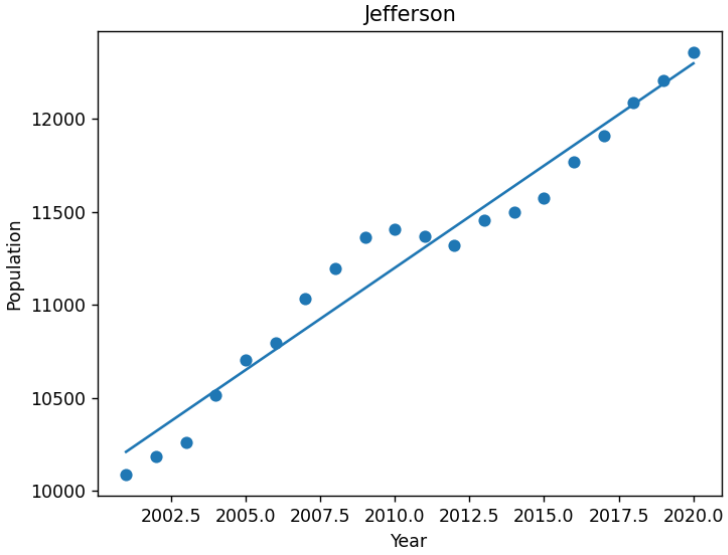

Figure 26: Linear Regression For Jefferson County

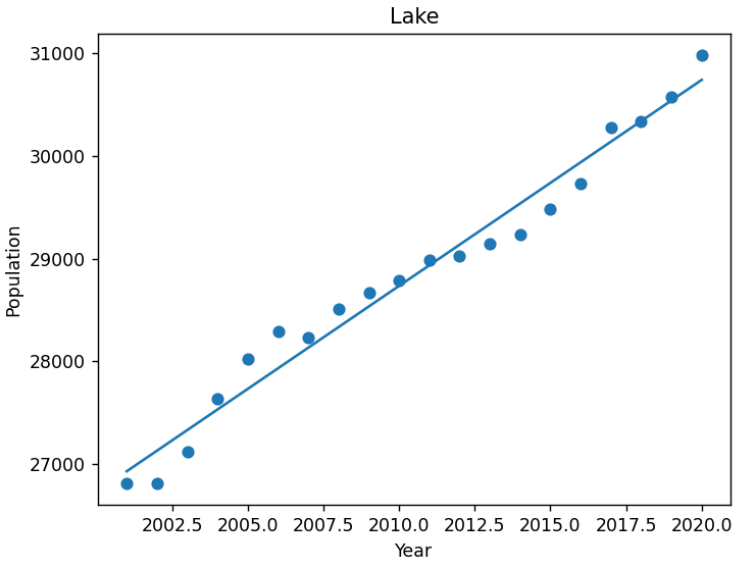

Figure 27: Linear Regression For Lake County

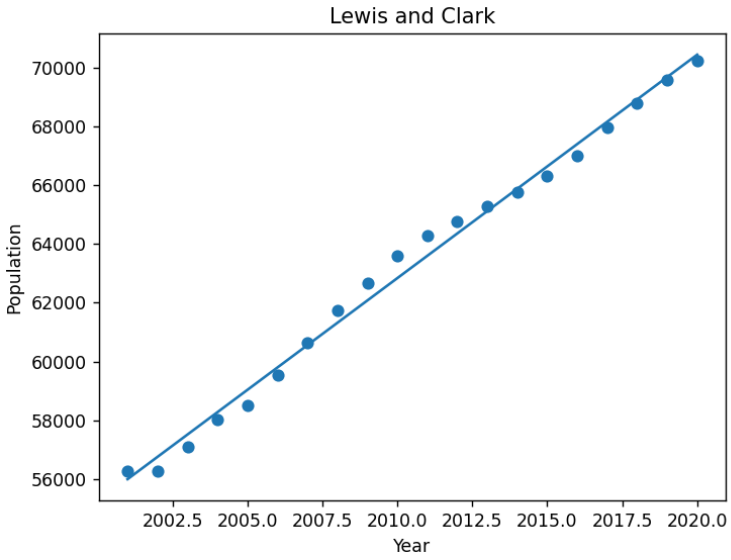

Figure 28: Linear Regression For Lewis and Clark County

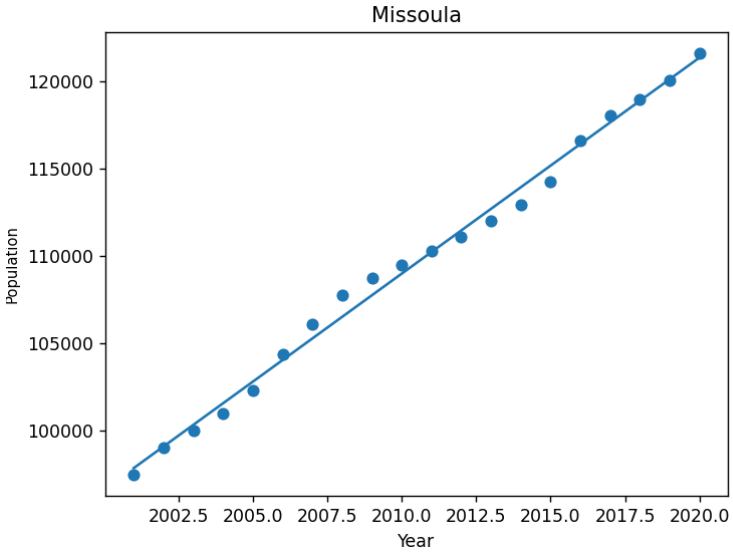

Figure 29: Linear Regression For Missoula County

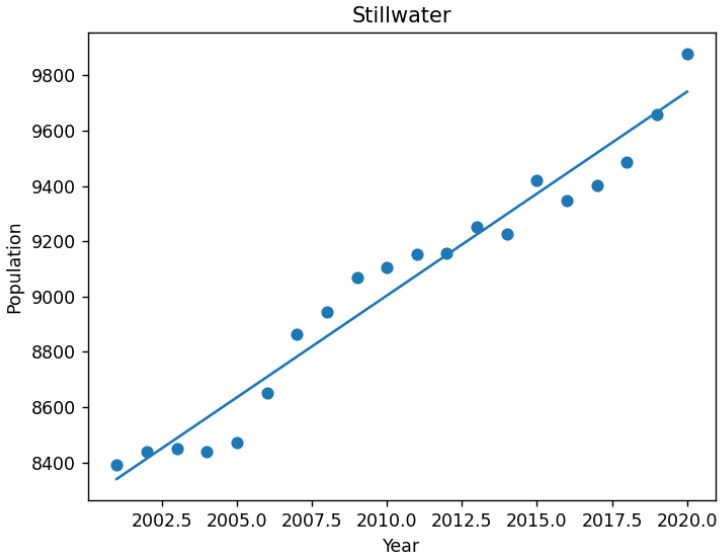

Figure 30: Linear Regression For Stillwater County

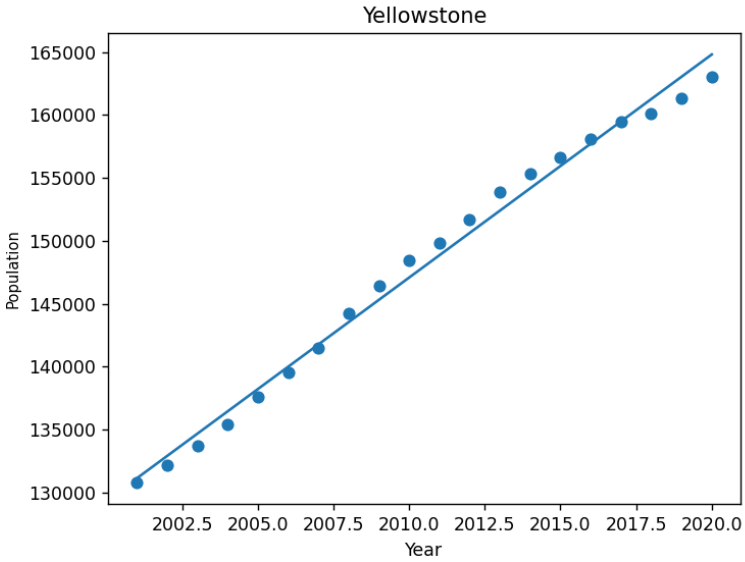

Figure 31: Linear Regression For Yellowstone County

7.2.2 Poor Linear Regression

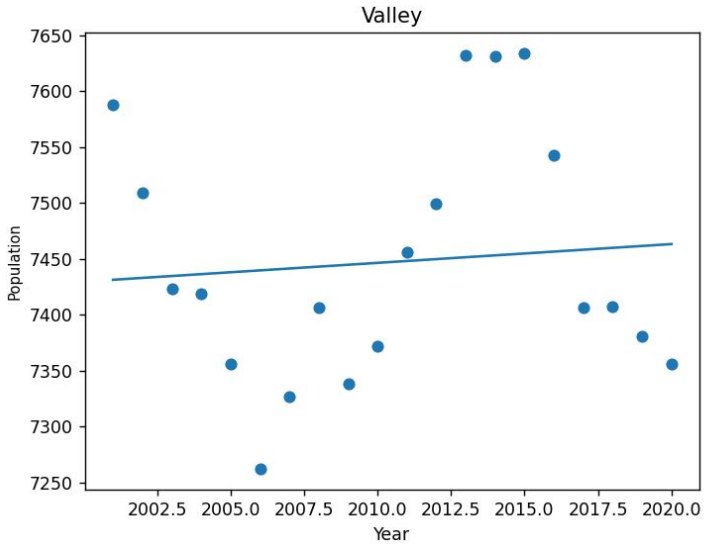

Figure 32: Linear Regression For Valley County

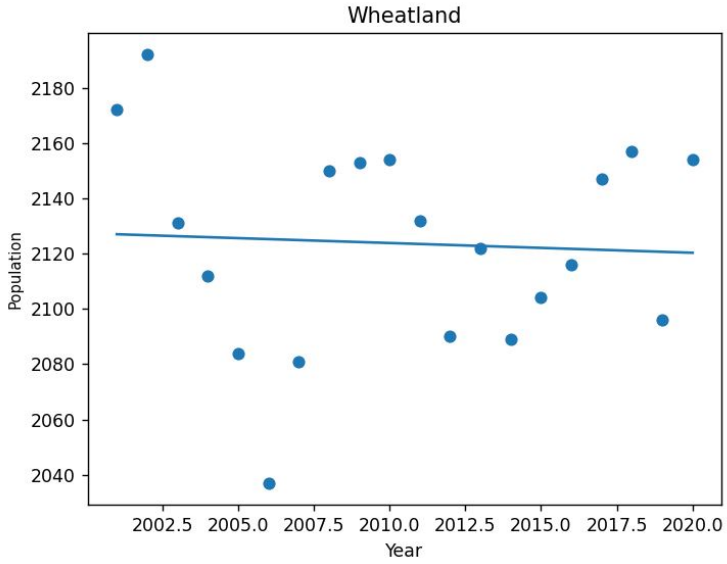

Figure 33: Linear Regression For Wheatland County

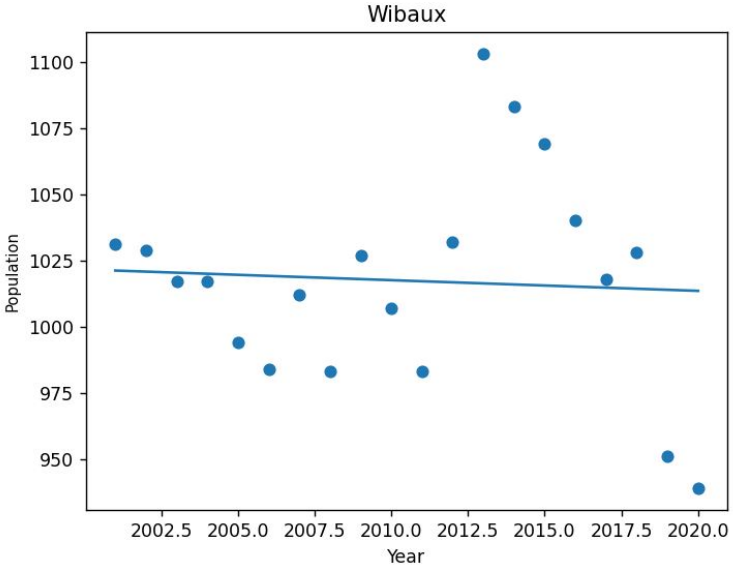

Figure 34: Linear Regression For Wibaux County

7.3 Linear Model Predictions

