A Tale Told by Two Data Sets:
A Review of The Complex Growth of State Prison
Populations From 1978 to 2018
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Introduction
A common simplifying practice by authors of articles about prison population growth is to show a chart that shows the growth of the combined populations of all 100 state female and male prisons. This is misleading because no state prison has the growth properties of the combined system and nobody has the authority to alter the properties of the combined system. To understand how prison growth really happened it is necessary to deal with prison population growth state by state.

In this report state female and male prison growth for all 50 states between 1978 and 2018 were studied state by state to determine when the growth occurred and if there was both positive and negative growth. The report used two sets of state prison population data published by the Bureau of Justice Statistics. To determine the reasons for positive growth and how some states were able to reverse the growth to negative growth will have to be done state by state.

If a state has more than one prison they aggregate the data by gender before they send it to the Bureau of Justice Statistics. The Bureau of Justice Statistics compiles the state prison data and publishes it in annual reports. In addition they publish data sets on their web site. The female and male prison populations for 1978 to 2016 were among those sets. I appended the 2017 and 2018 data from the annual reports to extend the time interval covered to 2018. The resulting two data sets (one for each gender) consisted a table of 50 columns (one for each state) and 41 rows (one for each year) of end of the year counts of prison inmates.

Interannual Fluctuations
It is common for annual prison admissions and releases to differ so that when one subtracts the number of releases from the number of admissions the result can be either negative or positive. The resulting interannual fluctuations in a prison population can be larger than the annual changes caused by growth. For female and male prisons the interannual fluctuations determined for the entire data set averaged 5.5% for female prisons and 5.3% for male prisons. The average fluctuations between 1979 and 1999 were larger with averages of 7.4% for female prisons and 7.5% for male prisons. Between 2000 and 2018 the averages were smaller with 3.4% and for female prisons and 2.8% for male prisons.

Normalization of The Prison Growth Curves
The minimum female prison population was 2 for North Dakota in 1979 and 1980 and the maximum was 14,435 for Texas in 2018. The minimum male population was 184 (also for North Dakota in 1979) and the maximum was 163,535 for California in 2006. The ratios of Max/Min were 7,212 for female prisons and 889 for male prisons both very large ratios. Such large population ranges meant that either a logarithmic scale would have to be used or normalization of the data. I tried using a log scale and was not satisfied with the results and that was also the case when I normalized to the maximum or the average. Min-Max normalization with the minimum equal to 0% and the maximum equal to 100% gave the best results. Because of the large interannual fluctuations the population data was smoothed with three year moving average before it was normalized.

Color Contour Charts of State Prison Population Growth
In order to show all state growth curves in a single chart it is necessary to use color to denote the normalized percentage of maximum growth. The colors were;
1. Black for 0% to 1% or minimum.
2. Blue for 2% to 30%.
3. Green for 31% to 60%.
4. Yellow for 61% to 90%.
5. Red for 91% to 98%.
6. Light gray for 99% to 100% or maximum.

The following states were not included Alaska, Connecticut, Delaware, Hawaii, Rhode Island and Vermont because they have integrated jails and prisons and the jail inmates were included in the reported population a major complicating factor. In addition the growth curve for the female prison of Maine was anomalous and it was not included in the female chart.

There were 43 or 44 rows one for each state. The states were sorted in order of increasing year of maximum from bottom to top. There were 41 columns one for year year. To facilitate comparison between female and male prisons figures 2 and 3 are on the same page. Simple inspection shows that the female growth curves were more complex than the male curves.

States with early maxima are in the lowest rows and they were able to establish and maintain negative growth. For many of the states in the middle rows the growth slowed and then plateaued. The states in the upper rows has variable positive growth to a late maximum. For those at the very top the maxima were in 2018 the last year of the data set and some of them could still have increasing prison populations.

The widths of the blue, green and yellow contours are how long it took for the population to increase or decrease by 30%. The width of the blue contour had a tendency to increase toward the upper rows (more so for female prisons than male prisons) an indication of slow initial growth. The most rapid growth was between 30% and 60% (green contour) and for several states it was so narrow that the growth was a step function.

Interesting features in the female chart are several red bands within yellow contours prior to maximum growth. They were caused by positive growth followed by a temporary interval of negative growth. There is only one such very narrow feature in the male chart.

Years of Attainment of Growth Stages by State Prison
Because the state prisons do not march in step to the beat of the federal drum for each state prison the years of minimum, maximum and when 30%, 60% and 90% of the growth had been achieved were determined.

