# Appendix C to the 2015 Utah Growth Model Report
# Investigation of Potential Ceiling and Floor Effects.

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# 1 Introduction

In the 2013-2014 academic year, Utah transitioned from its previous Utah Criterion Referenced Tests (CRT) to the Student Assessment of Growth and Excellence (SAGE). The transition included numerous changes to the assessment system including the incorporation of new performance standards and moving to a vertical scale. As other states have gone through similar assessment transitions in 2014-2015, many have observed ceiling and floor effects in the new assessments (i.e. a relatively large proportion of students scoring at/near the scale extremes). This has occurred despite purported improvements in assessment qualities that should prevent these effects (e.g. adaptive tests). Regardless of the source of assessment ceilings/floors, they can telegraph onto the Student Growth Percentile (SGP) calculations making these estimates questionable.

Although very similar in nature, ceiling effects are somewhat more problematic than floor effects because students that consistently achieve the highest scores receive lower than expected growth percentiles and are therefore negatively impacted. Conversely, the consistently lowest achieving students have higher estimated SGPs than would be expected. Although this could be interpreted as a positive impact for these students by giving them higher SGPs, it can also conceal unacceptably low growth that needs to be identified and addressed.

Essentially these problems are caused by the way in which a "percentile" is most typically defined to begin with, and the inability of the assessments (and therefore the SGP model) to make granular distinctions between kids who score at the extremes of the test year after year. As an example, if a group of students were tested with a relatively easy test and 20% of the students had a perfect score, these students would be defined as being in the $80^{th}$ percentile because they scored higher than 80% of their peers. This is somewhat misleading however, because their score was *equal to* or greater than *all* of their peers and so could be also described as achieving at the $99^{th}$ percentile under an equally valid definition.

To extend this heuristic from achievement to growth, if 50% of those top students also scored perfectly on the next test, we might estimate that they had $50^{th}$ percentile growth. Although there is nothing *technically* incorrect about this estimate since their growth is fairly typical for their academic peer group, it is an inadequate or unsatisfactory assessment of their growth because they have consistently attained at the highest observable level. Furthermore, if it is typical for their peers to maintain perfect scores then even small deviations from a perfect score could produce *low growth* SGP estimates.

Given these impacts and the difficulty in detecting them using traditional SGP diagnostic tools, the Center for Assessment has added "Ceiling/Test Effects" indicators to the SGP model goodness of fit plots and is providing all clients even more rigorous diagnostic and descriptive analyses through this Appendix to the annual technical report. This report includes:

1. Plots of the scale score distributions for the current and prior years' tests, which may provide an indication of whether a ceiling or floor is present in either (or both) the current or historical data.
2. Box plots showing the range and distribution of SGPs for *only* the highest and lowest achieving students in the current year.

# 2 Prior and Current Year Score Distributions

The marginal and conditional distributions of scale scores can serve as a preliminary indicator of potential ceiling or floor effects in the calculation of student growth percentiles. Some minor problems could present themselves if these characteristics are present in either prior or current year scores, and are particularly likely when present in both. The plots below depict distributions for the current year and the most recent prior year used in the SGP calculations. The marginal (individual or univariate) distributions for each year are shown in the first subsections below, followed by the conditional (joint) distributions. End-of-grade test (EOGT) content area plots are disaggregated by grade, while end-of-course test (EOCT) subject plots are not.

## 2.1 Marginal Distributions

Generally there is little evidence of potential issues with the Utah SAGE tests in either the prior (2014, shown in blue) and current (2015, shown in red) scale scores for the end of grade tests (EOGT). There are some indications of minor floor effects in the Mathematics assessments, particularly in the 2014 transition year. The end of course test (EOCT) distributions are not concerning for the content areas within the sciences domain, but there is evidence of a floor effect in the Secondary Mathematics assessments. These effects (which appear as spikes at the extreme left side of the distributions) are more prominent in the prior scores, but are notable in the current year as well. This conforms to what was observed first in the SGP model goodness of fit plots (see 2015 technical report Appendix A), and conditional density and SGP distribution box plots in subsequent sections confirm this floor effect.

### 2.1.1 ELA

**Fig. C.1:** Marginal distributions of prior scale scores: EOGT ELA.

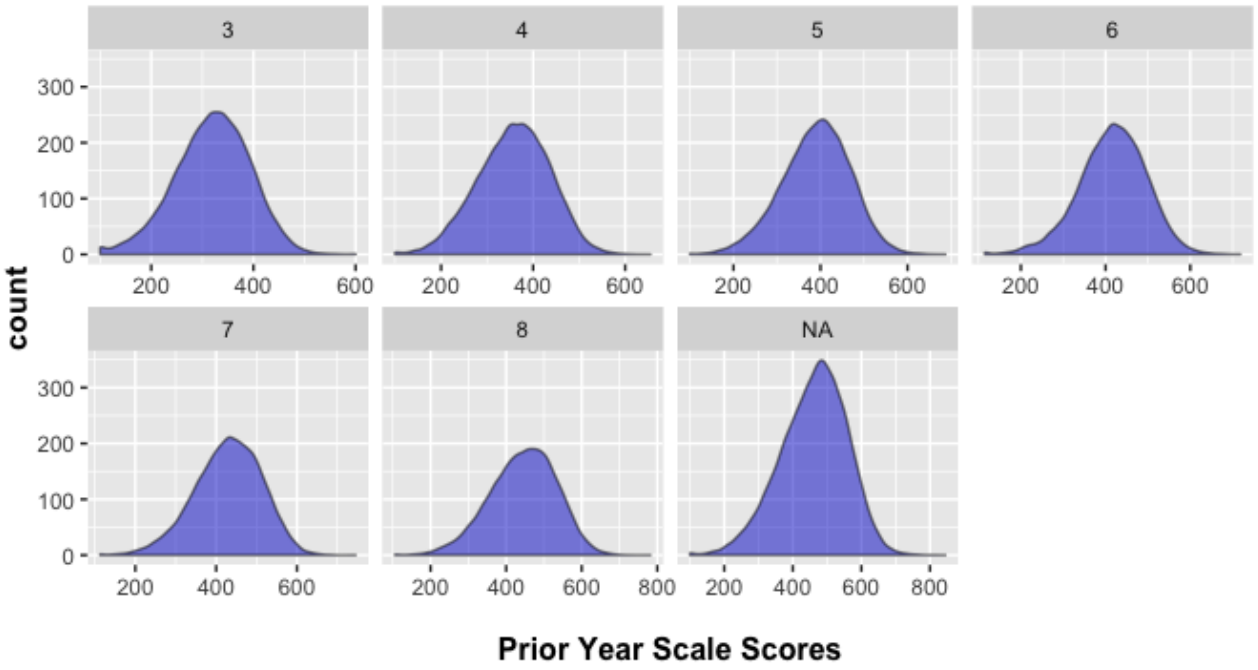
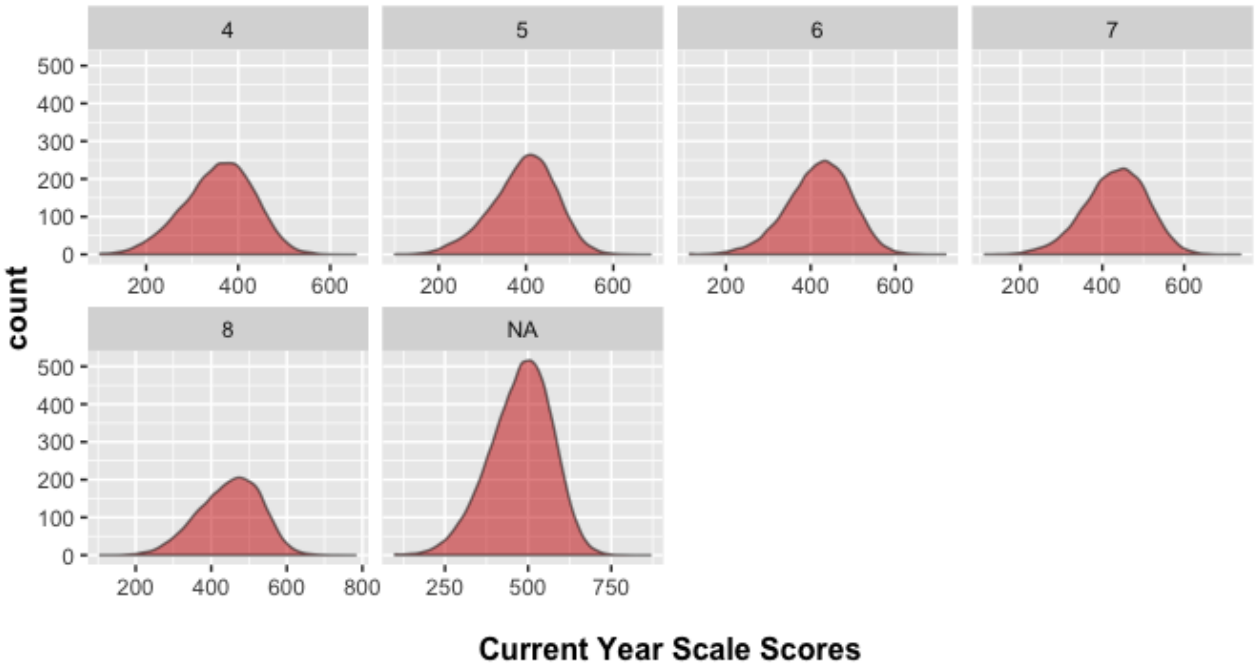