County	2021	2022	2023	2024	2025	2026	2027
Beaverhead	9543	9575	9607	9638	9670	9701	9733
Big Horn	13425	13469	13513	13558	13602	13647	13691
Blaine	6672	6676	6680	6684	6689	6693	6697
Broadwater	6446	6544	6642	6741	6839	6937	7035
Carbon	10836	10898	10960	11022	11084	11146	11208
Carter	1155	1150	1145	1139	1134	1128	1123
Cascade	82303	82426	82550	82673	82797	82920	83044
Chouteau	5763	5761	5759	5757	5755	5753	5751
Custer	11753	11765	11778	11790	11802	11815	11827
Daniels	1649	1638	1627	1616	1605	1594	1583
Dawson	9057	9064	9071	9078	9085	9091	9098
Deer Lodge	9142	9135	9128	9121	9114	9107	9100
Fallon	3063	3080	3096	3113	3130	3146	3163
Fergus	11116	11088	11059	11031	11003	10975	10946
Flathead	106087	107522	108956	110391	111826	113260	114695
Gallatin	117046	119398	121751	124104	126457	128810	131162
Garfield	1271	1273	1275	1277	1280	1282	1284
Glacier	13853	13890	13928	13965	14003	14040	14078
Golden Valley	764	752	740	728	715	703	691
Granite	3352	3376	3400	3424	3448	3472	3496
Hill	16522	16550	16578	16605	16633	16661	16688
Jefferson	12409	12519	12629	12739	12849	12959	13069
Judith Basin	1889	1872	1856	1839	1823	1806	1790
Lake	30944	31145	31346	31547	31748	31949	32150
Lewis and Clark	71199	71959	72719	73479	74239	74999	75759
Liberty	2458	2472	2486	2500	2514	2528	2541
Lincoln	20011	20069	20128	20186	20244	20303	20361
Madison	8744	8842	8941	9039	9137	9235	9333
McCone	1637	1628	1619	1610	1601	1592	1583
Meagher	1832	1828	1824	1819	1815	1810	1806
Mineral	4417	4441	4466	4490	4514	4539	4563
Missoula	122618	123858	125098	126338	127578	128818	130058
Musselshell	4743	4763	4783	4804	4824	4845	4865
Park	16476	16531	16586	16641	16696	16751	16806
Petroleum	497	497	498	498	498	499	499
Phillips	3975	3955	3935	3916	3896	3876	3856
Pondera	5903	5883	5863	5844	5824	5804	5784
Powder River	1704	1698	1693	1688	1683	1677	1672
Powell	6855	6845	6835	6825	6815	6805	6795
Prairie	1086	1082	1078	1074	1070	1066	1062
Ravalli	44172	44518	44865	45211	45557	45904	46250
Richland	11724	11865	12007	12149	12290	12432	12574
Roosevelt	11274	11328	11382	11436	11490	11544	11598
Rosebud	9127	9122	9118	9113	9108	9104	9099
Sanders	12012	12080	12148	12217	12285	12353	12421
Sheridan	3346	3327	3309	3291	3272	3254	3236
Silver Bow	35211	35306	35400	35495	35590	35684	35779
Stillwater	9814	9888	9962	10035	10109	10183	10257
Sweet Grass	3666	3667	3668	3669	3670	3671	3672
Teton	6040	6031	6022	6014	6005	5996	5988
Toole	4863	4845	4827	4809	4791	4773	4755
Treasure	645	637	629	622	614	606	599
Valley	7464	7466	7468	7469	7471	7473	7475
Wheatland	2119	2119	2119	2118	2118	2118	2117
Wibaux	1013	1012	1012	1011	1011	1011	1010
Yellowstone	166576	168348	170121	171893	173666	175438	177211