People who work in corrections and related fields are aware that there are dips in the populations of prisons when there is major war. The historical record shows dips during the Civil War, WW I, WW II and the Vietnam War were the minimum occurred in 1972. Normally it takes about 5 years for the prison population to return to the prewar level. For the data sets used in this study the earliest minimum was in 1978 the first year in the data set and the latest was in 1983.
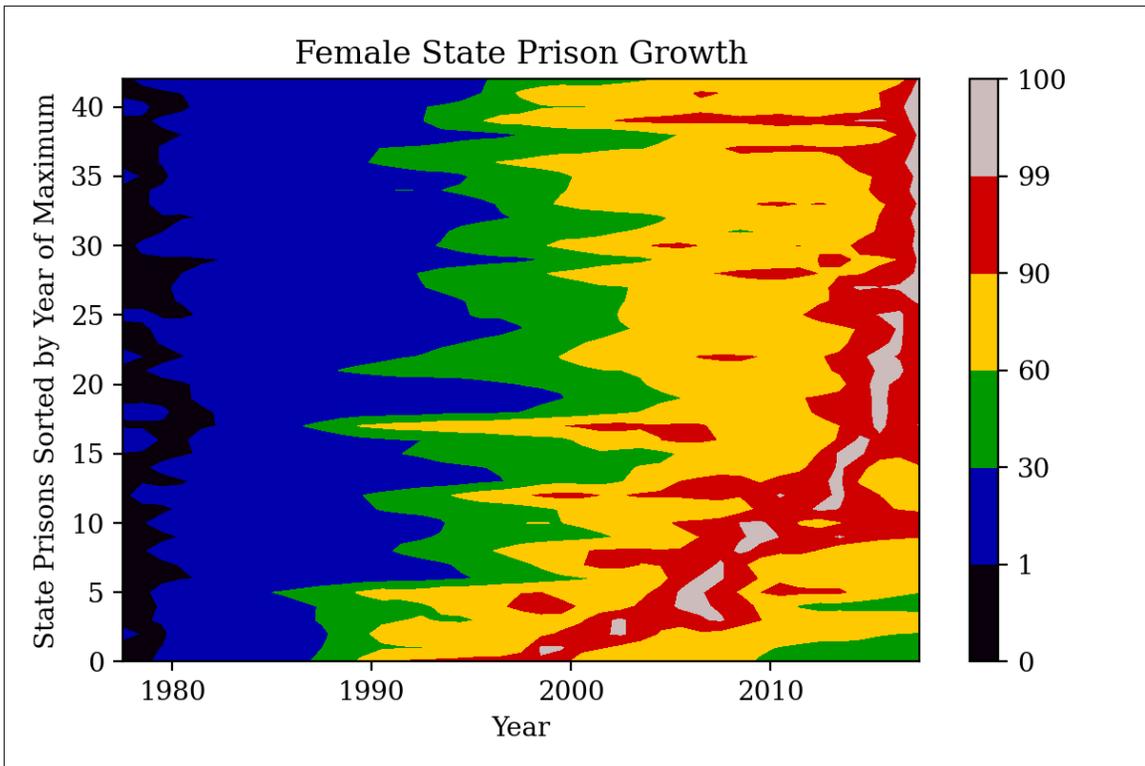
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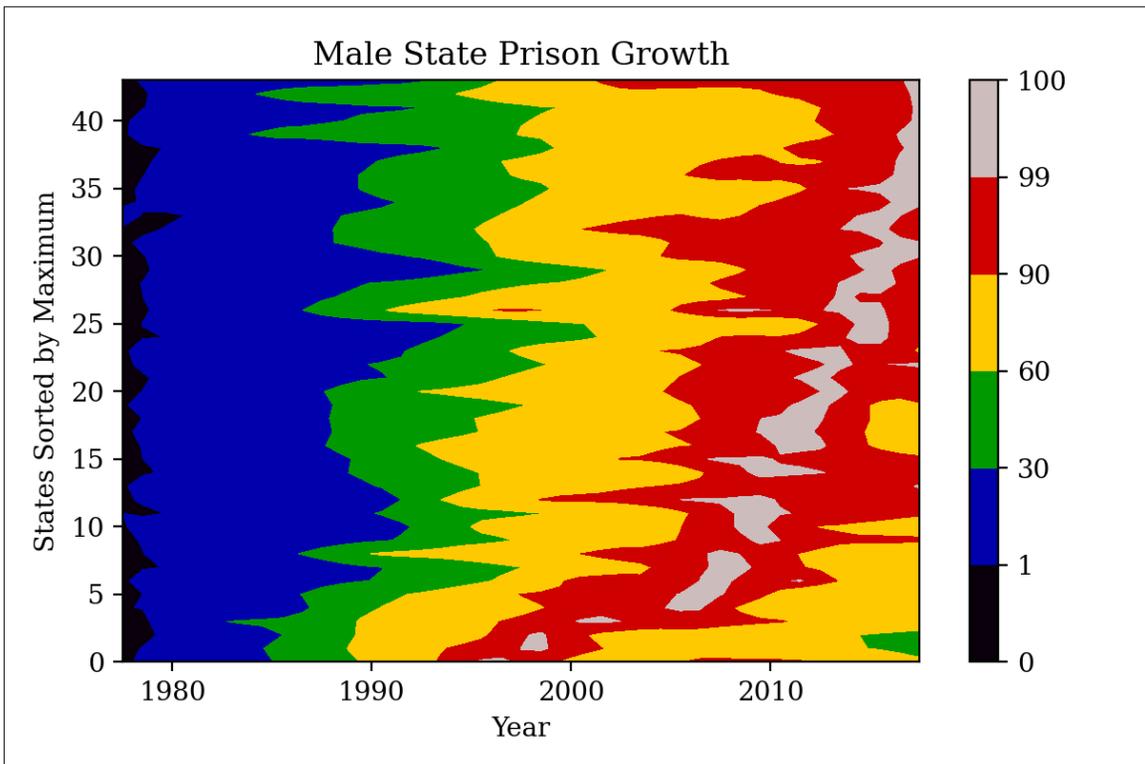Figure 1: Color contour map of state female prison growth curves.

