Investigating the Current Trend and Predicting the Future Needs for BackPack Programs: BackPack Beginnings in Guilford County, North Carolina

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Derrick N. Black is a second-year graduate student in the Department of Mathematics at North Carolina Agricultural and Technical State University, where he is majoring in Applied Mathematics. His research on food insecurity is through the National Science Foundation National Research Traineeship program.

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Abstract

Food insecurity, defined by the lack of access to healthy food options, is a major world problem that deserves serious attention and analysis. This study seeks to help solve the problem of food insecurity among schoolchildren in Guilford County, North Carolina through computational data science. School backpack programs exist in many cities and states in the United States. They attempt to help solve the problem of child food insecurity by supplying schoolchildren with food to take home on weekends and holiday breaks when school cafeterias are unavailable. BackPack Beginnings (BPB), a nonprofit school backpack organization that services Guilford County, North Carolina schools, was analyzed. Its current Food Bag Program distribution per school was used to generate least-squares linear regression models. These models were used to create a food-insecurity ranking system for schools in the Guilford County school system not currently being serviced by BPB. Schools that ranked highest for student food insecurity were recommended as possible expansion schools for the organization. Methods and techniques for meeting these new needs were suggested to help BPB maximize the impact of their growth efforts.

CHAPTER 1

Introduction

One of the more widely-accepted definitions of food security was given at the 1996 World Food Summit:

> Food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (Jones, Ngure, Pelto, & Young, p. 482).

Then it follows that the absence of food security – that is, the lack of access to sufficient, safe, and nutritious food – yields lives that are inactive, unhealthy, or both. The "physical and economic access" mentioned in the above definition is not achieved when there exist entire residential regions where fresh, nutritious food markets are absent, while cheap, unhealthy fast-food restaurants are plentiful. These "food deserts" are common among non-farming rural communities and low-income urban communities. According to D. Stanley Eitzen (2000), modern American society suffers greatly from "(1) excessive individualism; (2) heightened personal isolation; (3) the widening income and wealth gap; and (4) the deepening racial/ethnic/religious/sexuality divide". Certainly these factors and many more interact to create and worsen the food insecurity problem in the United States of America today.

1.1 The Sociologist Perspective

Peter Berger defined a sociologist as "a person intensively, endlessly, shamelessly interested in the doings of men" (1963). By this definition, a man or a woman is not required to pursue an advanced degree in the social sciences to qualify as a sociologist. A sociologist does not suffer from factors (1) and (2) cited by Eitzen, for a sociologist is passionate in his concern

for the individuals, households, and communities around and distant from him. The source of the energy and fervor of a 'Berger sociologist' is the idea of a vibrant, prosperous society. Thus, all men should consider themselves sociologists instead of viewing sociology as a distant, foreign discipline unrelated to their own lives. However, as stated above, an even partially food-insecure society is neither truly vibrant nor prosperous. Interdisciplinary research is greatly needed to solve this human problem.

1.2 Child Food Insecurity in Guilford County, North Carolina

Common factors that contribute to food insecurity include but are not limited to income level, proximity to food deserts, education level, access to transportation (public or private), etc. Many adults struggle to control these factors in their own lives, but children have little to no control over these factors that cause them to be food-secure or food-insecure. If the previously-stated definition of a sociologist is to be assumed as true, then it follows that child food insecurity is a matter of even greater importance than food insecurity of the general population. A 2016 Feeding America report on child food insecurity in North Carolina by county cites a child food insecurity rate of 21.0% (24,480 / 116,451) for Guilford County. The report also states that 71% of the child-food-insecure in Guilford County are likely income-eligible for federal nutrition assistance, which means that 29% are likely to not be income-eligible for this assistance. However, qualifying for federal nutrition assistance alone does not make a child food-secure. Oftentimes, a community of sociologist-minded people combines its resources to ensure that the children among them never want for food. One such community, led by Berger sociologist Parker White, formed an organization in 2010 to help meet that exact need.

1.3 BackPack Beginnings

BackPack Beginnings (BPB) is a nonprofit 501(c)(3) organization that seeks to help solve the child food insecurity problem in Guilford County, North Carolina. Its mission is "to deliver child-centric services to feed, comfort, and clothe children in need", and its vision is "a community of healthy and well-nourished children… one BackPack at a time" (BackPack Beginnings, 2018). BPB services area children through four food programs: Food BackPacks, Food Pantries, Clothing Pantries, and Comfort BackPacks. The organization, founded by Parker White in 2010, began by servicing one school. Now it provides food programs and services to 12 Head Start and 21 elementary schools.

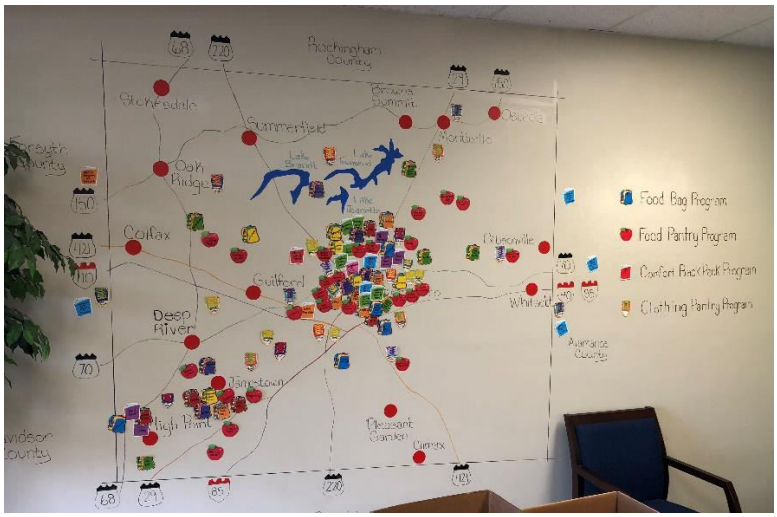

Figure 1. Outreach area of BPB.

Figure 2. BPB service areas and partner agencies in the heart of Guilford County.

Its main program is the Food BackPack (FBP) program, where staff and volunteers assemble plastic bags of food items and work closely with school social workers to distribute these food bags to students on Fridays. This helps ensure that these students will have food to eat over the weekends while school cafeterias are closed. BPB communicates with school staff members to gauge the food insecurity needs of schools. With these partnerships and the written consent of parents, BPB provides FBP services to new schools and new students. Mrs. White has recorded data of the weekly distribution of FBP food bags from BPB from the 2015-2016 school year until now.

1.4 Research Questions

While BPB certainly has grown since its inception, there are still more schools and students in need in Guilford County that do not receive any services from BPB. Servicing 21 elementary schools in the county school system is impressive growth; however, there are 69 elementary, 22 middle, 27 high, and 7 alternative schools (125 total) in the Guilford County school system. Mrs. White has expressed great concern and interest in assessing and identifying

the true needs of the children in Guilford County. Considering the possible negative effects this may bring, the organization should be mindful and careful when deciding to offer help to new schools. Which schools have the greatest food insecurity needs within their student populations? Which schools that do not yet receive food bags should the organization prioritize? In what order should BPB consider partnerships with these schools? This research answers these questions and more through intelligent solving using computational data science.

CHAPTER 2

Literature Review

2.1 Food Insecurity in the United States

The United States Department of Agriculture (USDA) defines food insecurity as a lack of consistent access to enough food for an active and healthy life (USDA: Economic Research Service, n.d.). Many families lack access to a sufficient quantity of affordable, nutritious foods for an active and healthy lifestyle; in other words, they are food insecure. This has been confirmed by research studies (Alaimo, Briefel, Frongillo, & Olson, 1998) and documents ("Hunger in America: Ten years later", 1979; Wehler, Scott & Anderson, 1995), which reveal that food insufficiency is a persistent problem in the United States. In 2017, an estimated one in eight Americans were food insecure, equating to 40 million Americans including more than 12 million children (Coleman-Jensen, Rabbitt, Gregory, & Singh, 2018). In fact, more than 46 million people still turn to the Feeding America network each year for extra support.

Being food insecure affects nearly every aspect of life, even beyond the immediate and obvious effects on physical health. It makes it difficult for children to concentrate in school, and for adults to maintain adequate job performance. Policy evaluation, through both quantitative and qualitative research, reveals food insecurity to be a complex problem. The study by Alaimo et al. shows that food insufficiency is not limited to very low-income persons, specific racial/ethnic groups, family types, or the unemployed (1998). Many do not have what they need to meet basic needs and these challenges increase a family's risk of food insecurity. Effective responses to food insecurity will need to address these overlapping challenges. A recent study (Choi, Fram, & Frongillo, 2017) reveals that household experiences of very low food security are associated with different predictors for different types of households and often occur at the intersection of

multiple characteristics spanning unmet medical needs, poor health, disability, limitation, depressive symptoms, low income, and food assistance program participation. These predictors built complex trees with various combinations in different types of households.

It is important to know that hunger and food insecurity are closely related, but distinct, concepts. Hunger refers to a *personal, physical sensation* of discomfort, while food insecurity refers to a *lack of available financial resources* for food at the level of the household (Feeding America, "Hunger in America"). Hunger can affect people from all walks of life. Many Americans are one job loss or medical crisis away from food insecurity – but some people, including children and seniors, may be at greater risk of hunger than others.

Though many of us may not realize the grave disparities that exist in our own communities, people struggle with hunger in every county and congressional district in North Carolina. They could be our neighbors, kids in our children's classes – the possibilities go on. In North Carolina, about 1.5 million people are struggling with hunger – and of them almost 480 thousand are children. One in seven people and one in five children struggles with hunger. People facing hunger in NC are estimated to report the needing of $770 million more per year to meet their food needs (Feeding America, "Food Insecurity in the United States").

2.2 Child Food Insecurity

Food insecurity impacts every community in the United States. A study "Map the Meal Gap" conducted by Feeding America ("Food Insecurity in the United States", "Hunger in America") reports the overall food insecurity and child food insecurity in every state, congressional district and even county.

Children who do not get enough to eat — especially during their first three years — begin life at a serious disadvantage. When they are hungry, children are more likely to be hospitalized

and they face higher risks of health conditions like anemia and asthma. As they grow up, children struggling to get enough to eat are more likely to have problems in school and other social situations. Children facing hunger may struggle in school — and beyond. They are more likely to repeat a grade in elementary school, experience developmental impairments in areas like language and motor skills, and have more social and behavioral problems. Hunger deprives American children of more than just food. It is a simple fact: A child's chance for a bright tomorrow starts with getting enough food to eat today. But in America, one in six children may not know where they will get their next meal. For the more than 12 million kids in the United States facing hunger, getting the energy they need to learn and grow can be a daily challenge (Feeding America, "Hunger in America").

Several recent studies have shown that significant racial disparities exist in child food insecurity prevalence rates. Hispanic and non-Hispanic Black households have higher food-insecurity rates than the national average. A 2011 USDA report prompted the following response:

> "The new USDA findings are disturbing. It is very upsetting that so many Americans struggle on a daily basis to find enough nutritious food to feed themselves and their families. But it is also particularly of concern that Latinos and African Americans are so disproportionately affected," said Vicki Escarra, president and CEO of Feeding America. "Our nation must do everything possible to help end these inequities. We must make sure that all American, especially our children, are properly nourished, so that they can lead healthy, happy and productive lives." (Escarra, 2011, as cited in Feeding America, 2011)

However, these disparities would not improve over the years. ChildTrends.org cited 2016 data that showed a food insecurity prevalence rate among households headed by non-Hispanic White

adults of approximately 13%, while rates among households headed by non-Hispanic Black adults and households headed by Hispanic adults were approximately 26% and 24%, respectively (2018). Clearly, food insecurity prevalence rates among these minority groups almost doubled that of non-Hispanic Whites. USDA Economic Research Service data reports from 2017 cited the national food insecurity average at 11.8%, while rates for Hispanic and non-Hispanic Black households were 18.0% and 21.8%, respectively. Systemic disparities "regarding poverty, government programs, and education cause minorities to be victims of food insecurity rather than the majority" (Cooper, 2018). Thus, the food insecurity gap between minority groups (especially African-Americans and Hispanics) and the rest of the nation is an ongoing problem in the United States that also significantly affects the children in those households. This problem has existed since the founding of BackPack Beginnings and continues to exist today, so the organization must recognize these trends when considering how to make the greatest mission-centered impact on its service area.