7.4 Baseline Model Predictions

County	2021	2022	2023	2024	2025	2026	2027
Beaverhead	9372	9371	9371	9370	9370	9369	9369
Big Horn	12954	12858	12761	12664	12567	12470	12373
Blaine	6825	6648	6471	6293	6116	5939	5761
Broadwater	7349	7852	8355	8859	9364	9868	10373
Carbon	11020	11529	12039	12549	13059	13570	14082
Carter	1404	1394	1385	1375	1366	1357	1347
Cascade	81887	79440	76988	74530	72067	69599	67126
Chouteau	5856	5813	5770	5727	5684	5641	5598
Custer	11590	11321	11052	10783	10513	10243	9973
Daniels	1640	1623	1605	1587	1569	1552	1534
Dawson	8718	8514	8309	8104	7900	7695	7490
Deer Lodge	9466	9519	9572	9625	9678	9732	9785
Fallon	2980	2926	2873	2820	2766	2713	2660
Fergus	11481	11505	11530	11554	11578	11602	11627
Flathead	110555	116350	122159	127982	133819	139670	145536
Gallatin	125114	130740	136380	142034	147701	153383	159080
Garfield	1207	1241	1276	1311	1345	1380	1415
Glacier	13682	13617	13552	13487	13421	13356	13290
Golden Valley	828	837	845	854	862	871	879
Granite	3404	3500	3596	3692	3788	3885	3981
Hill	15864	15477	15089	14702	14314	13925	13536
Jefferson	12978	13823	14670	15517	16366	17215	18065
Judith Basin	2010	2002	1995	1988	1980	1973	1966
Lake	32306	33355	34406	35459	36513	37569	38627
Lewis and Clark	73280	75472	77669	79870	82076	84287	86502
Liberty	1917	1874	1831	1789	1746	1703	1660
Lincoln	20676	21623	22570	23519	24470	25422	26375
Madison	8571	8485	8398	8312	8226	8139	8053
McCone	2288	2843	3398	3954	4509	5064	5620
Meagher	1936	1947	1958	1969	1980	1991	2002
Mineral	4783	5002	5220	5439	5657	5876	6095
Missoula	119511	120787	122065	123347	124632	125921	127212
Musselshell	4896	5045	5195	5344	5494	5643	5793
Park	17738	18283	18829	19376	19924	20472	21021
Petroleum	505	512	519	526	533	540	547
Phillips	4106	4021	3937	3853	3768	3684	3600
Pondera	5806	5731	5655	5579	5503	5428	5352
Powder River	1704	1715	1726	1737	1747	1758	1769
Powell	6985	7037	7088	7139	7191	7242	7294
Prairie	1075	1075	1074	1074	1073	1073	1072
Ravalli	46935	49524	52118	54716	57320	59929	62543
Richland	11544	11588	11631	11675	11718	11762	11805
Roosevelt	10593	10406	10219	10031	9844	9656	9468
Rosebud	8083	7868	7653	7437	7222	7006	6790
Sanders	13200	13951	14702	15454	16206	16960	17714
Sheridan	3408	3298	3188	3078	2968	2857	2747
Silver Bow	34998	34828	34657	34486	34315	34143	33971
Stillwater	9395	9781	10167	10554	10940	11327	11715
Sweet Grass	3734	3797	3860	3923	3987	4050	4113
Teton	6246	6250	6255	6259	6263	6267	6271
Toole	4828	4691	4555	4418	4281	4145	4008
Treasure	759	757	755	752	750	748	746
Valley	7483	7416	7348	7280	7213	7145	7077
Wheatland	2063	2034	2004	1975	1945	1916	1886
Wibaux	905	883	860	838	815	792	770
Yellowstone	167917	170797	173684	176579	179481	182391	185309