Figure 2: Color contour map of state male prison growth curves.

Table 1: Ranges and Averages for Years of Attainment

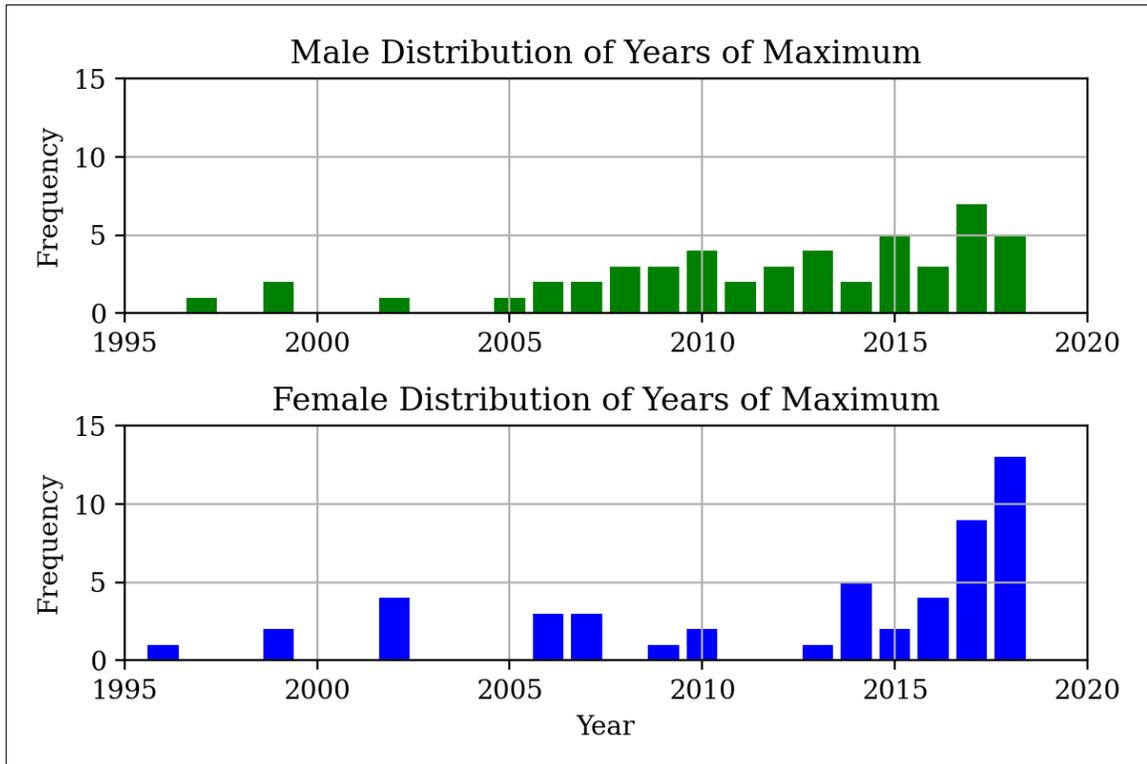| Growth Stage	Female Prisons		Male Prisons	
	Range	Average	Range	Average
Y-min	1978-1981	1978.6	1978-1983	1978.4
Y-30%	1985-2000	1992.9	1983-1996	1989.7
Y-60%	1989-2006	1999.6	1989-2002	1996.1
Y-90%	1992-2017	2008.7	1993-2013	2005.6
Y-max	1996-2018	2013.5	1997-2018	2012.2

Figure 3: Distributions of years of maximum for female and male state prison populations.