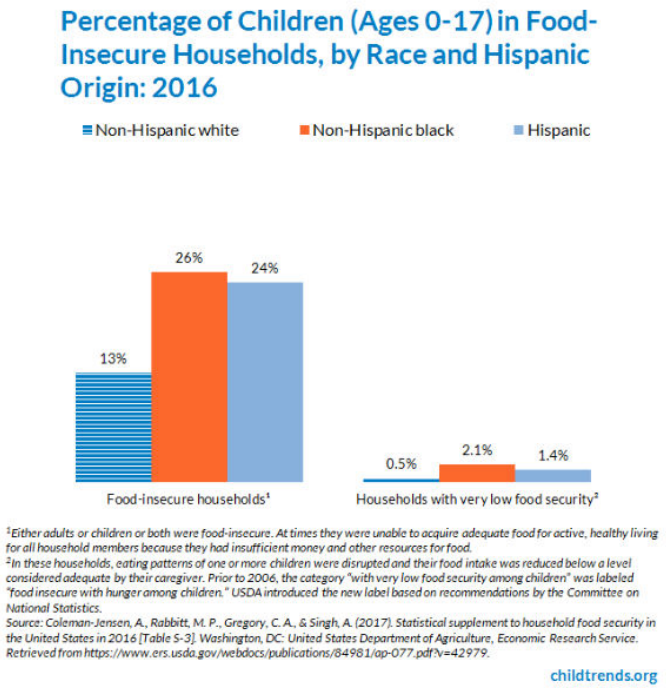

Figure 3. Prevalence of food insecurity in the United States, 2016.

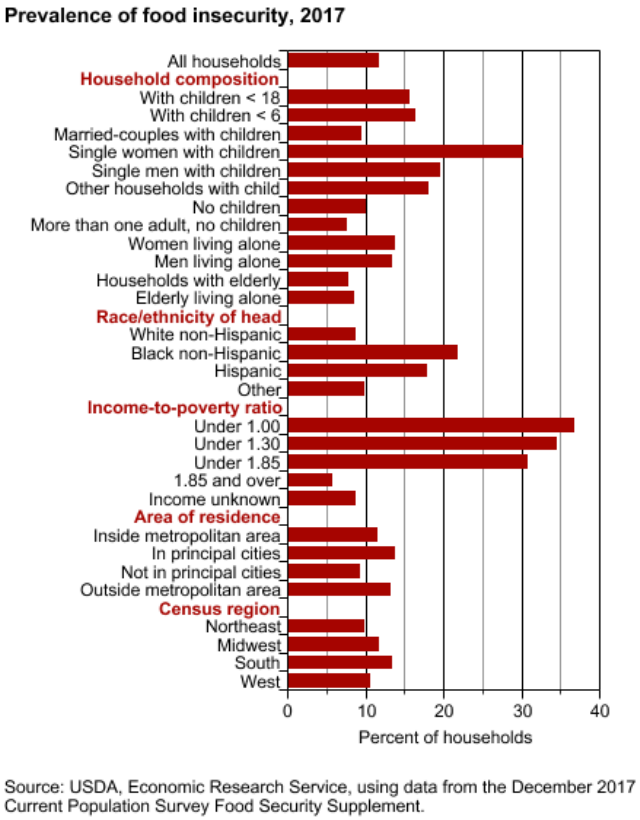

Figure 4. Prevalence of food insecurity in the United States, 2017.

2.3 Effects of Child Food Insecurity

Child food insecurity is related to hunger and malnutrition, but it also includes experiences of worry, stigma, and shame related to food challenges (Fram, Bernal, & Frongillo, 2015). It is predictive of severe physiological outcomes such as stunting, but also of the more moderate nutritional deficiencies that precede those severe and sometimes irreversible outcomes (Bernal, Frongillo, Herrera, & Rivera, 2014). Child food insecurity focuses attention on food, but also on other interconnected domains of the daily lives of children, highlighting the role that food plays in their choices between school and paid work, between their own well-being and between their responsibilities to siblings and parents. Children experiencing food insecurity also means that they are under stress given the important role that food has in family well-being and functioning.

Child food insecurity is associated with a range of negative developmental consequences, including behavior problems, poor health (Casey et al., 2005), disrupted social interactions, delayed early childhood language development (Saha et al. 2009), shamefulness (Jaffe, Bernal, & Herrera, 2014), poor school performance, absenteeism at school (Bernal et al., 2014; Jyoti, Frongillo, & Jones, 2005), lower physical activity (Fram, Ritchie, Rosen, & Frongillo, 2015), altered daily activities (Bernal et al., 2014), poor dietary intake (Fram et al., 2015), high intake of energy-dense foods (Sharkey, Nalty, Johnson, & Dean, 2012), less healthy diets, and inadequate intake of micronutrients such as calcium, iron, and zinc (Bernal et al., 2014).

2.4 Backpack Programs

To identify and respond to child food insecurity and hunger, schools already respond formally and informally, and in some haphazard ways. Federal school lunch, breakfast, and snack programs provide a primary food source for many low-income children. Supplementing these formal programs, about 53% of teachers in a recent survey reported purchasing extra food to give to students without sufficient food to eat (Share Our Strength, 2012). Some schools also provide holiday food baskets, in-school food pantries, and food backpack programs.

The first documented school-based food backpack program (BPP) began in Arkansas in 1994. A school nurse observed a trend of many children arriving at school on Mondays tired and hungry, which impeded their abilities to learn (Education World, 2015). The general BPP model is simple to understand. Teachers, school staff, and sometimes parents express concern for schoolchildren suspected of experiencing constant hunger. At the end of each week, these children, with the written permission of their parents, are then given backpacks or bags filled with easy to-prepare, shelf-stable foods to combat their weekend hunger. Children take the food

home, happily eat it, and then return the empty backpack to school on Monday for the next week's refill (Fram & Frongillo, 2018).

In recent years, school-based BPPs have spread throughout America as a response to a perceived crisis of child hunger. Administering bags of free child-friendly portions of food to schoolchildren to sustain them throughout school year weekends, BPPs, through private donors, faith communities, and public schools, directly help solve an important problem: if their children are hungry, they give them food. Thus, it is easy to see why BPPs have expanded rapidly (Fram & Frongillo, 2018). BPPs now reach $>$ 800,000 children across $\geq$ 45 states (Feeding America, "BackPack program"), and are relied upon to provide extra food to sustain schoolchildren over many weekends. BPPs benefit greatly from collaborations with and donations from corporate, educational, nonprofit, and faith-based organizations (Northwestern University, 2015), and the Internet is full of messages, comments, posts, articles, blogs, and videos about how important BPPs are to the health and well-being of children (Hunger Free Colorado, 2011).

Some studies show that school staff consider BPPs as helpful, and evidence exists that families show overall satisfaction with these services (Cotugna & Forbes, 2008). A study by Rodgers & Milewska cite higher average test scores among schools offering BPP services than the average test scores among schools not offering those same services (2007). Teachers and schools have reported improvements in test scores, positive behavioral gains, decrease in number of unexcused absences and an increased recognition of potential career paths (Food Bank of Central and Eastern North Carolina, n.d.). However, not much information is known about recipients of BPP services, their experiences, or their personal impacts as a result of their BPP participation. In considering all these aspects, a recent study (Fram & Frongillo, 2018) assesses the BPP model as it currently exists, concluding that BPPs fit poorly with the needs of the

majority of children living in food insecure households in the United States and consequently put children at risk of negative consequences associated with worry, shame, stigma, and disruptions to family functioning. Finally, they provide recommendations for practice and research, emphasizing the importance of (1) responding to children's actual needs throughout program implementation, (2) avoiding unnecessary risks by effective targeting of services to only those children who need them, and (3) rigorously evaluating program outcomes and unintended consequences to determine whether, even for the small number of US children who experience hunger, the benefits of the BPP model outweigh its psychosocial costs.

2.5 Predicting the Needs of BackPack Programs

Although food insecurity in the United States is quite common (about 20% of households with children in 2012), very low food security (VLFS) among children is relatively uncommon (about 1.2% of households in 2012) (USDA: Economic Research Service, 2018). Even though households with VLFS among children make up a small percentage of households, the percent of households with this status has roughly doubled over the last decade. While household income certainly plays an important role in determining VLFS among children, the study (Anderson, Butcher, Hoynes, & Schanzenbach, 2016) finds that some household characteristics and patterns of program participation have important additional explanatory power. Finally, the examination of the NHANES data suggests an important role for both mental and physical health of adults in the household in determining the food security status of children.

The study (Frongillo, Fishbein, & Fram, 2013) finds that the most salient causes of food insecurity in children are lack of money (i.e., a major cause), parental physical and mental health, transportation barriers to accessing food in stores or sources of food assistance, parent work demands and schedule (e.g., not available to cook), and stigma.

Based on the existing literature on food insecurity in children and BPPs, we propose to develop a prediction model that will estimate the food-insecurity need of Guilford County schools not currently receiving FBP services. As there are currently no state or federally funded weekend food programs established for Guilford County schoolchildren (BackPack Beginnings, 2018), FBP program implementation in new schools could potentially make great impacts in the lives of many new students. We choose the possible factors for our prediction model as percentages of economically disadvantaged students, percentages of students severely absent from school, rural / urban school locations, percentages of African-American and Hispanic students, Title I school statuses, and percentages of low-income students.

CHAPTER 3

Methodology

3.1 Data Collection

Data sets for this study were collected from BackPack Beginnings, the district offices of Guilford County Schools public school system, and the State of North Carolina Department of Public Instruction.

3.1.1 BackPack Beginnings data. Internal data sets from BPB were submitted (P. White, personal communication, September 21, 2018). Each data set contained information for a different school year, and these data sets included:

- numbers of food bags distributed to each school;
- organizational food bag assembly data, categorized by date, number of bags assembled, and staff member assembler name;
- donations of food bags by date, donor name, and number of bags donated;
- individual items purchased for food bags, whether donated or purchased by staff members;
- discarded items and reasons for discarding;
- school snack pantry inventory and distribution information; and
- fresh produce delivery data.

For the purposes of this study, it was decided that the numbers of food bags distributed to each school was the most relevant for analysis, thus used in this study as the response variable.

3.1.2 Guilford County Schools data. Public data collected from school district website https://www.gcsnc.com/domain/13168 included School Information Dashboard data such as:

- Enrollment (3 Year) Snapshot, which, according to the website description, "shows district and school enrollment for three years based on Day 20. Data include grade level, race/ethnicity, and gender. Users may filter by school year, school name, school type, grade level, school zip code, and gender" (https://www.gcsnc.com/Page/44123); and
- Chronic Absences, which, according to the website description, "shows chronic student absences, including those due to suspension from school, by school for the previous and current school years. Data are based on total daily absences and not absences for each class period. Filters by school year, school type and by school name" (https://www.gcsnc.com/Page/44123). Like the Enrollment Snapshot, data for Chronic Absences was also available for the previous three school years.

Lists of Title I schools for the previous two years were also collected from the Title I office section of the district web site. According to the "About Title I" section (https://www.gcsnc.com/domain/5042):

> Title I, Part A (Title I) of the Every Student Succeeds Act (ESSA) provides financial assistance to school districts and schools with high numbers or high percentages of children from low-income families to help ensure that all children meet challenging state academic standards.
>
> School districts allocate the Title I funds they receive to schools with the highest percentages of children from low-income families. In Guilford County Schools, Title I programs operate as "schoolwide" programs only. Title I funds are used to supplement state and local resources, to support children who are most at risk of not meeting state academic standards, and to support meaningful parent engagement.

3.1.3 State of North Carolina Department of Public Instruction data. Online public data sets downloaded included:

- Free & Reduced Meals Application Data (http://www.ncpublicschools.org/fbs/resources/data/#meal-application). These data sets provide total enrollment numbers, numbers of students who receive free lunch, numbers of students who receive reduced lunch, and percentages of economically-disadvantaged students (% EDS) for each public school in each county of North Carolina. Data sets are available for each school year from the 2006-2007 school year to the 2017-2018 school year.
- Title I Schools Information (http://www.ncpublicschools.org/program-monitoring/titleIA/). Title I schools were identified for each public school in each county of North Carolina, as well as the total enrollment and the numbers and percentages of low-income students from each school. Data sets were available for each school year from the 2003-2004 school year to the 2017-2018 school year.

3.2 Statistical Modeling

This study utilized the predictive modeling method of multiple linear regression. This method was an extension of the simple linear regression model that could be used for several predictors simultaneously (James, Witten, Hastie, & Tibshirani, 2013). For p distinct predictors, the multiple linear regression model is

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_{p-1} X_{p-1} + \beta_p X_p + \varepsilon$$

$$= \beta_0 + \left(\sum_{i=1}^{p} \beta_i X_i \right) + \varepsilon,$$

where:

- Y represents the variable to be predicted, also known as the response variable;
- $X_1, X_2, \dots, X_{p-1}, X_p$ represents the p distinct predictor variables;
- β_0 represents the intercept – the prediction of Y when all predictors $X_1, X_2, \dots, X_{p-1}, X_p$ are set equal to 0;
- $\beta_1, \beta_2, \dots, \beta_{p-1}, \beta_p$ represents the slopes of the predictor variables, defined as the amount of average change (positive or negative) in the response variable expected per one-unit increases in predictor variables $X_1, X_2, \dots, X_{p-1}, X_p$, respectively; and
- ε represents the random error term.