**Fig. C.2:** Marginal distributions of current scale scores: EOGT ELA.



### 2.1.2 Mathematics

**Fig. C.3:** Marginal distributions of prior scale scores: EOGT Mathematics.

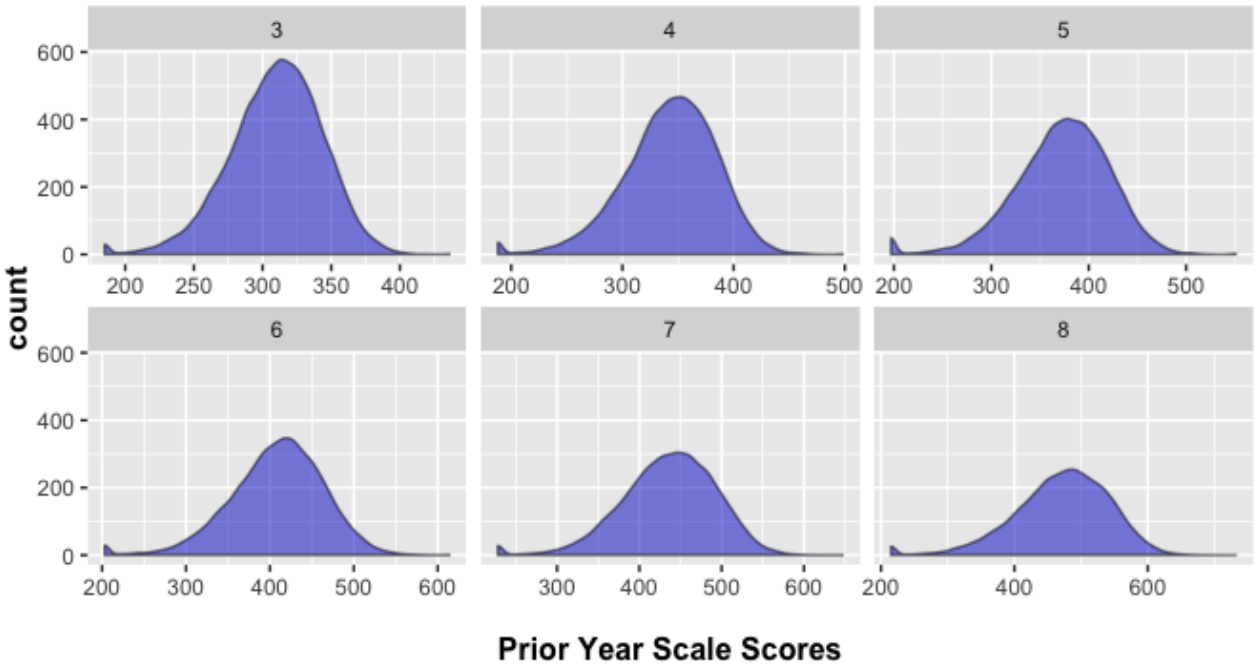
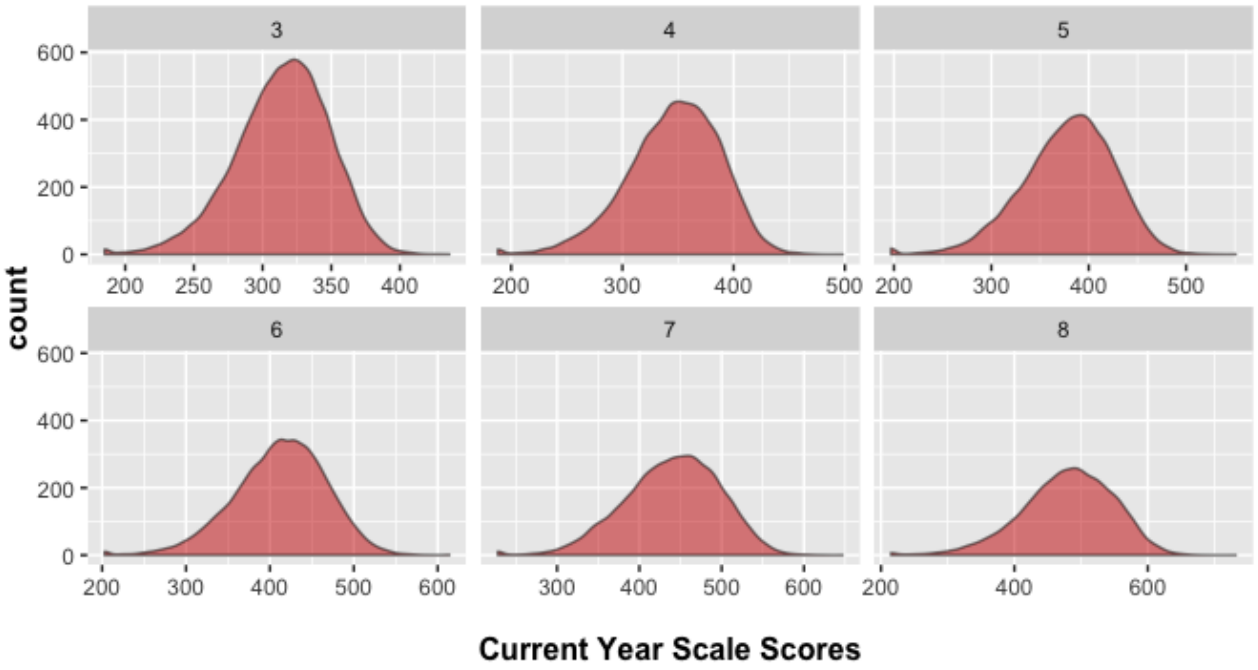