7.5 Income Model Predictions

County	2021	2022	2023	2024	2025	2026	2027
Beaverhead	9524	9554	9583	9612	9642	9671	9700
Big Horn	13356	13395	13433	13471	13510	13548	13586
Blaine	6624	6623	6623	6622	6622	6621	6621
Broadwater	34934	35865	36795	37726	38657	39587	40518
Carbon	10807	10866	10925	10984	11043	11102	11161
Carter	1173	1170	1166	1162	1159	1155	1151
Cascade	82250	82369	82489	82608	82728	82847	82966
Choteau	5776	5776	5775	5774	5773	5772	5772
Custer	11804	11822	11839	11856	11874	11891	11908
Daniels	1746	1745	1743	1742	1740	1738	1737
Dawson	9207	9228	9249	9270	9291	9313	9334
Deer Lodge	9157	9151	9146	9140	9135	9129	9124
Fallon	3063	3080	3097	3114	3131	3148	3165
Fergus	11151	11126	11101	11075	11050	11025	11000
Flathead	118671	120386	122101	123816	125531	127246	128961
Gallatin	115592	117777	119962	122147	124331	126516	128701
Garfield	1830	1831	1832	1833	1834	1835	1836
Glacier	13788	13820	13852	13885	13917	13949	13981
Golden Valley	788	778	768	757	747	737	727
Granite	3341	3364	3387	3409	3432	3455	3477
Hill	16475	16498	16521	16545	16568	16592	16615
Jefferson	12397	12505	12614	12722	12830	12938	13046
Judith Basin	1923	1910	1897	1884	1871	1858	1845
Lake	30866	31058	31250	31442	31634	31826	32018
Lewis and Clark	70576	71284	71992	72700	73408	74116	74823
Liberty	2424	2434	2445	2455	2466	2476	2487
Lincoln	20045	20107	20169	20231	20293	20354	20416
Madison	8748	8847	8946	9045	9144	9243	9342
McCone	1687	1683	1679	1675	1671	1667	1663
Meager	1840	1836	1832	1829	1825	1821	1817
Mineral	4430	4456	4481	4507	4533	4559	4584
Missoula	121896	123057	124217	125378	126539	127700	128860
Musselshell	4754	4776	4797	4819	4840	4862	4883
Park	16520	16579	16638	16697	16756	16815	16874
Petroleum	492	492	492	492	492	492	492
Phillips	4010	3994	3977	3960	3944	3927	3910
Pondera	5956	5941	5926	5911	5897	5882	5867
Powder River	1737	1735	1733	1731	1729	1727	1725
Powell	6839	6827	6816	6805	6794	6783	6771
Prairie	1105	1102	1100	1098	1096	1094	1092
Ravalli	44210	44560	44910	45259	45609	45959	46309
Richland	11561	11686	11811	11937	12062	12187	12312
Roosevelt	11209	11256	11303	11350	11397	11444	11491
Rosebud	9146	9143	9140	9138	9135	9132	9129
Sanders	12023	12092	12162	12231	12300	12370	12439
Sheridan	3456	3448	3441	3433	3425	3417	3410
Silver Bow	34705	34753	34801	34848	34896	34944	34992
Stillwater	9763	9831	9898	9966	10033	10100	10168
Sweet Grass	3696	3700	3704	3708	3712	3716	3720
Teton	6042	6033	6024	6016	6007	5998	5989
Toole	4961	4952	4943	4934	4925	4916	4907
Treasure	665	659	654	648	642	637	631
Valley	7503	7509	7514	7520	7525	7530	7536
Wheatland	7133	7132	7132	7131	7130	7130	7129
Wibaux	1037	1039	1041	1043	1045	1047	1049
Yellowstone	166236	167968	169700	171431	173163	174895	176627