The coefficients $\beta_0, \beta_1, \beta_2, \dots, \beta_{p-1}, \beta_p$ were parameters – coefficients that represented the entire population. Since it was often unrealistic for statisticians to have access to data for every member of a population, these coefficients were generally unknown values. Thus, these parameters must be estimated, and these estimates, denoted $\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2, \dots, \hat{\beta}_{p-1}, \hat{\beta}_p$, were such that the sum of the squares of the residuals – "the difference of the observed response and the predicted value" (Kim, 2018) – was minimized. Therefore, the prediction of Y, denoted $\hat{Y}$, had the following model (James et al., 2013):

$$\hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X_1 + \hat{\beta}_2 X_2 + \cdots + \hat{\beta}_p X_p$$

$$= \hat{\beta}_0 + \left(\sum_{i=1}^{p} \hat{\beta}_i X_i \right).$$

Data set columns that were most relevant to study outcomes were combined in one data file and used as predictor variables. These predictor variables were:

- *PctEDS*: Percentage of economically-disadvantaged students per school;
- *PctSevAbs*: Percentage of severely absent students per school;
- *RurUrb*: Categorical variable with the following binary assignment:

$$RurUrb = \begin{cases} 0\ if\ school\ is\ located\ in\ a\ rural\ area \\ 1\ if\ school\ is\ located\ in\ an\ urban\ area \end{cases};$$

- *PctMinority*: Sum of percentages of Hispanic and Black students per school;
- *TitleI_NoYes*: Categorical variable with the following binary assignment:

$$TitleI\_NoYes = \begin{cases} 0\ if\ school\ did\ not\ receive\ Title\ I\ funding \\ 1\ if\ school\ received\ Title\ I\ funding \end{cases};$$

- *PctLowInc*: Percentage of low-income students per school.

The response variable, *Score*, represented the need of each school for FBP services from BPB. *Score* values were included for schools already receiving FBP services based on the total number of food bags provided to those schools for the school year. An additional categorical variable, *Level* (1 for Elementary, 2 for Middle, 3 for High, 4 for Alternative) was included to indicate the educational level of each school. This variable was not used as a predictor but was used later in the process for data visualization clarity. Full data sets were then separated into training data and prediction data. Training data sets included schools already receiving FBP services, and prediction data sets included schools not yet receiving those services. Training data was used to create best-fit linear regression models so that those models could be applied to the prediction data to generate predicted scores. Copies of full data sets from both school years are provided in Tables A.1 and A.2 in the Appendix section.

3.2.1 Investigating the current trend. First, training data schools were compared and analyzed to identify possible trends within them. All 20 schools from the 2016-2017 training data set were also serviced by BPB in the 2017-2018 school year. BPB also added Shadybrook Elementary School to its FBP program in 2017-2018. The following were calculated for each of the 21 schools serviced during the 2016-2017 and 2017-2018 school years:

- *SumFBPTotal*: Sum of food bags issued to each school in 2016-2017 and 2017-2018;

- *AvgPctEDS*: Mean of *PctEDS* from 2016-2017 and 2017-2018 for each school;
- *RurUrb*: Same variable from original data sets as defined in Section 3.2. This is the only variable among the predictors that remained constant for all schools. It represented the geographical location of the school itself, which would not be affected by student population changes;
- *AvgPctMinority*: Mean of *PctMinority* from 2016-2017 and 2017-2018 for each school;
- *AvgTitle1_NoYes*: Mean of *Title1_NoYes* from 2016-2017 and 2017-2018 for each school. Since *Title1_NoYes* was a binary variable, then integer *AvgTitle1_NoYes* values of 0 or 1 indicated no change in Title I status from 2016-2017 to 2017-2018, while decimal *AvgTitle1_NoYes* values of 0.5 indicated a change in Title I status; and
- *AvgPctLowInc*: Mean of *PctLowInc* from 2016-2017 and 2017-2018 for each school.

These calculations were used to identify similarities, patterns, or extremities in multiple categories related to the model predictors being considered.

3.2.2 Linear regression. With these predictors, the linear regression function *lm* in R / RStudio software (R Core Team, 2017) was used to estimate intercept parameter β_0 and slope parameters $\beta_1, \beta_2, \ldots, \beta_6$ for each of the six predictor variables. These results were obtained for 2016-2017 school year data, 2017-2018 data, and a combined data set with 2016-2017 and 2017-2018 data included together. These estimates were used to construct three least-squares regression line "full model" equations. Diagnostic checks were performed on each full model with Residual vs Fitted plots, Normal Quantile-Quantile plots, Scale-Location plots, and Residual vs Leverage plots to confirm that the following classical assumptions of linear regression were satisfied for full models

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_{p-1} X_{i(p-1)} + \beta_p X_{ip} + \varepsilon_i$$

$$= \beta_0 + \left(\sum_{j=1}^{p} \beta_j X_{ij} \right) + \varepsilon_i, i = 1, \dots, n:$$

- Linearity in parameters
- Zero population mean: $E(\varepsilon_i) = 0$
- Homoscedasticity: $Var(\varepsilon_i) = \sigma^2$
- No serial correlation: $E(\varepsilon_i \varepsilon_{i'}) = 0$ for all $i \neq i'$
- Exogeneity: $E(x_{ij}\varepsilon_i) = 0$ for all $i = 1, \dots, n$ and $j = 1, \dots, p$
- No perfect collinearity: $E(x_{ij}x_{ij'}) \neq 0$ for all $j \neq j'$, and
- Normality: $\varepsilon_i \sim N(0, \sigma^2)$. (Kim, 2018)

The four plots used in these diagnostic checks were Residuals vs Fitted, Normal Q-Q, Scale-Location, and Residuals vs Leverage.

3.2.2.1 Residuals vs Fitted. Observing residuals – error terms, or distances between observed response values and predicted response values generated from the model – aided in verifying linear regression assumptions as well as discovering other patterns in the model (Kim, 2015). In the Residuals vs Fitted plot, linear relationships between predictors of a model and its response were shown by a graph of equally dispersed residuals surrounding a red horizontal line. Extreme values in each of the four diagnostic plots were highlighted with row numbers from which the extreme value originated beside the plot points. This study sought after models which generated Residuals vs Fitted plots with near-horizontal red center lines.

3.2.2.2 Normal Q-Q. Quantile-Quantile (Q-Q) plots compared quantiles (also known as percentiles) of an observed set of residuals with the theoretical quantiles of a specific distribution (Ford, 2015). If the observed quantiles aligned with the quantiles of the known distribution, then the points of the Q-Q plot were expected to form an approximate positively-sloped diagonal line;

that is, the least-squares regression line formed would closely approximate $y = x$. Q-Q plots could be formed to compare observations to any known distribution, but the purpose of Q-Q plots for this study was to verify the "normality" assumption of linear regression. Thus, the Normal Q-Q plot standardized the residuals from linear regression fitted models

$$z_{\varepsilon_i} = \frac{\varepsilon_i - E(\varepsilon_i)}{\sqrt{Var(\varepsilon_i)}}$$

and compared these standardized residual quantiles with the quantiles of the Normal distribution $N(0, \sigma^2)$.

3.2.2.3 Scale-Location. Homoscedasticity (equal variance) among residuals of given linear models was checked with scale-location plots (Kim, 2015). As with the Residuals vs Fitted graph, the red line in the center of the plot was the indicator. The homoscedasticity assumption was verified for scale-location plots with approximately horizontal red center lines surrounded by randomly-dispersed points above and below.

3.2.2.4 Residuals vs Leverage. The final diagnostic plot was the Residuals vs Leverage graph, which helped in the identification of influential points – values in the data that have large residuals and high leverage (Chouldechova, n.d.). Large residuals meant large variation from the model, and high leverage meant that model results could be altered greatly if these points were excluded. Thus, influential points should be further investigated if they exist. Residuals vs Leverage plots displayed a dotted "Cook's Distance" boundary. Cook's Distance D_i, derived by R. Dennis Cook (1977), provided "a measure of the distance between $\hat{\beta}_{(-i)}$ and $\hat{\beta}$ in terms of descriptive levels of significance" (p. 16), where $\hat{\beta}_{(-i)}$ represented "the least squares estimate of β [the $n \times p$ matrix of slope coefficients] with the point deleted" (p. 16). Points with Cook's

Distances beyond the dotted Residuals vs Leverage threshold were identified as influential, and their row numbers were displayed alongside the points.

3.2.2.5 Collinearity check. After diagnostics plots were analyzed, separate checks for collinearity were necessary. Collinearity occurred when at least two predictor variables were very closely associated (James et al., 2013). As mentioned in Section 3.2.2, one of the assumptions of linear regression was the assumption that perfect collinearity did not exist for any pair of predictors. However, even in the absence of perfect collinearity, extremely high or low correlation coefficients could create problems for linear regression models. Correlation matrices were generated for initial insight towards collinearity issues, but the possibility of multicollinearity – the presence of collinearity between at least three variables without extreme correlation values for any two of those variables (James et al., 2013) – required better collinearity detection methods for final conclusions. Thus, more direct comparisons were made with the variance inflation factor (VIF), defined by James et al. as "the ratio of the variance of $\hat{\beta}_j$ when fitting the full model divided by the variance of $\hat{\beta}_j$ if fit on its own" (p. 101). Values of VIF could be no lower than 1, but values greater than 5 or 10 indicated levels of collinearity that could lead to trouble in linear regression. For the purposes of this study, predictor variables such that VIF > 10 were deleted from the full model for that data set and would not be considered in any variable selection methods.

3.2.3 Variable selection. Reviewing the summaries of the full models created in R allowed for analysis of the *F*-statistic and the corresponding p-value of each full model. These statistics were used to reach conclusions regarding the hypotheses

$$H_0: \beta_1 = \beta_2 = \cdots = \beta_p = 0$$

versus

$$H_a\text{: at least one } \beta_j \text{ is nonzero for } j = 1,2, \dots, p$$

at previously designated significance level $\alpha = 0.10$. Rejection of the null hypothesis at that significance level meant there existed at least one predictor variable in the model such that a statistically significant linear relationship existed between that variable and the response variable (James et al., 2013). Then, variable selection methods were used to determine the best linear model for the data, whether the full model or a model with a smaller subset of predictors.

3.2.3.1 Backward selection. The backward stepwise variable selection process, more commonly known as "backward selection", started with the full model (with p predictors) and removed the statistically insignificant predictor with the largest p-value in each step (James et al., 2013). Each variable that was removed was considered to be the variable that was the least useful in explaining the linear relationship between the predictors and the response. Hence, this new model was expected to not only have a smaller residual sum of squares than the previous model but removing the predictor with the largest statistically insignificant p-value was considered to yield the best model of all possible models with $p - 1$ predictors. This validated its consideration as a better model than the previous. The process was repeated until only statistically significant predictors remained in the model. Backward selection considered the null model $Y = \beta_0$ and k versions of models with k predictors, for $k = 1,2, \dots, p$. That is, backward selection considered

$$1 + \sum_{i=1}^{p} i$$

$$= 1 + \frac{p(p+1)}{2}$$

$$= \frac{1}{2}(p^2 + p + 2)$$

models out of the

$$\sum_{i=0}^{p} \binom{p}{i} = 2^p$$

total subset models available for consideration (James et al., 2013), so this process was very practical for model selection, particularly for large values of p. However, backward selection was unable to be used for data sets such that number of predictors p exceeded sample size n (James et al., 2013). This was not the case for this study, so backward selection was utilized.

3.2.3.2 Forward selection. Forward stepwise variable selection, or forward selection, followed a similar algorithm to backward selection. However, forward selection began with the null model $Y = \beta_0$ and considered the p models obtained by adding a predictor to the null model. The best of these p models, defined as the model with the new predictor with the lowest statistically significant p-value (Kim, 2018), was chosen. This process was repeated until none of the remaining variables being considered for addition to the model were statistically significant after being added. As in backward selection, this process was also computationally efficient (James et al., 2013) because it did not require analysis of all 2^p subset models to locate a model that best explained the linear relationship between the predictors and the response.