**Fig. C.4:** Marginal distributions of current scale scores: EOGT Mathematics.



### 2.1.3 Science

**Fig. C.5:** Marginal distributions of prior scale scores: EOGT Science.

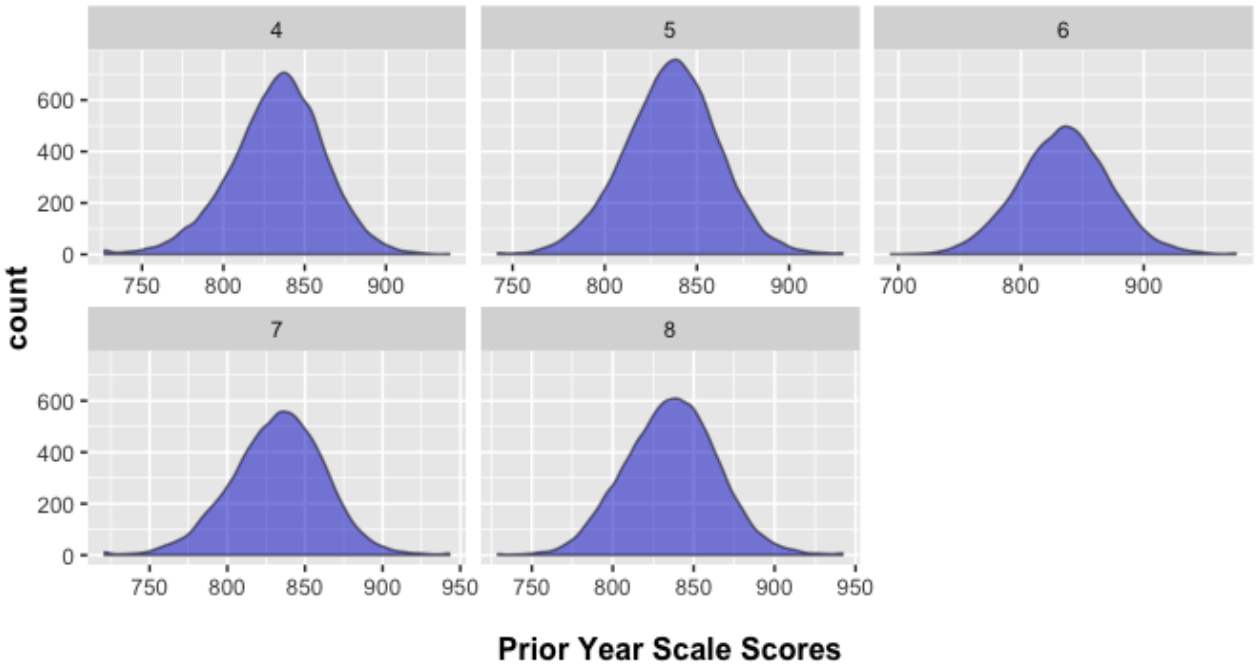
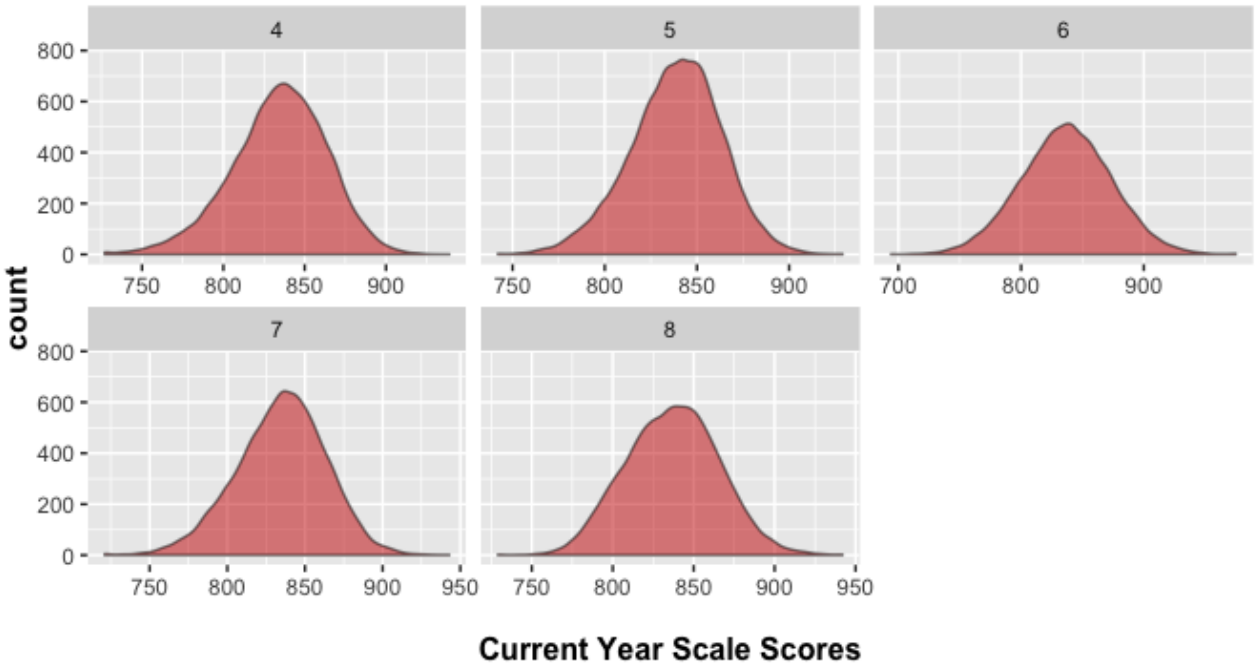



**Fig. C.6:** Marginal distributions of current scale scores: EOGT Science.



### 2.1.4 EOCT Content Areas

**Fig. C.7:** Marginal distributions of prior scale scores: EOCT Content Areas.

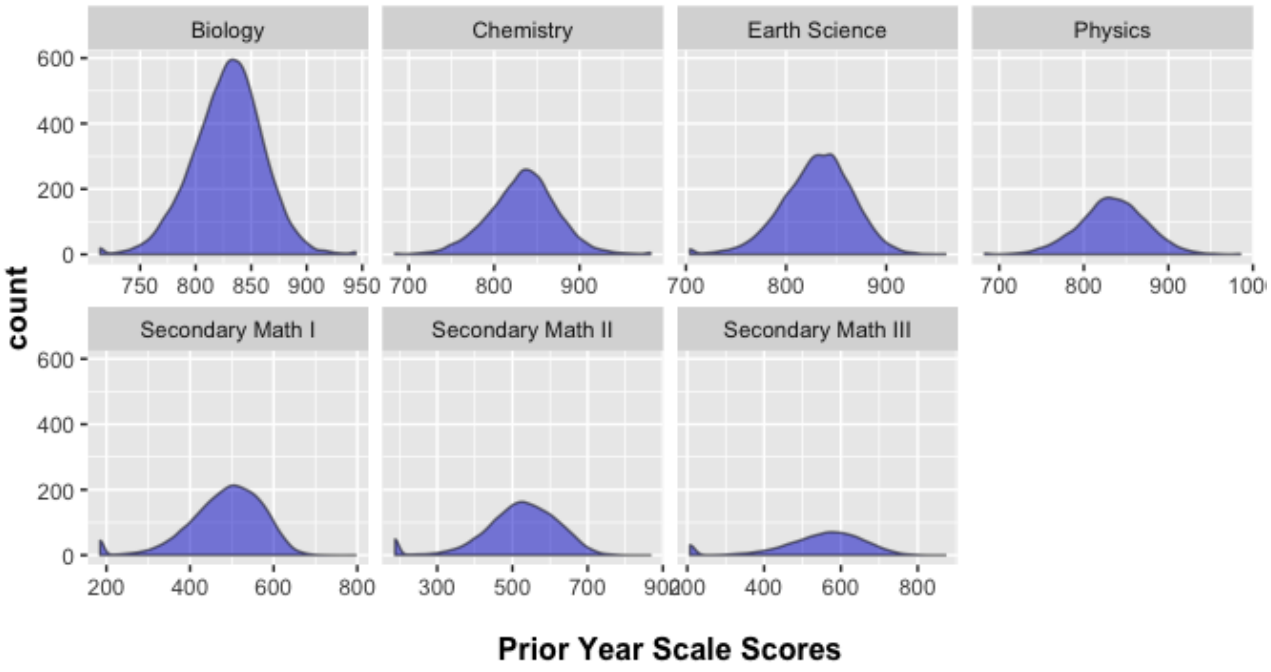
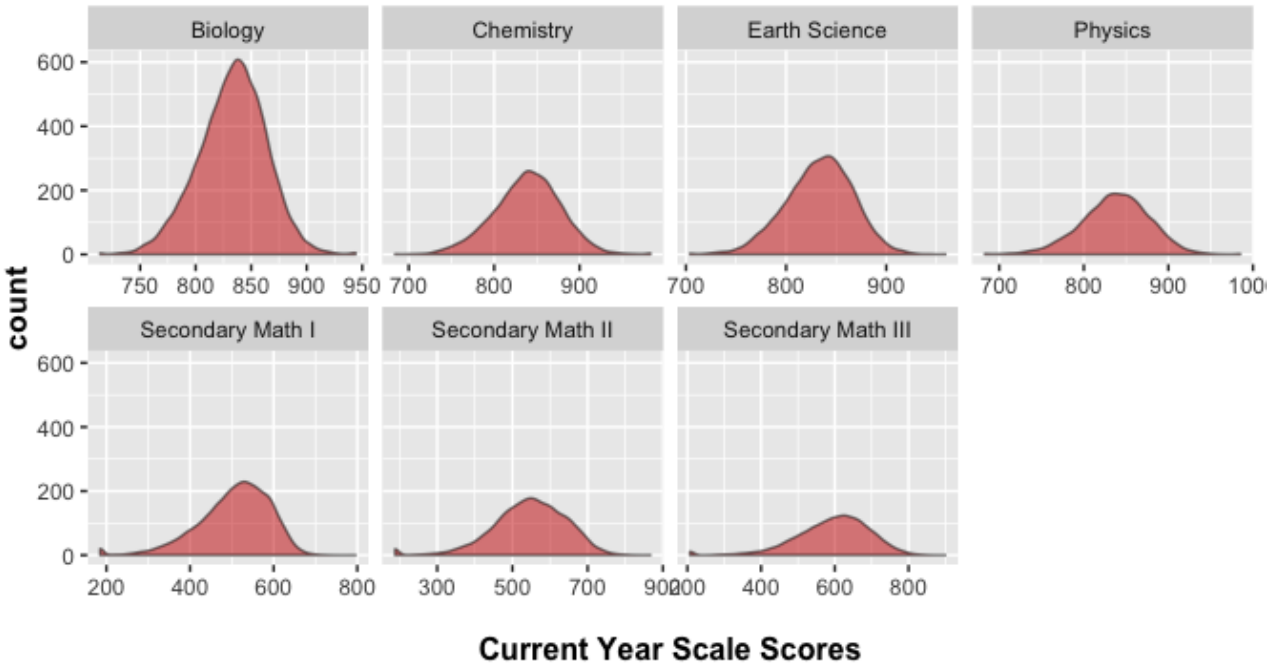