There were 28 female prisons and 20 male prisons had late maxima between 2015 and 2018. It is very likely that some of these prison populations are still increasing.

In figure 4 the year of attainment is shown for Y-min, Y-30%, Y-60%, Y-90% and Y-max vs rank in order of increasing Y-max for 44 male prisons and 43 female prisons.

The primary factors that determined when the growth started, the initial and subsequent growth rates and the year of maximum operated at the county, district and state levels. The federal crime act of 1964 was passed about the time that most state prisons had attained about half of their maximum growth.

The black dashed horizontal lines shown in the male panel include the time interval (1996 to 2001) when congress appropriated funds for state prison construction. Not all states obtained federal grants for that purpose. During that time interval 3 female and 3 male prisons had achieved maximum population and all but 2 of the male prisons had achieved 60% of the maximum growth. By 2001 the growth had slowed for almost all male prisons.

The growth for the female prisons started at the same time but lagged the male growth by an average of three years.
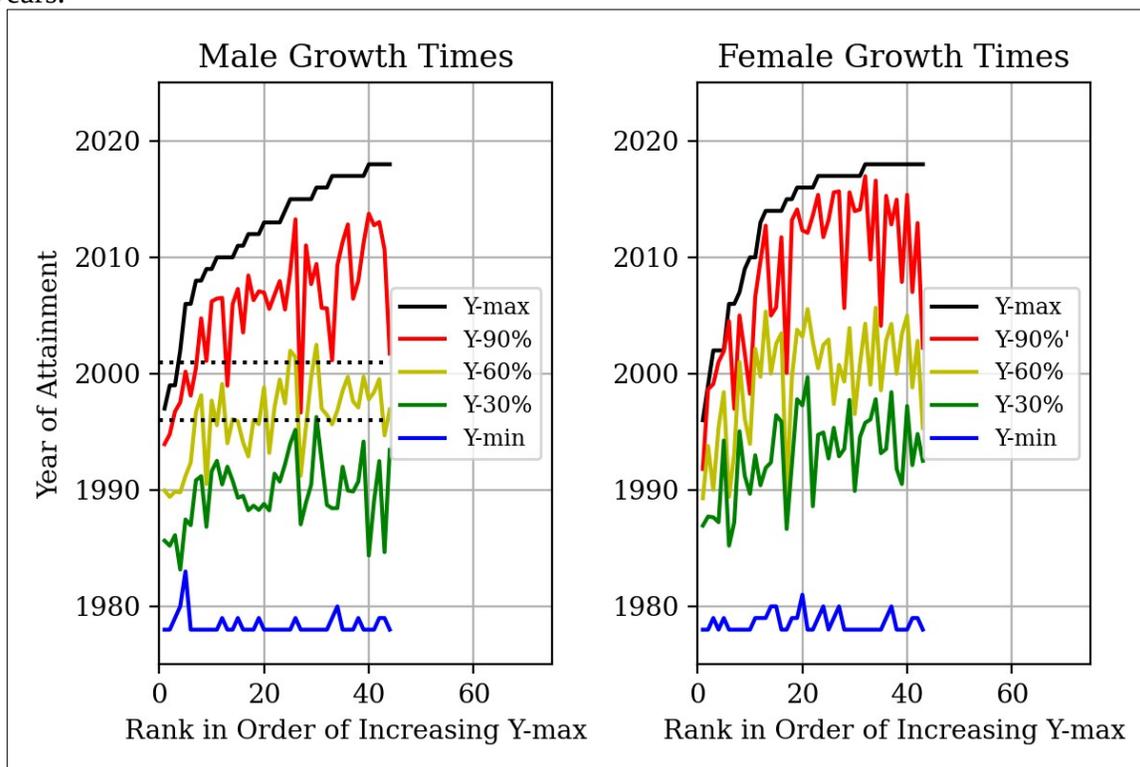

Figure 4: Year of attainment vs rank in order of increasing year of maximum for female and male state prisons.

Negative Prison Population Growth
A few of the state prisons were able to establish and maintain negative population growth. The final percent of maximum growth (in this case in 2018) is plotted vs year of maximum for state female and male prisons in figure 5.