3.2.3.3 Stepwise selection. Since there were $p = 6$ predictors being considered for each data set, then there existed $2^p = 2^6 = 64$ subset models for each of the three data sets (2016-2017 school year data, 2017-2018 school year data, and combined school year data) to be considered (Faraway, 2015). However, these subset models only contained main effects. Interaction effects – phenomena where a predictor affects the coefficient of another predictor (Kim, 2018) – must also be considered in these models. Since there were $p = 6$ predictor variables being used in this study, then there were

$$\binom{p}{2} = \binom{6}{2} = \frac{6!}{2!\,(6-2)!} = \frac{6 * 5 * 4!}{2 * 1 * 4!} = \frac{30}{2} = 15$$

possible distinct interaction terms of two variables. This expanded the full multiple linear model to

$$Y = \beta_0 + \left(\sum_{i=1}^{6} \beta_i X_i\right) + \left(\sum_{i=1}^{6} \sum_{j=i+1}^{6} \beta_{i,j} X_i X_j\right) + \varepsilon.$$

This pattern was continued to expand the full model to include interaction terms of three, four, five, and six variables:

$$\begin{aligned} Y = \beta_0 &+ \left(\sum_{i_1=1}^{6} \beta_{i_1} X_{i_1}\right) + \left(\sum_{i_1=1}^{6} \sum_{i_2=i_1+1}^{6} \beta_{i_1,i_2} X_{i_1} X_{i_2}\right) + \left(\sum_{i_1=1}^{6} \sum_{i_2=i_1+1}^{6} \sum_{i_3=i_2+1}^{6} \beta_{i_1,i_2,i_3} X_{i_1} X_{i_2} X_{i_3}\right) \\ &+ \left(\sum_{i_1=1}^{6} \sum_{i_2=i_1+1}^{6} \sum_{i_3=i_2+1}^{6} \sum_{i_4=i_3+1}^{6} \beta_{i_1,i_2,i_3,i_4} X_{i_1} X_{i_2} X_{i_3} X_{i_4}\right) \\ &+ \left(\sum_{i_1=1}^{6} \sum_{i_2=i_1+1}^{6} \sum_{i_3=i_2+1}^{6} \sum_{i_4=i_3+1}^{6} \sum_{i_5=i_4+1}^{6} \beta_{i_1,i_2,i_3,i_4,i_5} X_{i_1} X_{i_2} X_{i_3} X_{i_4} X_{i_5}\right) \\ &+ \left(\sum_{i_1=1}^{6} \sum_{i_2=i_1+1}^{6} \sum_{i_3=i_2+1}^{6} \sum_{i_4=i_3+1}^{6} \sum_{i_5=i_4+1}^{6} \sum_{i_6=i_5+1}^{6} \beta_{i_1,i_2,i_3,i_4,i_5,i_6} X_{i_1} X_{i_2} X_{i_3} X_{i_4} X_{i_5} X_{i_6}\right) + \varepsilon. \end{aligned}$$

The use of an interaction term (for example, $X_1 X_2$) in a model required the use of each main effect term from that interaction in the model (for example, X_1 and X_2) as well (Kim, 2018). This new full model contained

$$\sum_{i=0}^{p} \binom{p}{i} = 2^p$$

distinct terms. For $p = 6$, the new full model contained

$$\sum_{i=0}^{6} \binom{6}{i} = \binom{6}{0} + \binom{6}{1} + \binom{6}{2} + \cdots + \binom{6}{5} + \binom{6}{6}$$

$$= \frac{6!}{0!\,(6-0)!} + \frac{6!}{1!\,(6-1)!} + \frac{6!}{2!\,(6-2)!} + \cdots + \frac{6!}{5!\,(6-5)!} + \frac{6!}{6!\,(6-6)!}$$

$$= 1 + 6 + 15 + 20 + 15 + 6 + 1$$

$$= 64$$

$$= 2^6$$

distinct terms.

The stepwise selection process combined concepts from backward and forward selection. Each step either added statistically significant variables or deleted insignificant variables. This process allowed significant variables that may have been deleted in backward selection or not added in forward selection in favor of other significant variables to still be considered for the final model. With the inclusion of interaction effects, a wider range of models could be considered.

Manual backward and forward variable selection methods performed in this study compared p-values to determine levels of statistical significance. However, p-values were not the only statistics that could be used for comparisons in variable selection. Other measures were also explored to compare variables and models to ensure that only the best models were selected.

3.2.3.4 Akaike Information Criterion. In 1951, Solomon Kullback and Richard Leibler revealed their formula for calculating the distance between true model f – the model used to acquire all observed values in data set X – and approximate model g

$$I(f, g) = \int f(x) \log\left(\frac{f(x)}{g(x|\theta)}\right) dx,$$

where θ represented a vector of parameters in f that was estimated in g. This distance $I(f, g)$ was used to show the "information lost" in using model g to approximate f. However, true

model f is generally unknown, so the maximum-likelihood estimator of θ, denoted $\hat{\theta}$, was used (Faraway, 2015) to acquire the form

$$\hat{I}(f,g) = \int f(x) \log\left(\frac{f(x)}{g(x|\hat{\theta})}\right) dx$$

$$= \int f(x) \log f(x)\, dx - \int f(x) \log g(x|\hat{\theta})\, dx,$$

where the term $\int f(x) \log f(x)\, dx$ was observed to be constant to chosen approximated model g. In 1973, Hirotogu Akaike used the Kullback-Leibler information function to create an information criterion that would become known as AIC. As explained by Burnham & Anderson,

> He found that the maximized log-likelihood value was a biased estimate of relative, expected Kullback-Leibler information and that under certain conditions this bias was approximately equal to K [denoted as p in this paper], the number of estimable parameters in the approximating model g. (2002)

Akaike (1973) estimated the expected value of the Kullback-Leibler distance

$$E\left(\hat{I}(f,g)\right) = c_1 - \log L(\hat{\theta}) + p,$$

where c_1 was a constant, $\log L(\hat{\theta})$ was maximum log-likelihood function

$$\log L(\hat{\theta}) = \frac{-n}{2} \log\left(\frac{RSS}{n}\right) + c_2$$

and p was the number of predictors being considered for approximated model g. Finally, Akaike (1973) concluded with the criterion function in its final form

$$AIC = -2 \log L(\hat{\theta}) + 2p$$

which, when minimized, provided the best model g to use for approximating true model f.

3.2.3.5 AIC for small samples. While very useful in approximating Kullback-Leibler information, AIC should not be used when the ratio of sample size to estimated parameters

(n/p) is small (Burnham & Anderson, 2002). Generally, n/p ratios less than 40 are considered "small". As 2016-2017, 2017-2018, and Combined training data were of sizes $n = 20,21,41$, respectively, with $p = 6$ predictors, all n/p ratios in this study were small. These data sets required a correction factor to be applied to the bias term $2p$ in the AIC formula. Initially derived by Nariaki Sugiura in 1978 and further explored by Clifford Hurvich and Chih-Ling Tsai in 1989, the second-order AIC version for small samples, denoted AIC_c, was defined (Burnham & Anderson, 2002) as

$$AIC_c = -2\log L(\hat{\theta}) + 2p\left(\frac{n}{n-p-1}\right)$$

$$= -2\log L(\hat{\theta}) + \frac{2pn}{n-p-1}$$

$$= -2\log L(\hat{\theta}) + \frac{2pn - 2p^2 - 2p + 2p^2 + 2p}{n-p-1}$$

$$= -2\log L(\hat{\theta}) + \frac{2pn - 2p^2 - 2p}{n-p-1} + \frac{2p^2 + 2p}{n-p-1}$$

$$= -2\log L(\hat{\theta}) + \frac{2p(n-p-1)}{n-p-1} + \frac{2p(p+1)}{n-p-1}$$

$$= -2\log L(\hat{\theta}) + 2p + \frac{2p(p+1)}{n-p-1}$$

$$= AIC + \frac{2p(p+1)}{n-p-1}$$

for maximum log-likelihood $\log L(\hat{\theta})$, sample size n, and number of estimated parameters p. Notice that as n approaches infinity,

$$\lim_{n\to\infty} AIC_c = \lim_{n\to\infty}\left(AIC + \frac{2p(p+1)}{n-p-1}\right)$$

$$= \lim_{n\to\infty}(AIC) + \lim_{n\to\infty}\left(\frac{2p(p+1)}{n-p-1}\right)$$

$$= AIC + 0$$

$$= AIC.$$

Thus, this modified information criterion yielded similar results as AIC for sufficiently large sample sizes but was strongly preferred over AIC for small sample sizes. Therefore, AIC_c was used in this study. Backward, forward, and stepwise selection methods were performed using AIC_c to select models that minimized approximated Kullback-Leibler information lost.

3.2.4 Comparison of final models. After forward, backward, and stepwise variable selection methods (using p-values and AIC_c) narrowed these potential subset models down to a few finalists, then model comparison methods were used to select the best of the best. The random forest method, adjusted R^2 comparisons, and *F*-statistic p-value comparisons were used to measure the quality of fit of subset models, while discouraging overfitting – the use of unnecessarily complex models to explain random error in the data.

***3.2.4.1 Random forests*.** The random forest method was an improved low-variance decision tree method used in this study to compare final models. Many samples were taken from the training data and a regression tree was built from each sample (James et al., 2013). At each tree split, $m \approx \sqrt{p}$ randomly selected predictors were chosen as candidates for the split. Only one of those candidates were chosen for the final decision tree split (Kim, 2018). Each split of each decision tree considered new random selections of m predictors. This random predictor selection process prevented stronger predictors from dominating the decision trees, which in turn decorrelated the collection of randomly-generated decision trees (the "random forest"). Hence, averages of these trees would have lower variances and thus be more reliable (James et al., 2013).

The *randomForest* function in R from the *randomForest* library (Liaw & Wiener, 2002) was used for each finalist model to best estimate the mean of squared residuals (MSR) and the percentage of variance in response variable Score explained by the linear regression model (denoted by R^2) (Moore, Notz, & Fligner, 2013). Of course, the randomness involved in the algorithm meant that repeated executions of the *randomForest* function yielded different statistical output values each time. However, the purpose was not to generate exact values of these statistics, but instead was to determine the model from each data set with the lowest MSR and highest R^2 values.

3.2.4.2 Adjusted R^2. As mentioned in the previous section, values of R^2 estimated the percentage of variance of the response variable that was explained by the predictors in the model. This was referred to as the coefficient of determination for simple linear regression models, and is defined as

$$R^2 = \frac{TSS - RSS}{TSS}$$

$$= 1 - \frac{RSS}{TSS},$$

where residual sum of squares $RSS = \sum_{i=1}^{n}\left(Y_i - \hat{Y}_i\right)^2$ and total sum of squares $TSS = \sum_{i=1}^{n}(Y_i - \bar{Y})^2$ (James et al., 2013). For multiple linear regression models, R^2 was referred to as the coefficient of multiple determination and represented "the squared correlation between the observed outcome values and the predicted values by the model" (Kassambara, 2018).

This has been a commonly used metric to evaluate how well models fit the data from which they are derived. When models with the same number of predictors were compared, then R^2 sufficed in that analysis; the best model was the one that maximized the value of R^2.

However, comparisons of models with different numbers of predictors required a modification in the formula. Hence,

$$Adjusted\ R^2 = 1 - \frac{\left(\frac{RSS}{n-p-1}\right)}{\left(\frac{TSS}{n-1}\right)}$$

penalized the use of extraneous predictor variables that only yielded small decreases in RSS (James et al., 2013). Since extraneous predictors increased p, then $\frac{RSS}{n-p-1}$ increased. Thus, $\frac{\left(\frac{RSS}{n-p-1}\right)}{\left(\frac{TSS}{n-1}\right)}$ increased as well, and it followed that its complement $1 - \frac{\left(\frac{RSS}{n-p-1}\right)}{\left(\frac{TSS}{n-1}\right)}$ would then decrease. Adjusted R^2 yields maximum values for models with all relevant and no extraneous predictors.

3.2.4.3 F-statistic p-value. The p-values associated with the *F*-statistic mentioned earlier in the beginning of section 3.2.1 were revisited with the final models being considered for selection. The right-skewness of the *F* distribution meant that higher *F*-statistics yielded lower p-values. Thus, the model with the lowest p-value was the model of best fit for the training data set.

3.2.4.4 Making predictions using prediction data set. Each finalist model was used on the prediction data set to generate tables of predicted scores, which were then sorted by score in descending order. These tables can be found in the Appendix section. Distributions of these predicted scores were plotted on histograms for side-by-side comparisons of the finalist models.

With several well-defined methods and criteria in place, the best models for each training data set were selected. Data visualization generated for these best models included:

- training data scatterplots of best-model predictors with regression lines for simple linear regression best models or regression planes for multiple linear regression best models,
- prediction data scatterplots of predicted scores by school name, and

- prediction data histograms of best-model predictors.

A summary and analysis of results follows in the next chapter.