**Fig. C.8:** Marginal distributions of current scale scores: EOCT Content Areas.



## 2.2 Conditional Distributions

The marginal density plots provide a limited amount of information, particularly for the potential for ceiling/floor effects in the calculation of ***growth***. In order to provide a more nuanced view of the relationship between the prior and current scale scores, the following plots depict the conditional (joint) distributions for each content area and grade level. These plots start with a basic scatter plot of each student's scores, and on top of this is layered 1) **green contour lines** to provide a sense of the joint density, 2) a **magenta non-linear line** identifying the bivariate relationship between prior and current scores, and 3) **rug plots** that describe the marginal distributions (as above, the prior scores are blue and current scores are red).

Ceiling or floor effects often present themselves as dark shaded points in the extreme top-right or bottom-left corners of the plots. This suggests that staying at the extremes from year to year is not uncommon, which may lead to odd growth estimates for these chronically high/low achieving students. For the 2014 and 2015 Utah data, we again see very few issues in all content area and grade combinations, with the exception of the EOCT Secondary Mathematics courses. Whereas floor effects appear in single years in other places, these plots (Figure C.13) show consistent floor effects in both years and the prevalence of students scoring the lowest observable score for (at least) two years in a row.

### 2.2.1 ELA

**Fig. C.9:** Conditional distribution(s) of current and prior scale scores: EOGT ELA.

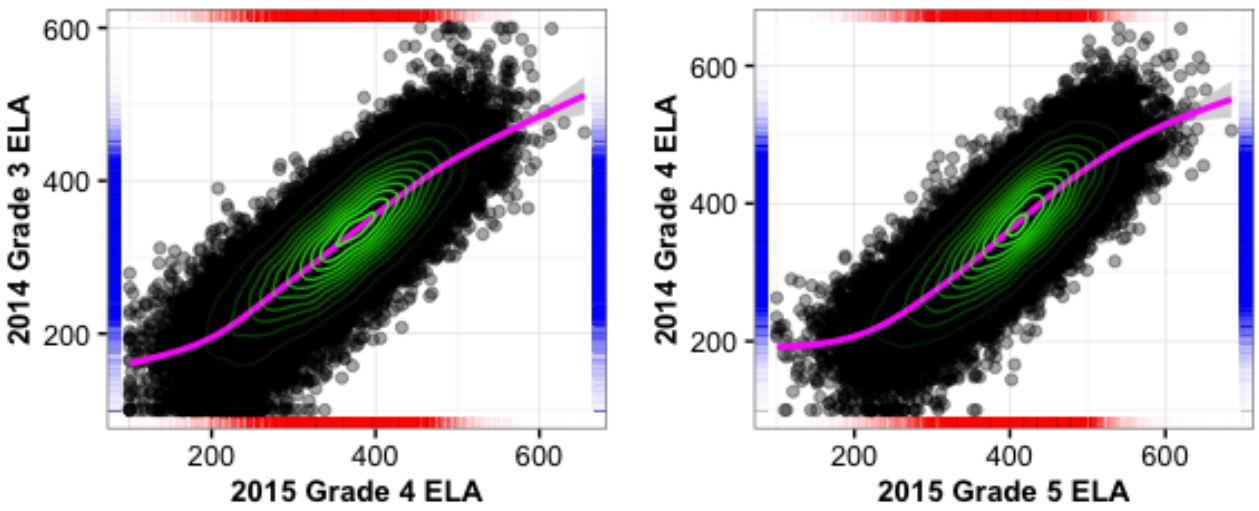
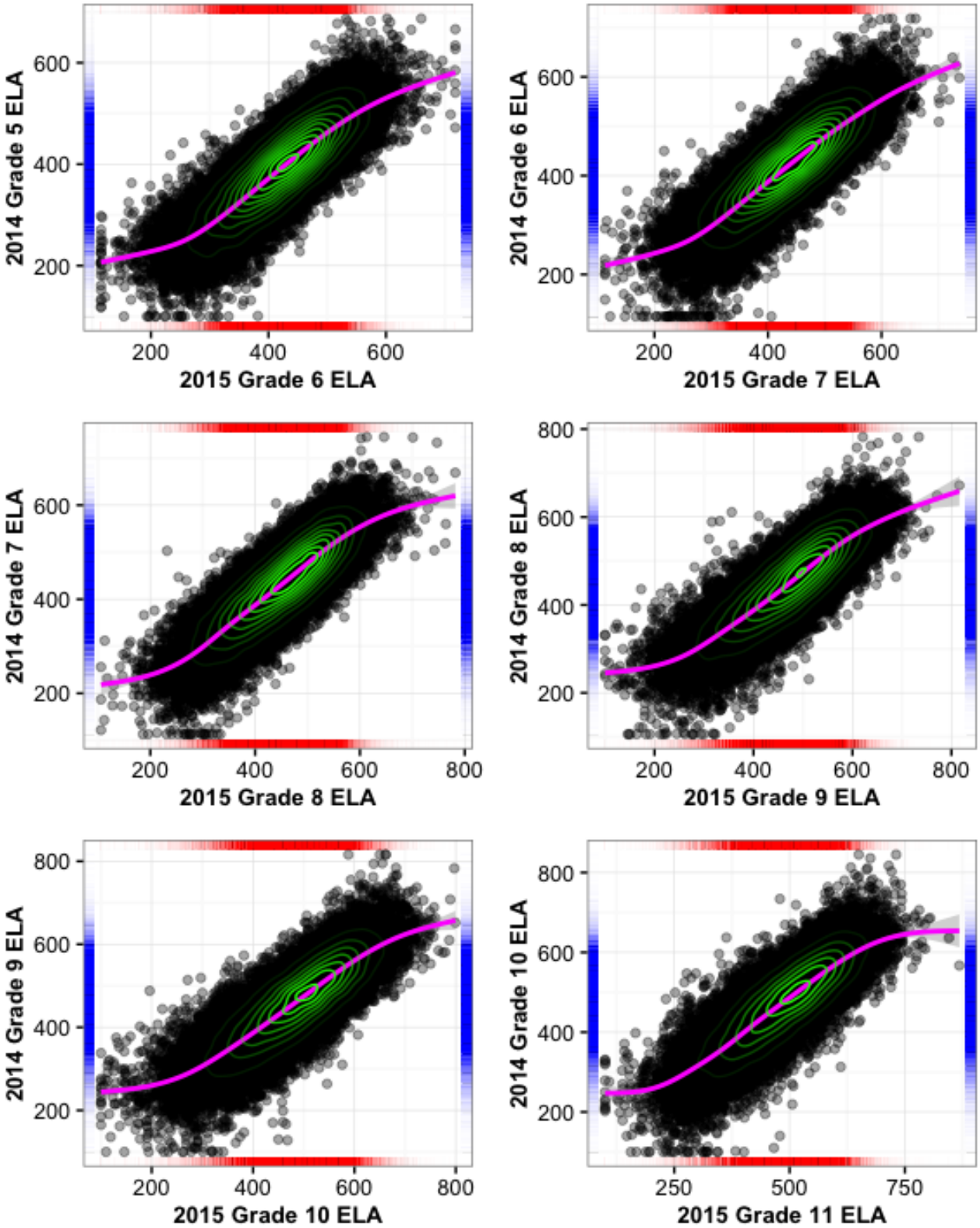
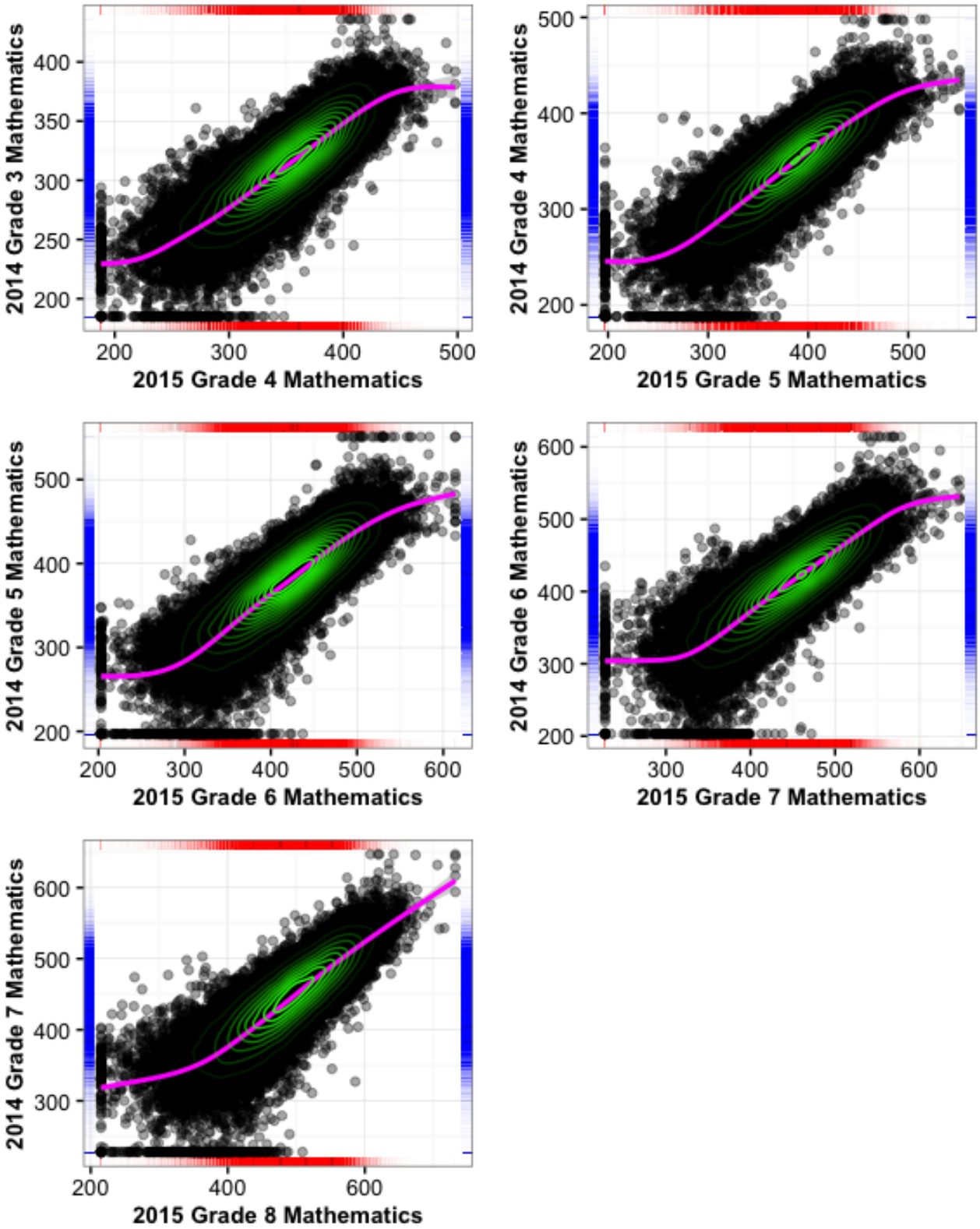