7.6 Combined Model Predictions

County	2021	2022	2023	2024	2025	2026	2027
Beaverhead	9503	9523	9543	9562	9582	9602	9621
Big Horn	13340	13369	13397	13426	13455	13484	13512
Blaine	6682	6667	6652	6637	6623	6608	6593
Broadwater	15079	15470	15862	16254	16645	17036	17428
Carbon	10863	10979	11094	11210	11326	11442	11558
Carter	1210	1210	1209	1208	1208	1207	1206
Cascade	82227	82149	82071	81992	81913	81833	81753
Chouteau	5772	5773	5774	5775	5776	5777	5778
Custer	11640	11607	11574	11540	11507	11474	11440
Daniels	1684	1681	1678	1675	1672	1669	1667
Dawson	9015	9020	9024	9028	9033	9037	9041
Deer Lodge	9174	9165	9158	9149	9142	9133	9126
Fallon	3029	3041	3053	3066	3078	3090	3103
Fergus	11147	11132	11116	11100	11084	11068	11052
Flathead	110111	111902	113693	115486	117280	119076	120873
Gallatin	117731	120304	122879	125456	128034	130613	133194
Garfield	1426	1428	1430	1432	1434	1435	1437
Glacier	13776	13789	13802	13815	13829	13842	13855
Golden Valley	791	784	778	771	764	757	751
Granite	3322	3335	3347	3359	3371	3384	3396
Hill	16462	16454	16447	16439	16431	16423	16415
Jefferson	12420	12580	12740	12900	13060	13220	13380
Judith Basin	1940	1931	1923	1914	1905	1896	1888
Lake	30962	31193	31425	31656	31888	32121	32353
Lewis and Clark	71081	71909	72738	73567	74397	75227	76058
Liberty	2386	2394	2402	2410	2419	2427	2435
Lincoln	19983	20059	20135	20211	20287	20363	20439
Madison	8696	8741	8786	8830	8874	8918	8963
McCone	1717	1766	1816	1866	1915	1965	2015
Meagher	1847	1846	1845	1844	1843	1842	1841
Mineral	4460	4500	4541	4581	4621	4662	4702
Missoula	122121	123363	124605	125848	127092	128335	129579
Musselshell	4753	4791	4828	4865	4902	4940	4977
Park	16771	16929	17088	17247	17406	17565	17723
Petroleum	487	483	480	476	472	469	465
Phillips	3990	3966	3942	3919	3895	3872	3848
Pondera	5878	5847	5817	5786	5756	5725	5694
Powder River	1718	1721	1723	1726	1728	1730	1733
Powell	6864	6862	6860	6859	6857	6856	6854
Prairie	1091	1091	1091	1091	1091	1092	1092
Ravalli	44519	45054	45589	46124	46660	47197	47734
Richland	11559	11687	11815	11943	12070	12198	12326
Roosevelt	11112	11116	11121	11125	11130	11134	11139
Rosebud	8982	8951	8921	8891	8861	8831	8801
Sanders	12102	12215	12329	12443	12557	12671	12785
Sheridan	3378	3356	3335	3313	3291	3270	3249
Silver Bow	34995	35040	35085	35130	35175	35220	35265
Stillwater	9728	9817	9906	9995	10083	10172	10261
Sweet Grass	3707	3722	3738	3753	3768	3784	3799
Teton	6088	6085	6082	6079	6076	6073	6070
Toole	4840	4807	4775	4742	4710	4678	4645
Treasure	678	675	673	671	669	667	665
Valley	7492	7503	7514	7524	7535	7545	7556
Wheatland	3607	3600	3594	3586	3580	3573	3566
Wibaux	1014	1021	1028	1035	1042	1049	1055
Yellowstone	166253	168114	169977	171840	173704	175568	177434