CHAPTER 4

Results

Guilford County Schools data, as Microsoft Excel files, were imported in RStudio software (R Core Team, 2017) via the "readxl" package (Wickham & Bryan, 2018). Each data set was then separated into two categories. The first category was the training data, sorted by the *FBPTotal* variable in the data file. This variable represented the total yearly units of food backpacks delivered to each school from BackPack Beginnings. Zeros were entered in this category for schools who did not receive services from BPB that year. Thus, the training data consisted of schools with nonzero *FBPTotal* entries, whereas the second category – the prediction data – consisted of schools with zero *FBPTotal* entries. Training data for 2016-2017, 2017-2018, and Combined school years were of sizes 20, 21, and 41, respectively. Thus, sample size to predictor ratios $\frac{n}{p}$ for all training data sets were small, which justified the use of small-sample variable selection criteria and methods described in Chapter 3.

4.1 Current Trend Analysis

As described in Section 3.2.1, a table of *SumFBPTotal, AvgPctEDS, AvgPctSevAbs, RurUrb, AvgPctMinority, AvgTitle1_NoYes,* and *AvgPctLowInc* statistics was created for 2016-2017 and 2017-2018 training data schools. These results, displayed in Table 1, were sorted in descending order by *SumFBPTotal* to show the extent of BPB support over these two school years. However, since *SumFBPTotal* was generated from private internal BPB data, those numbers are not shown in this report.

All but two of the schools showed high *AvgPctEDS* rates. The two schools with less-than-half *AvgPctEDS* rates also had the two lowest *SumFBPTotal* values. *AvgPctSevAbs* rates were consistently low for all schools, which was expected due to them all being Elementary

schools. Typically, severe absence rates were low for lower-level Guilford County schools and generally increased for higher-level schools.

Table 1

Current Trend Analysis, 2016-2017 and 2017-2018 Training Data Schools

School	AvgPctEDS	AvgPctSevAbs	RurUrb	AvgPctMinority	AvgTitleI_NoYes	AvgPctLowInc
Clara J Peck Elementary [Elementary]	0.771391411	0.028350158	1	0.7895	1	0.74235
Wiley Acel/Enrichment [Elementary]	0.853705295	0.102207792	1	0.9465	1	0.83985
Parkview Village Elementary [Elementary]	0.88857705	0.038536723	1	0.884	1	0.79945
W M Hampton Elementary [Elementary]	0.845653966	0.027487013	1	0.9195	1	0.72575
Irving Park Elementary [Elementary]	0.910005827	0.012537688	1	0.5645	1	0.48065
Ceasar Cone Elementary [Elementary]	0.920040988	0.066839869	1	0.8885	1	0.79435
Rankin Elementary [Elementary]	0.902375536	0.02840099	1	0.7885	1	0.6622
Oak Hill Elementary [Elementary]	0.932025779	0.020603376	1	0.7595	1	0.62995
Gillespie Park Elementary [Elementary]	0.89662483	0.065277778	1	0.9335	1	0.8011
Montlieu Avenue Elementary [Elementary]	0.93484923	0.028247839	1	0.8455	1	0.62865
Johnson Street Elementary [Elementary]	1	0.0075	1	0.749	1	0.52805
David D Jones Elementary [Elementary]	0.953007831	0.031816493	1	0.7235	0.5	0.4127
Northwood Elementary [Elementary]	0.883300992	0.041465704	1	0.7085	1	0.6325
Union Hill Elementary [Elementary]	0.963754647	0.025936255	1	0.7565	1	0.6487
Peeler Open Elementary [Elementary]	0.935911261	0.022936508	1	0.8465	1	0.55165
Washington Elementary [Elementary]	0.849320908	0.042833333	1	0.944	1	0.67125
Shadybrook Elementary [Elementary]	0.558744673	0.012821101	1	0.4765	0	0.35585
Jefferson Elementary [Elementary]	0.963633246	0.008736921	1	0.644	0.5	0.4115
Sumner Elementary [Elementary]	0.964232981	0.019443089	0	0.851	1	0.57605
Sternberger Elementary [Elementary]	0.222895461	0.0025	1	0.1645	0	0.11415
Jesse Wharton Elem [Elementary]	0.356802721	0.002053388	1	0.354	0	0.24965

As mentioned in Section 3.2.1, all *RurUrb* values would remain constant for each school year. However, all training data schools but one were in urban locations. *AvgTitleI_NoYes* values showed no change in Title I status for all but two schools. More variance was observed in rates of *AvgPctMinority* and *AvgPctLowInc*, as illustrated in Figure 5 and Figure 6 scatterplots. These graphs display overall positive associations between *AvgPctMinority* and *SumFBPTotal* variables, and between *AvgPctLowInc* and *SumFBPTotal.* With a better understanding of general

distribution characteristics of training data schools, individual school year analyses could now begin.

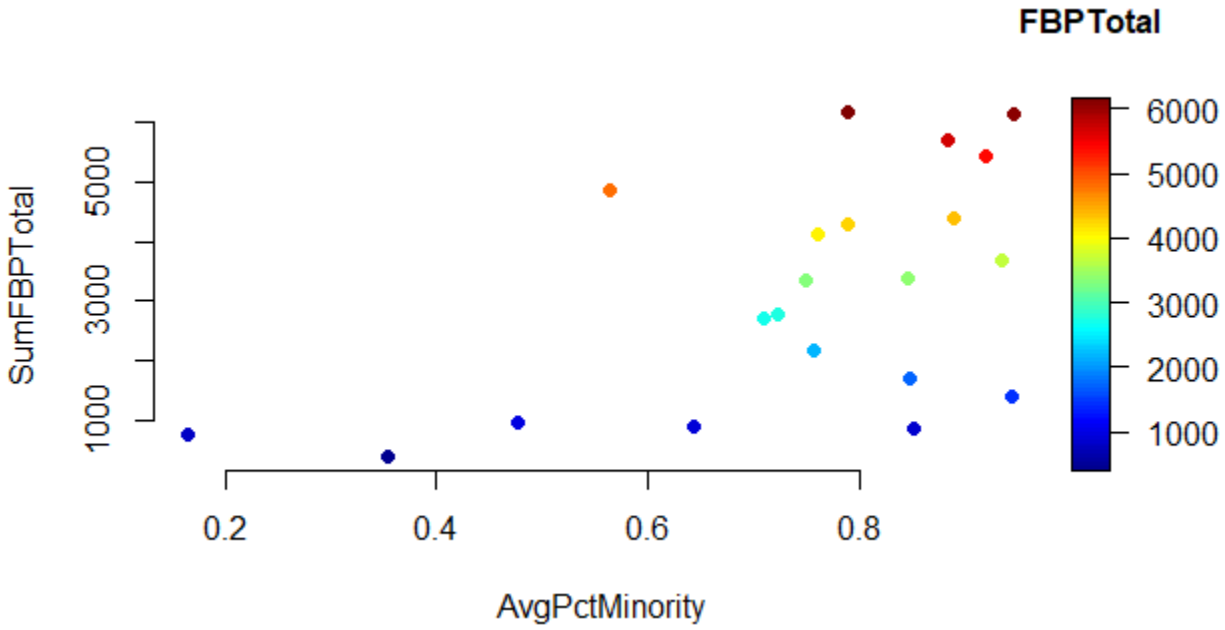

Figure 5. Current trend analysis, *AvgPctMinority / SumFBPTotal* scatterplot.

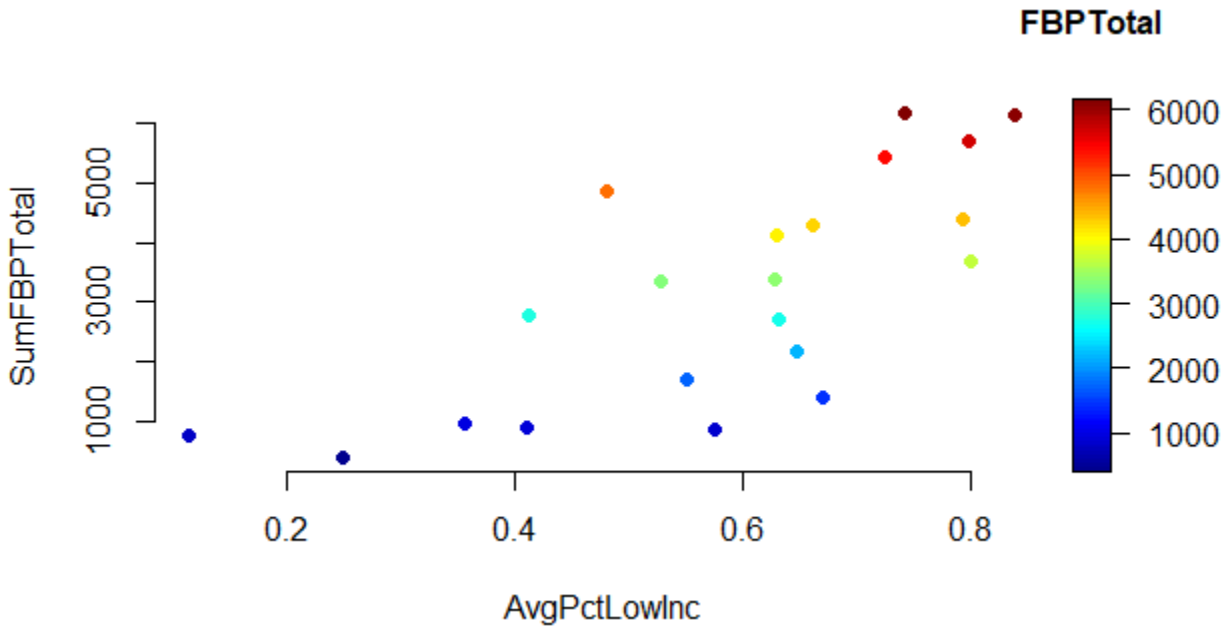

Figure 6. Current trend analysis, *AvgPctLowInc / SumFBPTotal* scatterplot.

4.2 2016-2017 School Year Analysis

Initial diagnostics on full model *Score* ~ *PctEDS* + *PctSevAbs* + *RurUrb* + *PctMinority* + *TitleI_NoYes* + *PctLowInc* revealed high VIF values for *PctMinority* (11.722406) and *PctLowInc* (10.767096). Since the highest value belonged to *PctMinority*, this variable was removed from the full model. This yielded new VIF values less than 10 (*PctEDS* = 1.672238, *PctSevAbs* = 2.130364, *RurUrb* = 1.070120, *TitleI_NoYes* = 3.686646, *PctLowInc* = 6.083727) for the five remaining predictors.

After performing manual backward selection, backward selection with AIC_c, manual forward selection, forward selection with AIC_c, and stepwise selection with AIC_c, one model emerged as the unanimous best. This model was *Score* ~ *PctLowInc*. Thus, random forest, adjusted R^2, and *F*-statistic p-value comparisons were not required for 2016-2017 analysis.

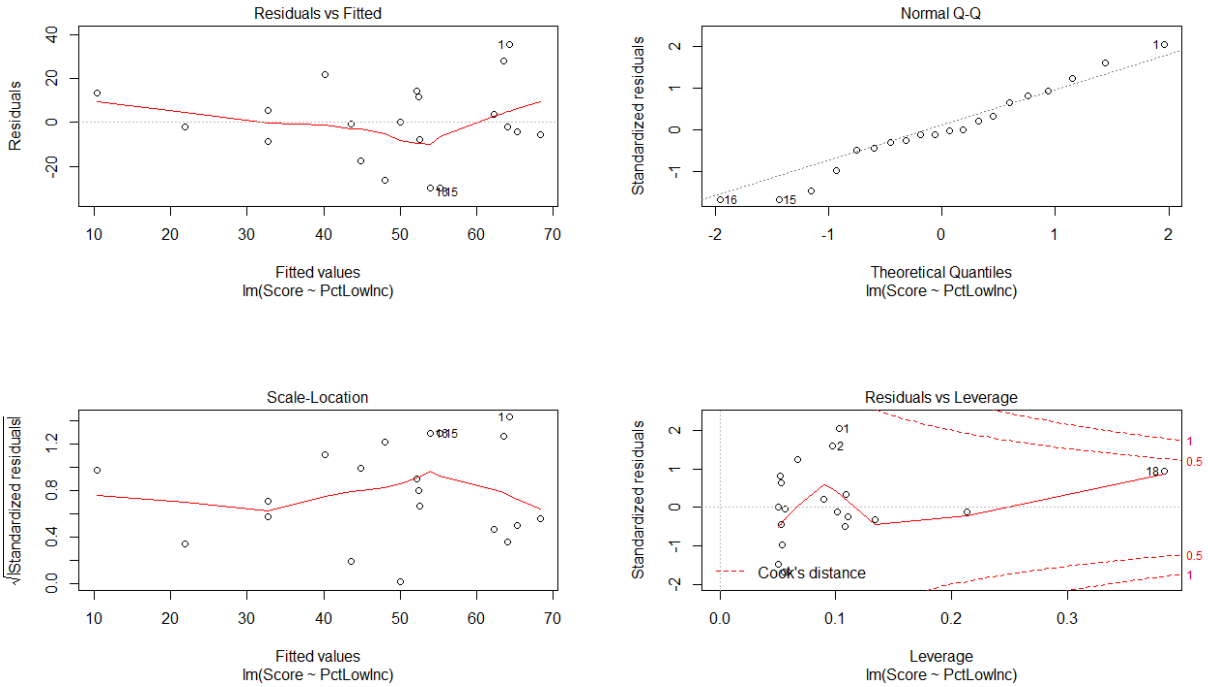

Figure 7. 2016-2017 diagnostics, Best model.