**Fig. C.10:** Conditional distribution(s) of current and prior scale scores: ELA *Continued*.



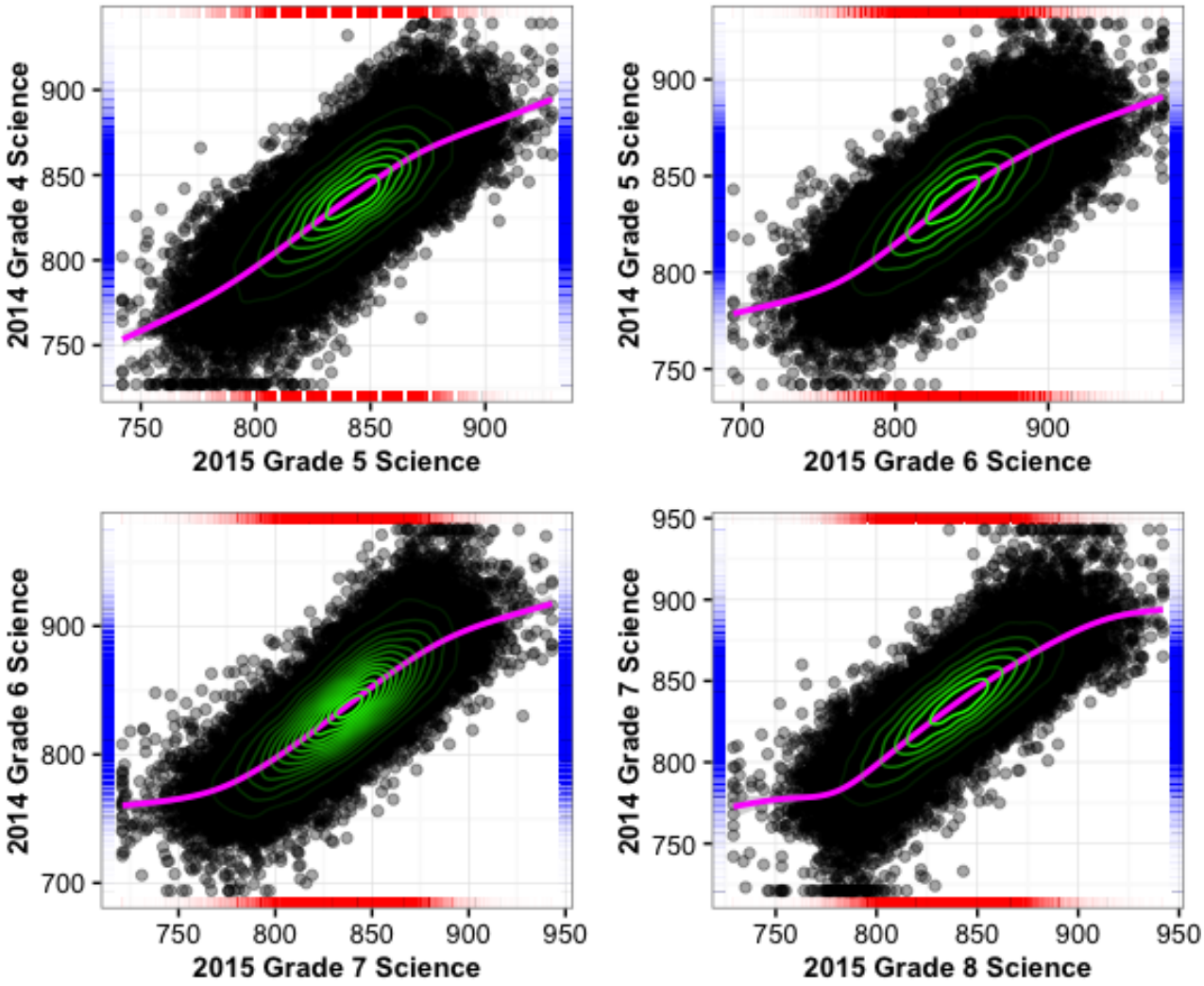
### 2.2.2 Mathematics

**Fig. C.12:** Conditional distributions of current and prior scale scores: EOGT Mathematics.



### 2.2.3 Science

**Fig. C.12:** Conditional distribution(s) of current and prior scale scores: EOGT Science.



### 2.2.4 EOCT Content Areas

The conditional density plots for the EOCT subjects are displayed below. The most recent prior is used in each plot to provide insight on the academic peer (norm) group that were analyzed separately. The 2014 and 2015 Secondary Mathematics courses' data show floor effects, including students scoring the lowest observable score for both years (visible as the dark shaded point in the extreme bottom-left corner of the plots in Figure C.13). This suggests that staying at the floor from year-to-year is not uncommon, which may lead to inflated growth estimates for these chronically low achieving students. Also of note is the dark shaded point in the extreme top-right corner of the Earth Science plot. Although this does not look particularly concerning here, this evidence of a minor ceiling effect is corroborated in the following section on the SGP distribution for the highest scoring students.