In this discussion I have assumed that the 8 female and 7 male state prisons with final percentages smaller than 80% and year of maximum earlier than 2010 were been able to establish and maintain negative growth at moderate rates between -1% per year and -4% per year. One has to keep in mind that negative growth will eventually be stopped before the prison has been emptied.
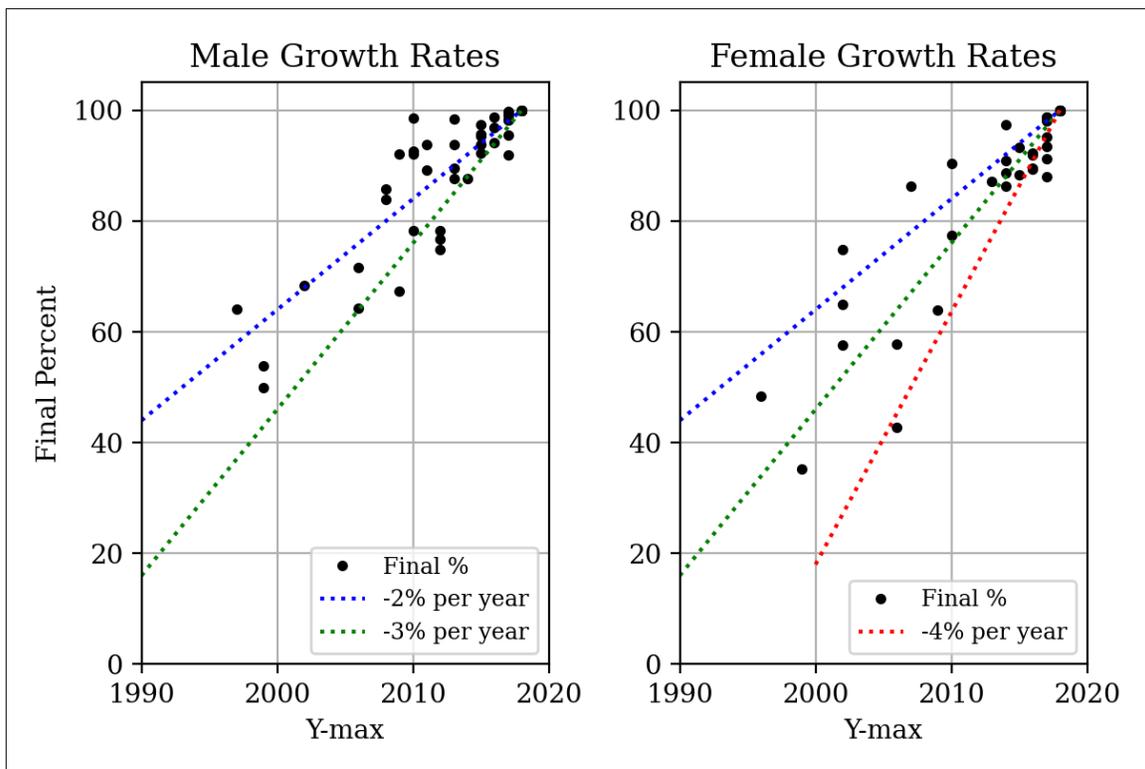
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Figure 5: Final percent of maximum growth vs year of maximum for female and male state prisons.

List of Findings
1. The growth curve for combined female and male state prisons does not match the growth curve for any state prison of either gender. This is not a new finding it has been known for many years.
2. It was necessary to remove states with integrated jail and prison systems from the study because the presence of the jail inmates caused major complications.
3. It was also necessary to remove the Maine female prison growth curve from the study because it did not match any other curve.
4. The average year of minimum was 1978.5 with a small range of 1978 to 1983.
5. The average year of maximum was 2012.8 with a large range from 1996 to 2018.
6. Although the growth of female and male prisons started about the same time the female prisons lagged behind the male prison by an average of 3 years.
7. There ranges for years of attainment for 30%, 60% and 90% growth were 15 to 25 years for female prisons and 10 to 13 years for male prisons. This suggests that the important factors that influenced prison population growth were those that operated at the county, district and state levels. The role played by federal initiatives while important is difficult to discern.
8. Late maxima were between 2015 and 2018 and there were 28 female and 20 male prison in that range. Some of them may plateau and others may still be growing.
9. There were 9 female and 11 male prisons with a final percent less the 80% who are most likely to have established negative growth.
10. The remaining prisons could be slowing their growth or have plateaued.
11. The progression was to first stop the positive growth, convert the resulting slow or zero growth to negative growth and then sustain the negative growth. There seems to be a problem in making the conversion from plateau to negative growth.