Diagnostic plots were generated for this model to check for the validity of linear regression assumptions, as shown in Figure 7. The Residuals vs Fitted plot showed randomness in residuals centered around a line with some decrease and increase, but a generally horizontal pattern. This was not the most ideal result desired, but the line was not distorted extremely enough to give reason for concern. The Normal Q-Q plot showed the greatest deviation from normality in the first few quartiles, but a vast majority of the standardized residual quartiles closely aligned with the quartiles of $N(0, \sigma^2)$. Scale-Location plot analysis was similar to that of Residuals vs Fitted; randomness among plot points, while not the most ideal, were evident. Finally, Residuals vs Leverage revealed all points within the Cook's Distance threshold (less than 0.5); therefore, no influential points existed within the 2016-2017 training data set for this model.

A table of predicted scores was generated using best model *Score ~ PctLowInc*, and the histogram of the distribution of those predicted scores was plotted. Full predicted score tables can be found in Appendix Table A.3, and the histogram is displayed in Figure 8.

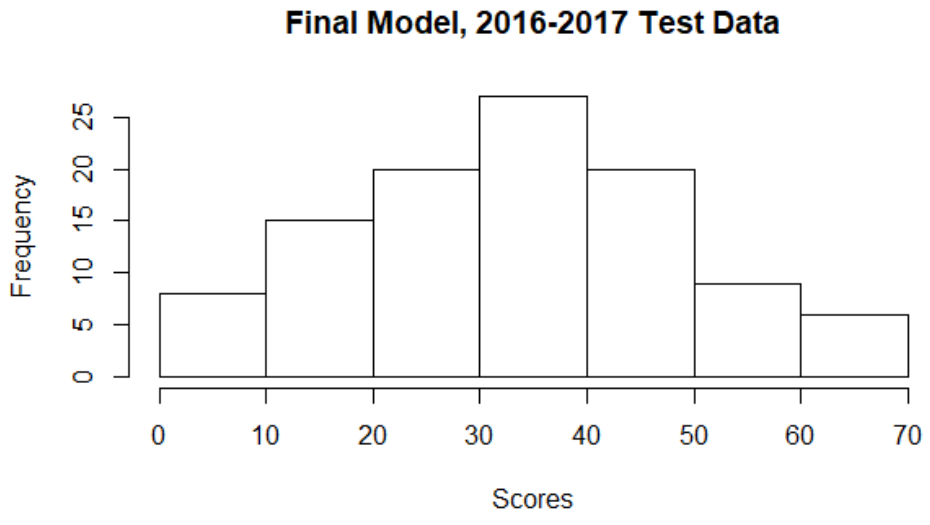

Figure 8. 2016-2017 histogram of predicted scores, Best model.

This histogram showed an approximately symmetrical distribution of scores predicted from the prediction data set with a median score in the 30-40 range. Linear regression output shown in Figure 9 allowed us to generate the equation used to derive the predicted scores from this histogram.

```
Call:
lm(formula = Score ~ PctLowInc, data = train.dat1617)

Residuals:
    Min      1Q  Median      3Q     Max
-29.900  -8.096  -1.278  12.018  35.670

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  -0.4495    14.1520  -0.032  0.97501
PctLowInc    86.9292    23.8303   3.648  0.00184 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 18.36 on 18 degrees of freedom
Multiple R-squared:  0.425, Adjusted R-squared:  0.3931
F-statistic: 13.31 on 1 and 18 DF,  p-value: 0.00184
```

Figure 9. Simple linear regression R output for 2016-2017 school year best model.

Thus, predictions of scores for 2016-2017 school year prediction data were best approximated with the formula

$$Score = -0.4495 + 86.9292 * (PctLowInc).$$

For example, a school with a *PctLowInc* of 0.7281 would receive a predicted score of

$$Score = -0.4495 + 86.9292 * (0.7281)$$

$$= -0.4495 + 63.29315052$$

$$= 62.84365052.$$

With the best model now revealed, further data visualization was performed for this model. Since the best model included one predictor, then a two-dimensional scatterplot was generated for the training data with that predictor, its corresponding scores, and the least-squares regression line, as displayed in Figure 10. If the left side of the red line in the scatterplot was

extended to touch the vertical axis, then that line would be expected to intersect the vertical axis at intercept estimate $\hat{\beta}_0 = -0.4495$ shown in the model equation $\hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X_1$. Therefore, an

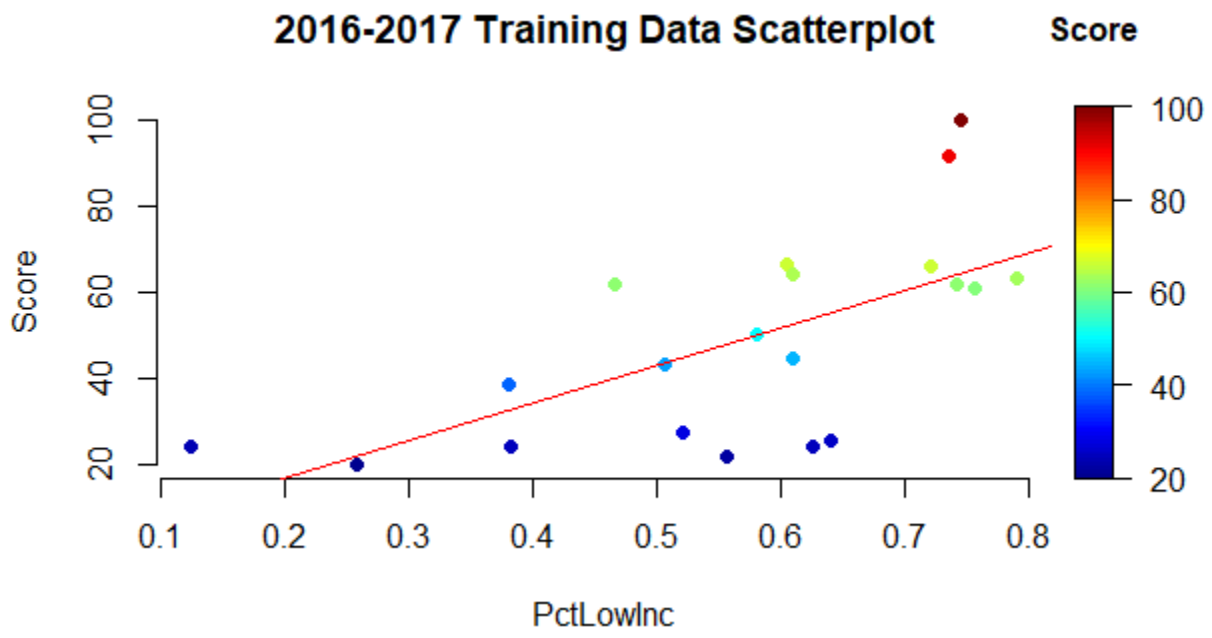

Figure 10. 2016-2017 training data: Scatterplot.

expected score of -0.4495 would correspond to a *PctLowInc* value of zero percent. This scatterplot also verified the positive association between *PctLowInc* and *Score* shown in the model equation $\hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X_1$, where predictor variable slope coefficient estimate $\hat{\beta}_1 = 86.9292$ was positive. Thus, for every $\frac{1}{100}$ (one percent) increase in *PctLowInc*, it was expected that *Score* would increase by $\frac{86.9292}{100}$.

Visualizations for 2016-2017 prediction data included a scatterplot by school name and a histogram of predictor variable *PctLowInc*, as shown in Figures 11 and 12, respectively. The scatterplot mirrored the histogram of predicted scores from Figure 8 in that the majority of predicted scores were located in the center 30-40 range, and it mirrored the model analysis above in that prediction data schools with higher *PctLowInc* values also received higher *Score* values. The color scheme generated in this scatterplot was separated by school education level, where

Level 1 (dark blue) represented Elementary, Level 2 (light blue) represented Middle, Level 3 (yellow) represented High, and Level 4 (dark red) represented Alternative. The top score went to an Alternative school, but Elementary and Middle schools occupied most of the other top ranks. High schools had low-to-middle-range scores, and Alternative school scores were distributed throughout the list. The prediction data histogram showed a slightly left-skewed distribution of *PctLowInc* that were used in prediction calculations. These 2016-2017 training and prediction data visualizations gave better clarity regarding the center and the spread of predictors and responses from model *Score ~ PctLowInc.*

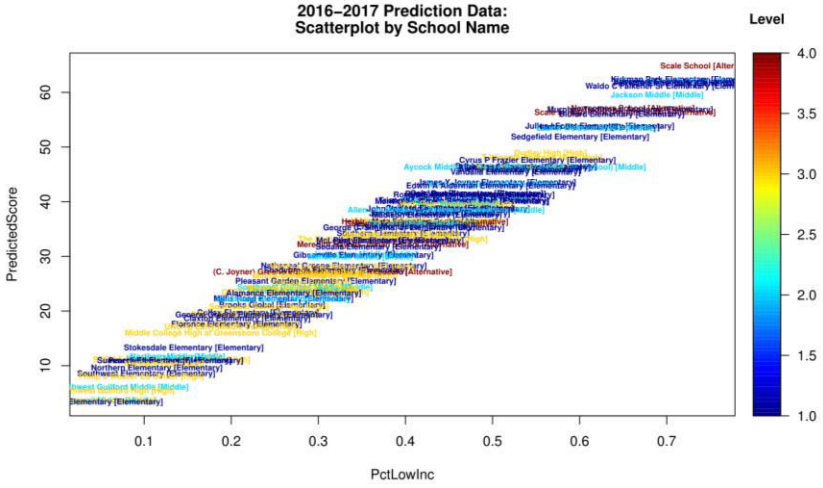

Figure 11. 2016-2017 prediction data: Scatterplot by school name.

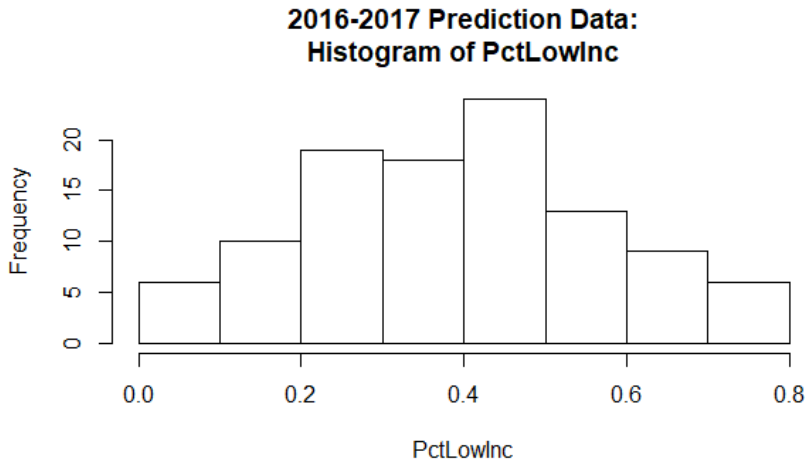

Figure 12. 2016-2017 prediction data: Histogram of *PctLowInc*.

4.3 2017-2018 School Year Analysis

Full model *Score* ~ *PctEDS* + *PctSevAbs* + *RurUrb* + *PctMinority* + *TitleI_NoYes* + *PctLowInc* initial diagnostics had high VIF values for *PctMinority* (9.858125), *TitleI_NoYes* (9.049403) and *PctLowInc* (9.366301). To combat potential collinearity issues, the predictor with the largest VIF greater than 10 would be removed from the full model. The VIF values of the predictors of this full model did not exceed 10. However, the VIF for *PctMinority* was very close to 10, so it was removed. VIF was recalculated for the new full model, and all remaining predictors had satisfactory VIF results (*PctEDS* = 6.397304, *PctSevAbs* = 2.358749, *RurUrb* = 1.068436, *TitleI_NoYes* = 8.395424, *PctLowInc* = 4.598785).