**Fig. C.13:** Conditional distribution(s) of current and prior scale scores: EOCT Mathematics.

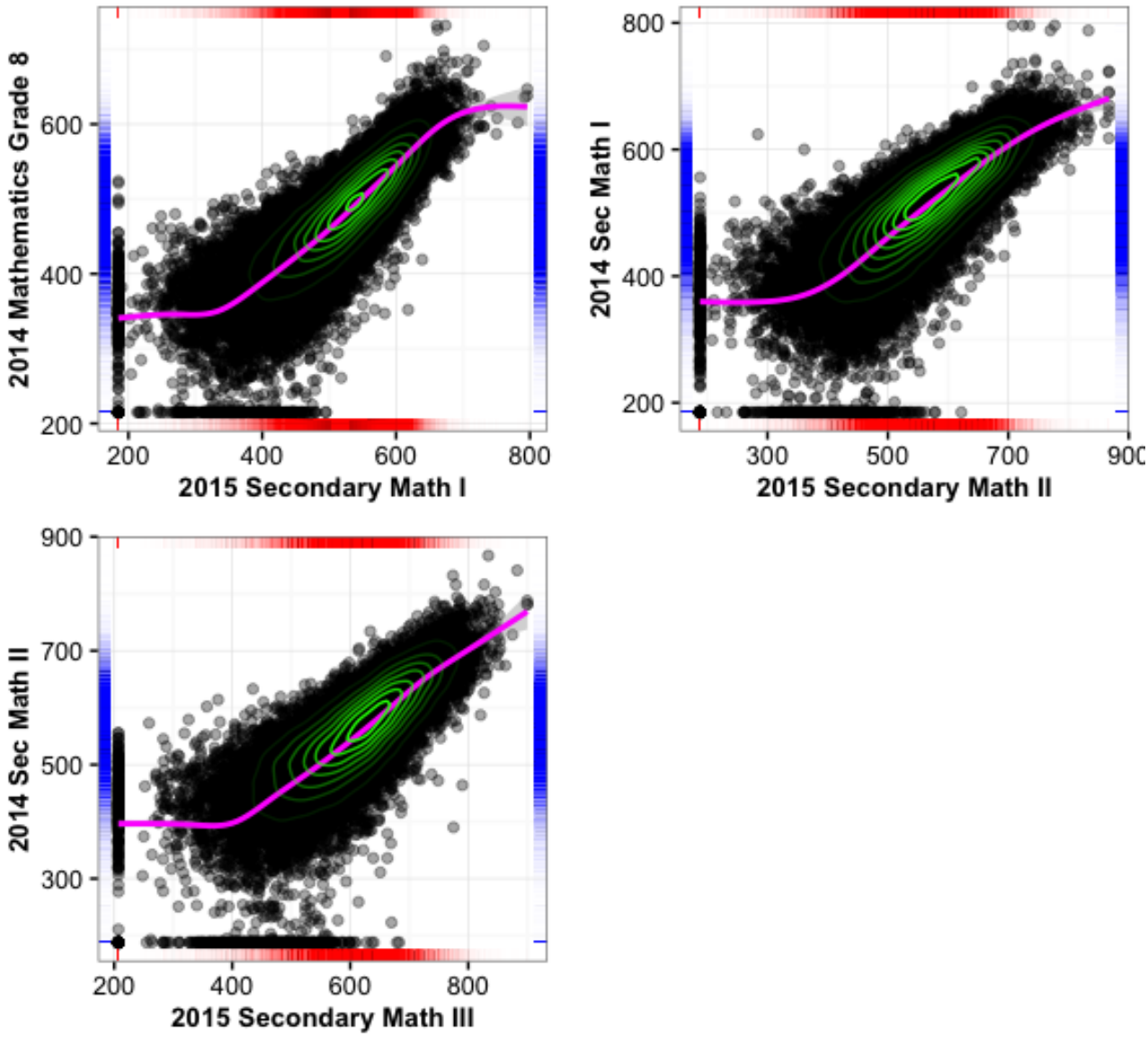
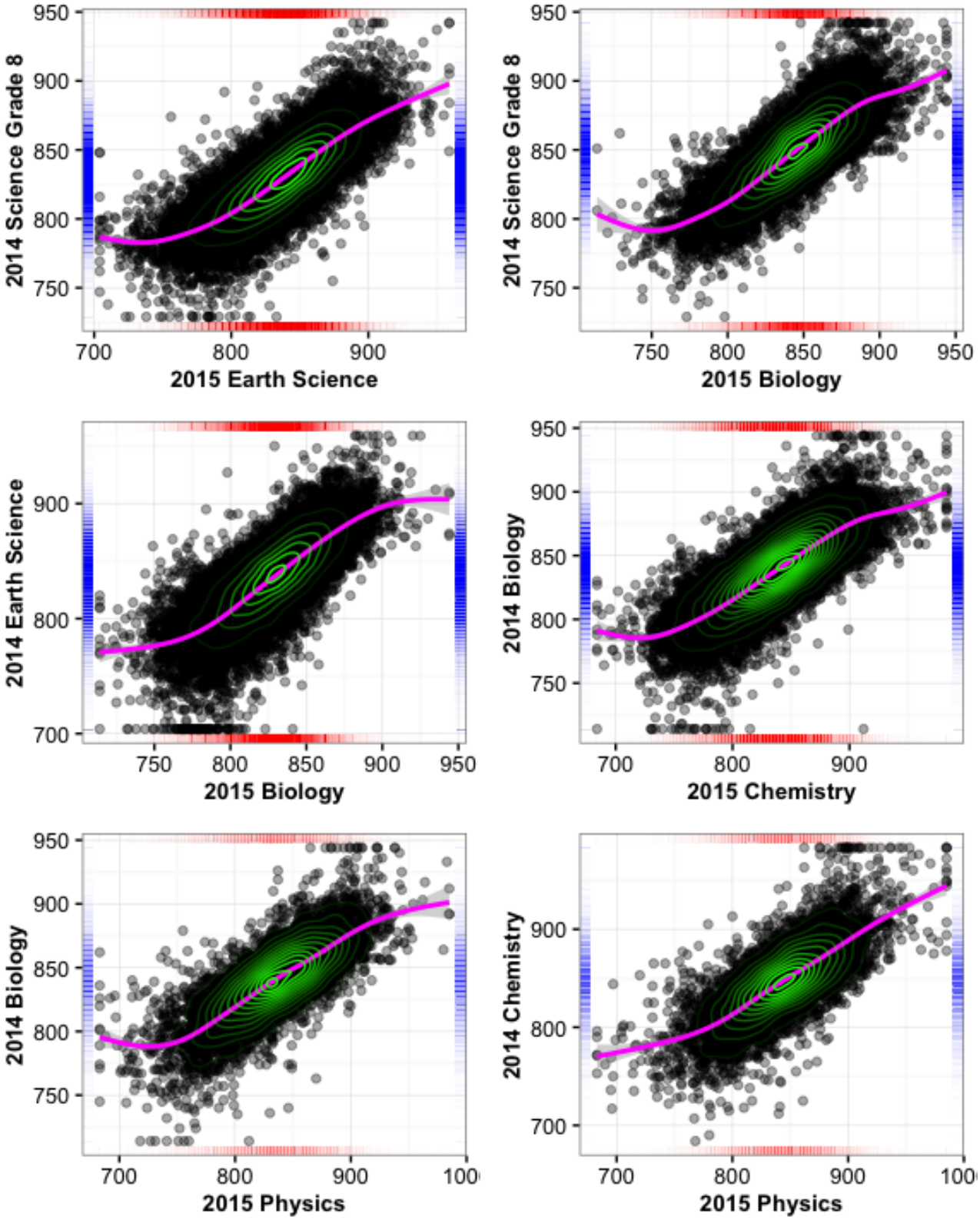