Manual backward selection, backward selection with AIC_c, manual forward selection, forward selection with AIC_c, and stepwise selection with AIC_c were then performed on 2017-2018 training data. Three models emerged from these methods as best model finalists. Final Model 1, *Score* ~ *PctSevAbs* + *TitleI_NoYes*, was the best model from backward selection with AIC_c and stepwise selection with AIC_c. Final Model 2, *Score* ~ *PctLowInc*, was the best model from manual forward selection and forward selection with AIC_c. Also recall that this model was the best model from the previous school year. Final Model 3, *Score* ~ *PctSevAbs*, was the best model from manual backward selection.

To choose the best model, these three finalists were compared by random forest, adjusted R^2, and *F*-statistic p-value computations. Final Model 1 had the highest adjusted R^2 value, while Final Model 2 was the preferred model from random forest and had the lowest *F*-statistic p-value. A summary of these results can be found in Table 2.

Diagnostic plots for all three final models are shown in Figures 13, 14, and 15. Tables of predicted scores were generated using all three finalist models, and histograms of predicted

Table 2

Final Model Analysis Summary, 2017-2018 School Year

	Backward Selection (Manual)	**Backward Selection (AIC_c)**	**Forward Selection (Manual)**	**Forward Selection (AIC_c)**	**Stepwise Selection (AIC_c)**	**Random Forest**	**Highest Adjusted R^2**	**Lowest *F*-statistic p-value**
Best Model	3	1	2	2	1	2	1	2

scores were generated using all three finalist models, and histograms of the distributions of those predicted scores were plotted. Full predicted score tables can be found in Appendix Tables A.4, A.5, and A.6. Histograms are displayed in Figure 16.

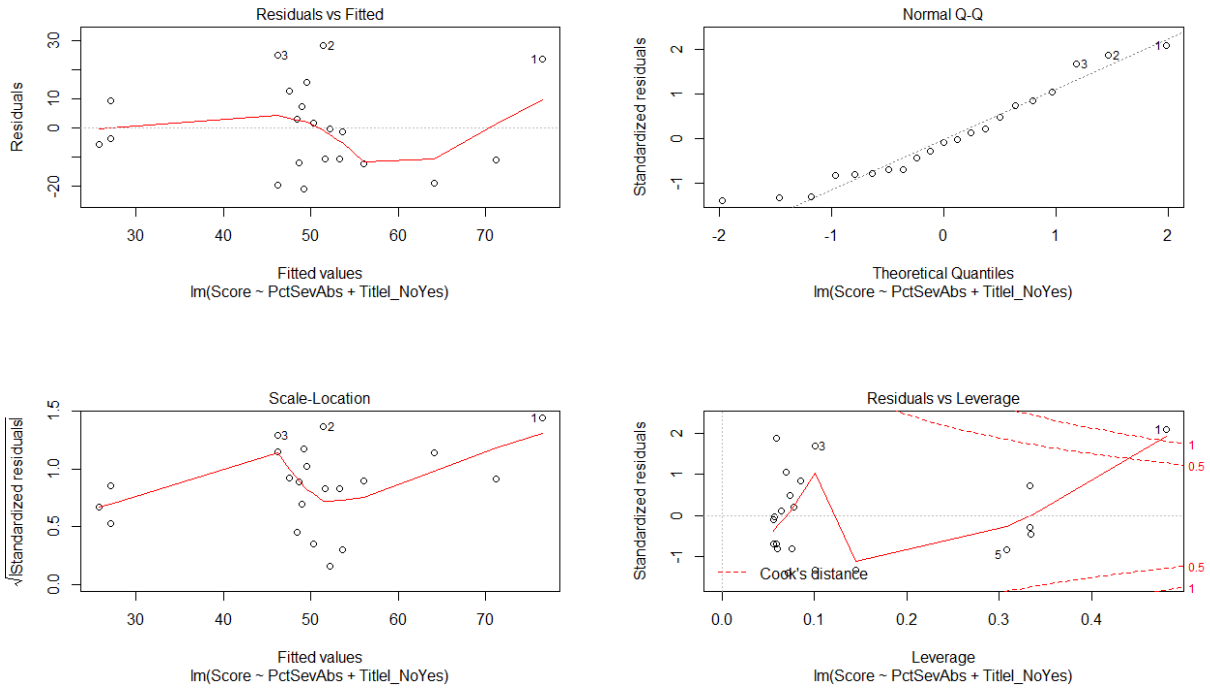

Figure 13. 2017-2018 diagnostics, Final Model 1.

Diagnostics for Final Model 1 showed nonlinear residual patterns in the Residuals vs Fitted and Scale-Location graphs, as indicated by the red trendlines in each. Normal Q-Q had a couple stray points, but most points aligned well with the central diagonal. Residuals vs

Leverage indicated that training data row 1 had a Cook's Distance outside the standard threshold. Thus, data row 1 contained values of *PctSevAbs* and *TitleI_NoYes* that were strongly influential, and the absence of this row of data would cause a significant change in the coefficients of Final Model 1. Overall, these diagnostics suggested that Final Model 1 was not a good linear fit for this data set.

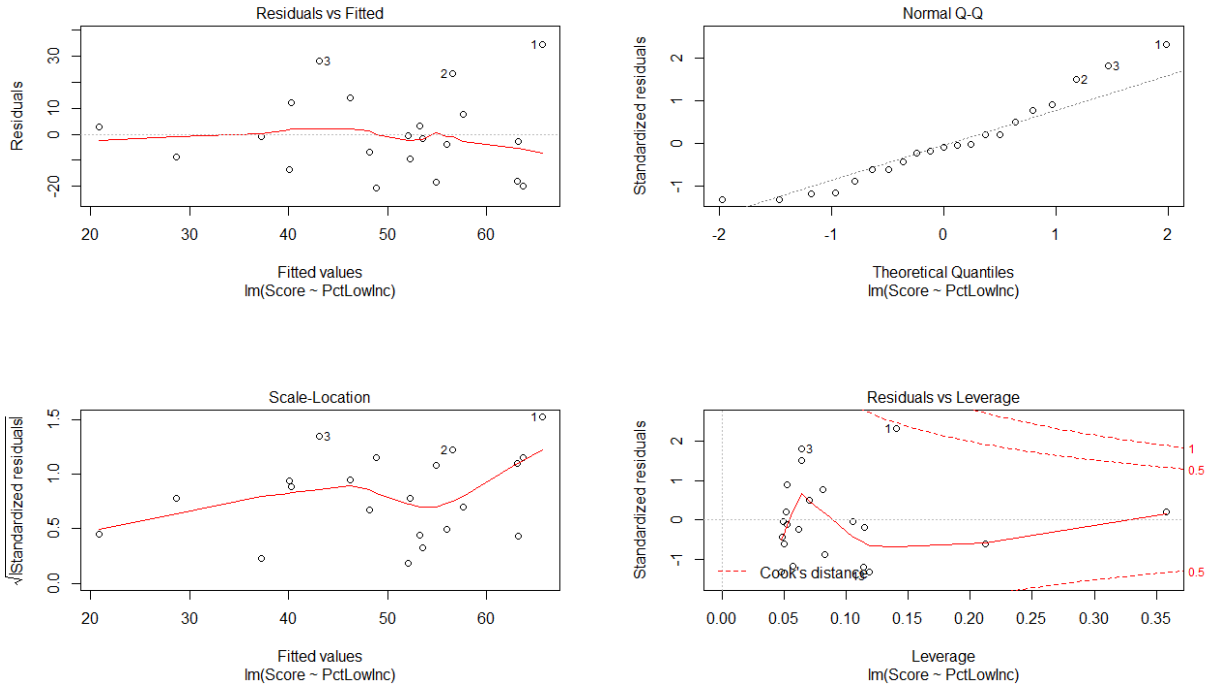

Figure 14. 2017-2018 diagnostics, Final Model 2.

Final Model 2 diagnostics were much more stable than that of Final Model 1. Notice the near-horizontal residual trendline displayed in the Residuals vs Fitted plot. Normal Q-Q showed good alignment to normality at the beginning but started to deviate more with the last three plot points. The Scale-Location plot showed a gradual increasing trend throughout most of the graph and a steeper increase at the end. The random dispersion of the residuals could be called into question here but was certainly an improvement from the Scale-Location plot of Final Model 1. The influential point from data row 1 in the Residuals vs Leverage plot of Final Model 1

appeared in the plot of Final Model 2 as well. Although it was close, this point nor any other points crossed the Cook's Distance threshold to be considered influential for this fitted model.

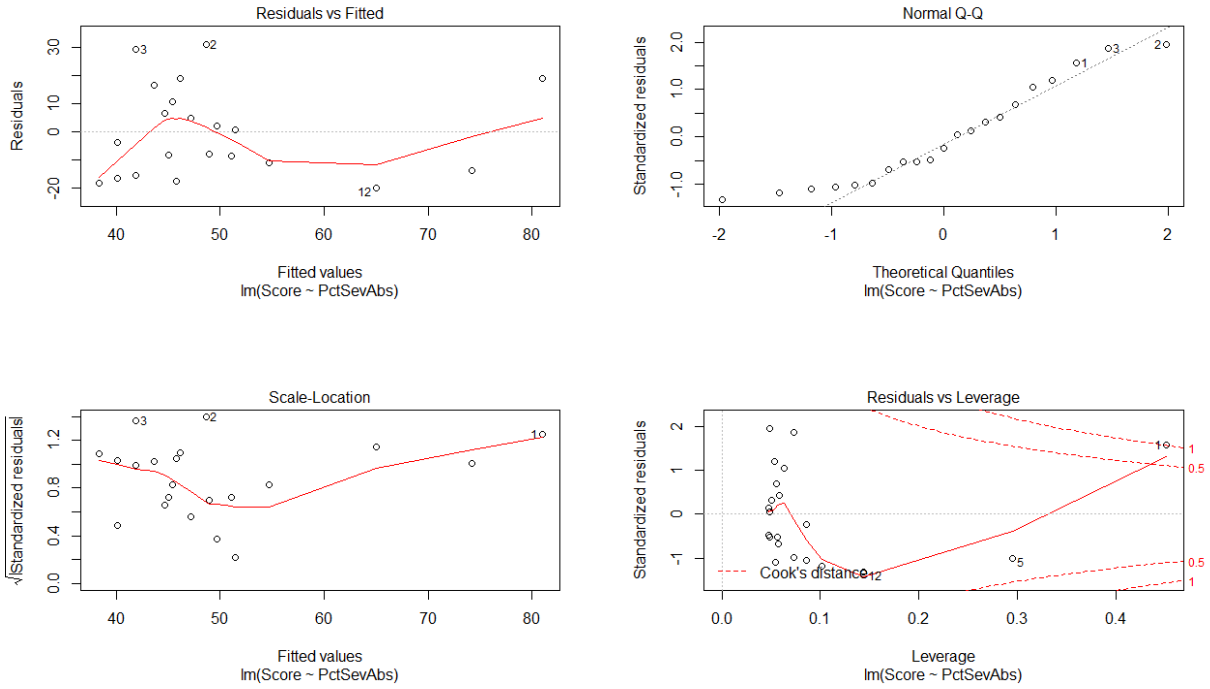

Figure 15. 2017-2018 diagnostics, Final Model 3.

Finally, Final Model 3 diagnostics were examined. Its Residuals vs Fitted plot and Scale-Location plot showed central instabilities similar to Final Model 1. Since the majority of the training data schools had low *PctSevAbs* rates, then most of the residual points in these two plots corresponded to low fitted values. Thus, most points were on the left sides of these graphs, which enabled center lines to greatly deviate from horizontality as they advanced forward. Normal Q-Q plot behavior for Final Model 3 was the reverse of that of Final Model 2. This plot showed the most deviance from the diagonal for lower quantiles, while higher quantiles aligned with the diagonal very well. Residuals vs Leverage showed all but one point within the normal Cook's Distance range. As with Final Model 1, data row 1 was labeled as influential with this fitted model with an extreme Cooks' Distance of approximately 1.