**Fig. C.14:** Conditional distribution(s) of current and prior scale scores: EOCT Sciences.



# 3 SGP Ranges for the Highest and Lowest Achieving Students

In order to isolate the impact of assessment ceilings/floors on student growth percentile (SGP) calculations, the following section provides box plots of the distribution of SGPs for the highest and lowest achieving students. We are specifically interested in the growth percentiles for students scoring at the highest/lowest obtainable scale score (HOSS/LOSS - i.e. the artificial test ceiling/floor) on the current year test. However, in order to assure that an adequate number of students are included, the first set of plots in each subsection uses, at a *minimum*, the highest/lowest 50 scores. Note that this roughly corresponds to the number of students used in the SGP model goodness of fit plots, and this is why these plots are provided as a starting point for this part of the investigation. All students with a score in these students' range of scores are included. Consequently, the number of students in each box plot may be greater than 50 (the exact number is shown at the margins in red text).

The second set of box plots in the following subsections isolate ***only*** those students scoring the HOSS/LOSS. These plots may then incorporate a widely varying number of students depending on the prevalence of a ceiling/floor in the current year. Note that because Georgia uses the SIMEX measurement error corrected SGP as the official SGP, that is the version used here.

The box plots provide several descriptive statistics. The dark line within the box marks the *median* SGP, while the ends ("hinges") of the boxes correspond to the first and third quartiles (the $25^{th}$ and $75^{th}$ percentiles). The upper whisker extends from the hinge to the highest value that is within 1.5 $\times$ IQR of the hinge, where IQR is the inter-quartile range, or distance between the first and third quartiles. The lower whisker extends from the hinge to the lowest value within 1.5 $\times$ IQR of the hinge. Data beyond the end of the whiskers are outliers and plotted as points. Evidence of a *lack* of either a ceiling or floor effect would be to have all high achieving students with SGPs near 99 and all low achieving students with SGPs near 1. That is, the desired visual evidence is a solid line at SGP = 99/1.

Overall there are no signs of major issues in the 2015 SGP results. In some analyses there are outliers which might require further consideration or manual adjustment.

## 3.1 EOGT Content Areas

In the 2015 Utah EOGT SGP analyses we see evidence of a minor ceiling effect in $8^{th}$ grade mathematics, as well as minor floor effects in grade level mathematics (the $5^{th}$ grade results in particular). In looking closely at the five students with the HOSS in $8^{th}$ grade mathematics, the estimated SGPs range from 76 to 98, with the lowest two SGPs attributed to the students with the highest prior scale scores. Although still relatively high, these values are somewhat questionable and demonstrate how ceiling effects begin to take shape. Ultimately these few outliers are not low enough to cause concern or require further consideration.

**Fig. C.15:** SGP distributions for highest and lowest 50+ scale scores by content area and grade level.

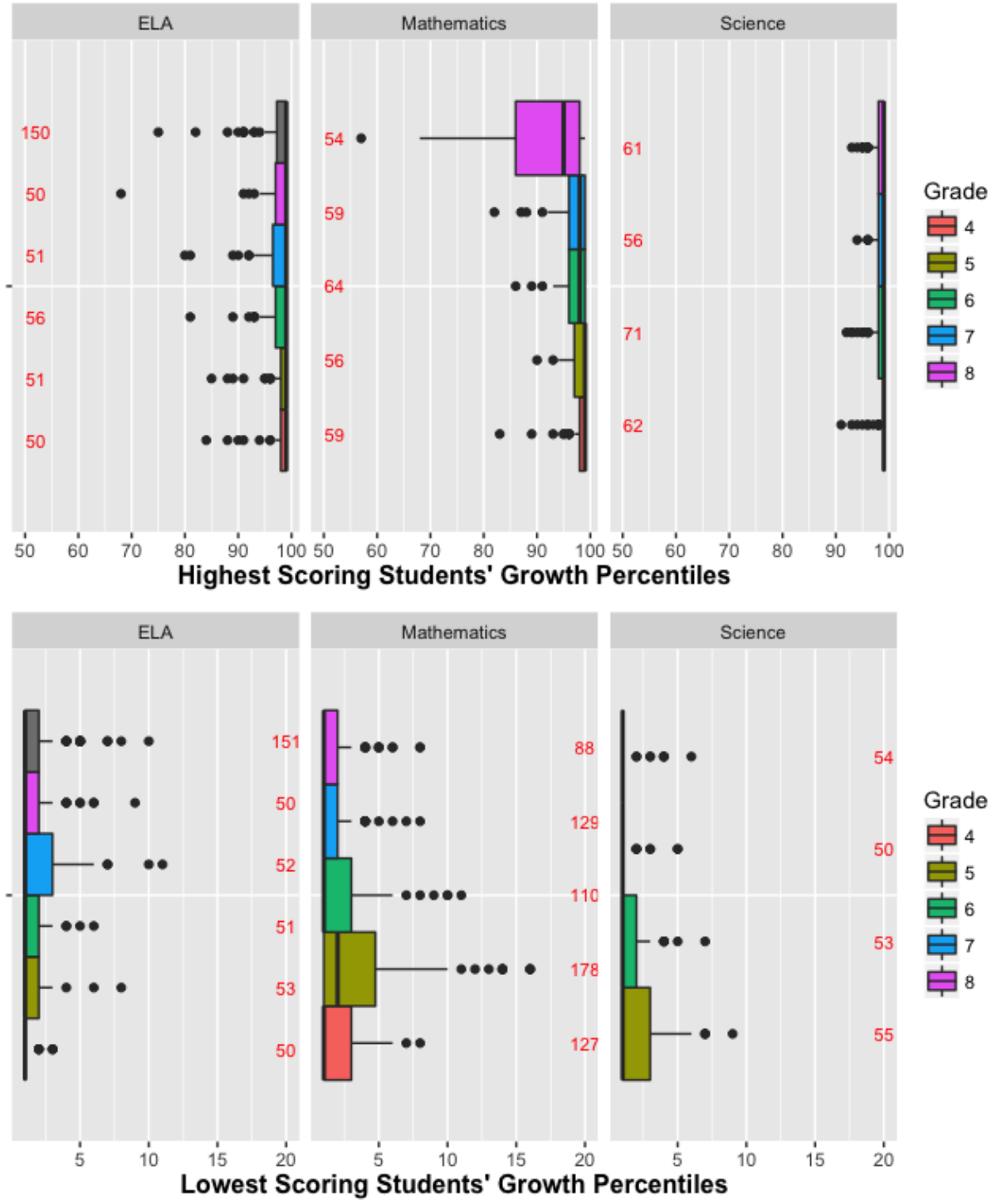
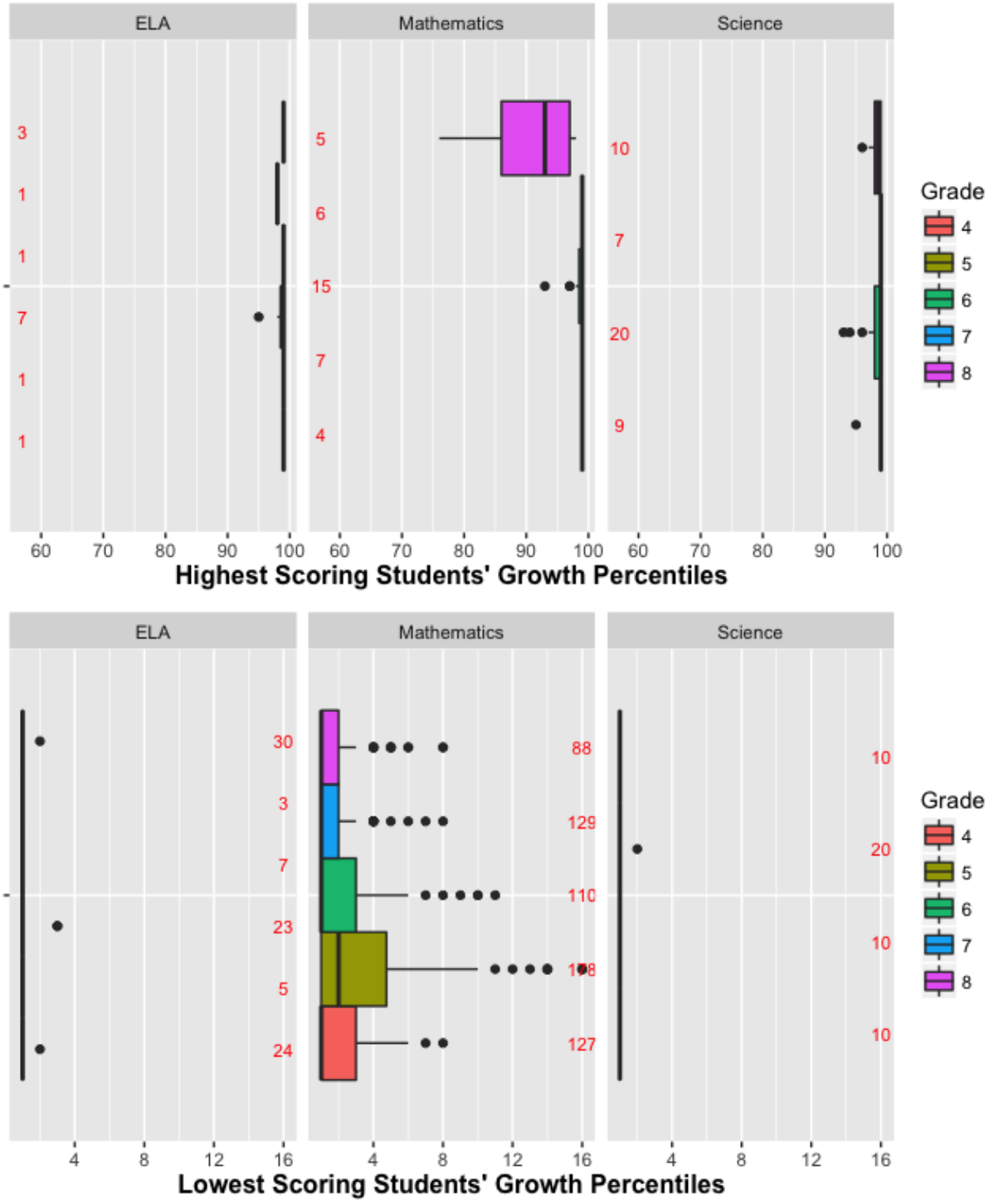


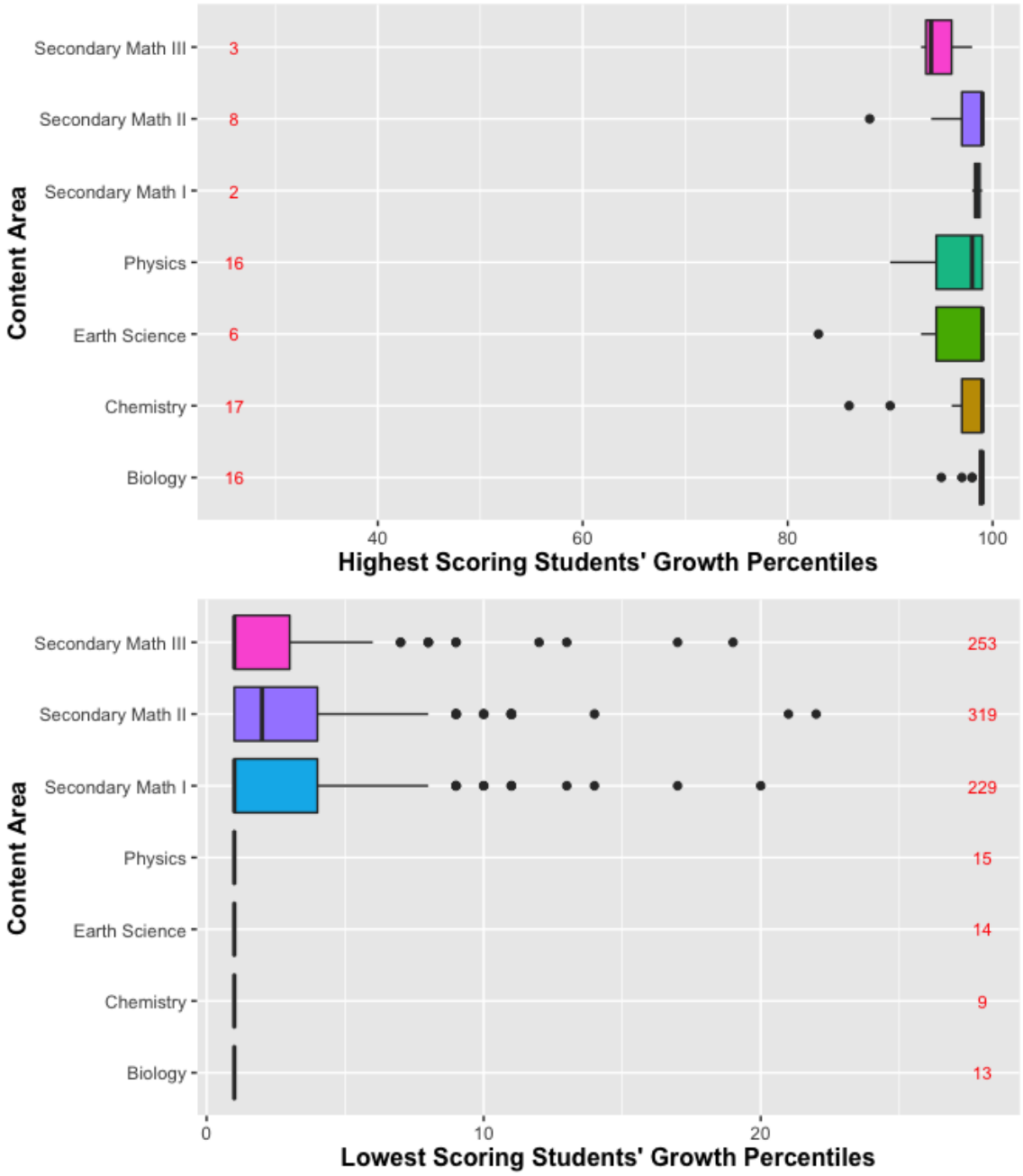
**Fig. C.16:** SGP distributions for the HOSS and LOSS scores by content area and grade level.



## 3.2 EOCT Subjects

The end-of-course subject results are shown here *only for students scoring exactly the HOSS and LOSS*. There are several subjects for which minor ceiling effects are evident. As in with the EOGT analyses, EOCT ceiling effects are minor and not widespread (all outlier SGPs are above 80). There is also evidence of a few students affected by a minor floor effect in the Secondary Mathematics analyses. However, the SGPs in these cases are still relatively low and should raise sufficient concern about these students' performance.

**Fig. C.17:** SGP distributions for the HOSS and LOSS scores by content area.



# 4 Discussion

Overall there is little evidence of major ceiling or floor effects in the 2015 Utah SGP analyses. There are a handful of outliers in some analyses that suggest minor effects on both sides. The magnitude of these effects are minimal and do not suggest the need for major corrections, although a review of some individual cases may be desired.

When ceiling or floor effects are encountered, there are several ways in which they can be "corrected" manually or analytically. These include (but not limited to):

1. Convert all students scoring at the HOSS (LOSS) to 99 (1).
2. Run SGP analyses with more granular scores. For example, many tests that use Item Response Theory (IRT) to analyse test results provide scaled scores that enforce an artificial ceiling (floor), but also have more granular achievement scores available (IRT $\theta$ estimates).
3. Leave the results without a correction.