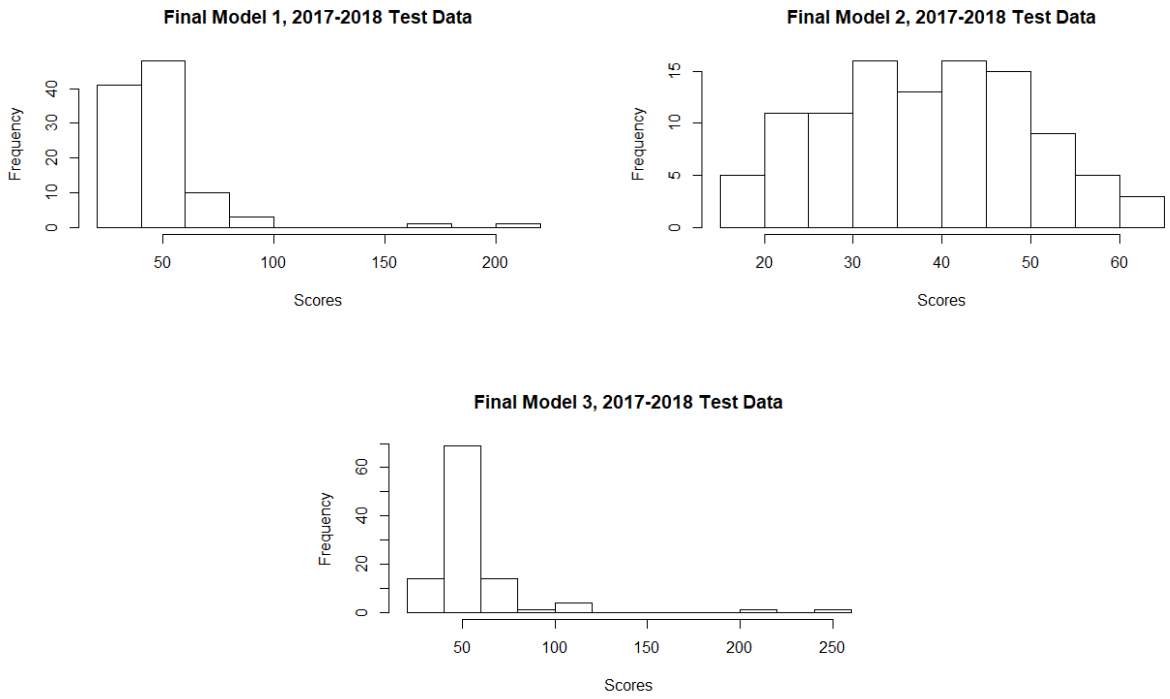

Figure 16. 2017-2018 histograms of predicted scores.

Histogram comparisons revealed the presence of outlier predicted scores in final models 1 and 3. These extremely high values distorted and skewed these distributions. Meanwhile, the histogram of Final Model 2 showed a much more balanced and symmetrical distribution of predicted scores.

```
Call:
lm(formula = Score ~ PctLowInc, data = train.dat1718)

Residuals:
    Min      1Q  Median      3Q     Max
-20.567  -9.510  -1.635   7.620  34.409

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)    14.84      11.26   1.318  0.20317
PctLowInc      57.16      17.54   3.259  0.00413 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 15.93 on 19 degrees of freedom
Multiple R-squared:  0.3586, Adjusted R-squared:  0.3248
F-statistic: 10.62 on 1 and 19 DF,  p-value: 0.00413
```

Figure 17. Simple linear regression R output for 2017-2018 school year best model.

After carefully considering all output, plots, and tables, Final Model 2 was chosen as the best model to approximate the observed 2017-2018 training data. Its linear regression output is shown in Figure 17. Therefore, the best model equation used for score predictions for 2017-2018 school year prediction data was

$$Score = 14.84 + 57.16 * (PctLowInc).$$

As with the 2016-2017 best model, slope coefficient estimate $\hat{\beta}_1 = 57.16$ represented the $\frac{57.16}{100}$ increase in predicted score resulting from a $\frac{1}{100}$ increase in *PctLowInc*. This positive slope coefficient estimate meant that *PctLowInc* and *Score* were positively associated. Intercept estimate $\hat{\beta}_0 = 14.84$ represented the score prediction when *PctLowInc* = 0. Since 0 was the smallest possible value for *PctLowInc* and since the slope coefficient estimate implied positive association, then $\hat{\beta}_0 = 14.84$ was the minimum score estimate, whereas the maximum score estimate was attained at maximum *PctLowInc* = 1.

With this best model, additional data visualization was performed. The training data scatterplot with the *PctLowInc* predictor, corresponding scores, and the least-squares regression line is displayed in Figure 18. The prediction data scatterplot by school name can be found in Figure 19, and the prediction data histogram of predictor variable *PctLowInc* is shown in Figure 20. The training data scatterplot supported the positive linear relationship between *PctLowInc* and *Score* explored in 2016-2017 analysis. Thus, as *PctLowInc* increased, *Score* was also expected to increase. The model as defined by the linear equation above was applied to prediction data schools so that the scatterplot by school name could be generated. This scatterplot also displayed color-coded levels of education with the same colors as from 2016-2017 (Elementary = dark blue, Middle = light blue, High = yellow, Alternative = dark red). Elementary and Middle schools were heavily represented among the schools with the highest

scores, while High schools appeared towards the middle and bottom of the list. Alternative schools were dispersed throughout the top half of the rankings. Finally, the histogram of prediction data *PctLowInc* values showed an approximately symmetrical and balanced distribution among the data set, with no outliers present to consider.

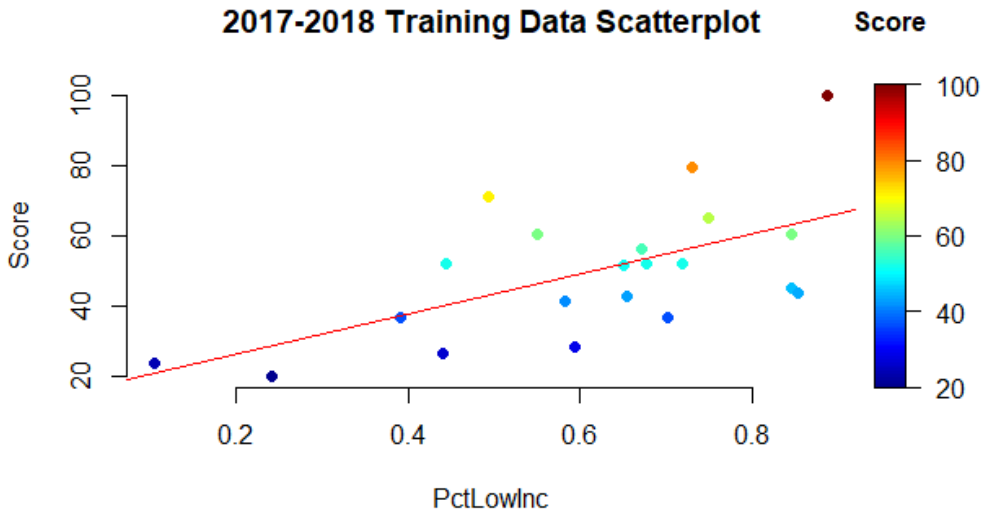

Figure 18. 2017-2018 training data: Scatterplot.

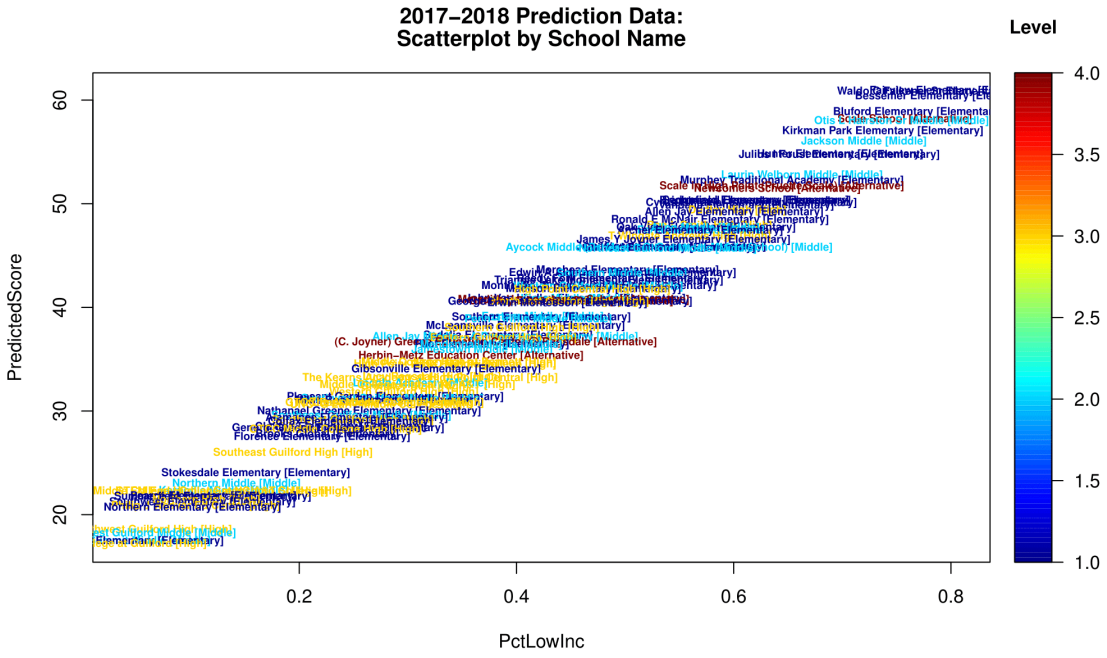

Figure 19. 2017-2018 prediction data: Scatterplot by school name.

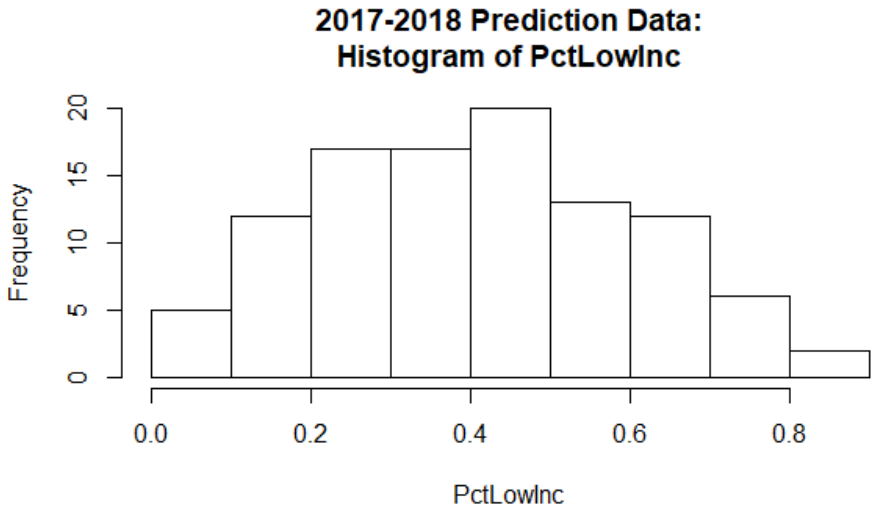

Figure 20. 2017-2018 prediction data: Histogram of *PctLowInc*.

4.4 Combined School Years Analysis

As with the previous two data sets, Combined analysis began with initial diagnostic check VIF comparisons for possible collinearity issues. VIF results for the full model (*PctEDS* = 3.212199, *PctSevAbs* = 2.280717, *RurUrb* = 1.116988, *PctMinority* = 8.632567, *TitleI_NoYes* = 3.722714, *PctLowInc* = 8.906067) did not require the removal of any predictors for final model consideration.

As in 2016-2017 analysis, performance of manual backward selection, backward selection with AIC_c, manual forward selection, forward selection with AIC_c, and stepwise selection with AIC_c processes on combined training data yielded one unanimous best model finalist. All processes concluded with *Score ~ RurUrb + PctLowInc*, as the best model. However, as with 2017-2018 analysis, previous best models were also considered as Combined finalists. Thus, Final Model 1 *Score ~ RurUrb + PctLowInc* was joined by Final Model 2, the 2016-2017 and 2017-2018 best model of *Score ~ PctLowInc*.

Once finalists were identified, they were processed through the comparison phase of random forest, adjusted R^2, and *F*-statistic p-value computations. Final Model 1 was the

preferred model from random forest, had the highest adjusted R^2 value, and had the lowest F-statistic p-value. The Combined finalist analysis results summary can be found in Table 3.

Table 3

Final Model Analysis Summary, Combined School Years

	Backward Selection (Manual)	**Backward Selection (AIC_c)**	**Forward Selection (Manual)**	**Forward Selection (AIC_c)**	**Stepwise Selection (AIC_c)**	**Random Forest**	**Highest Adjusted R^2**	**Highest F-statistic p-value**
Best Model	1	1	1	1	1	1	1	1

Diagnostic check plots for verification of linear regression assumptions for both final models are displayed in Figures 21 and 22. These plots were nearly identical in every way for both finalist models. Both had extremely horizontal center lines in their Residuals vs Fitted plots, which showed random disbursement of residuals. Both Normal Q-Q plots showed normality

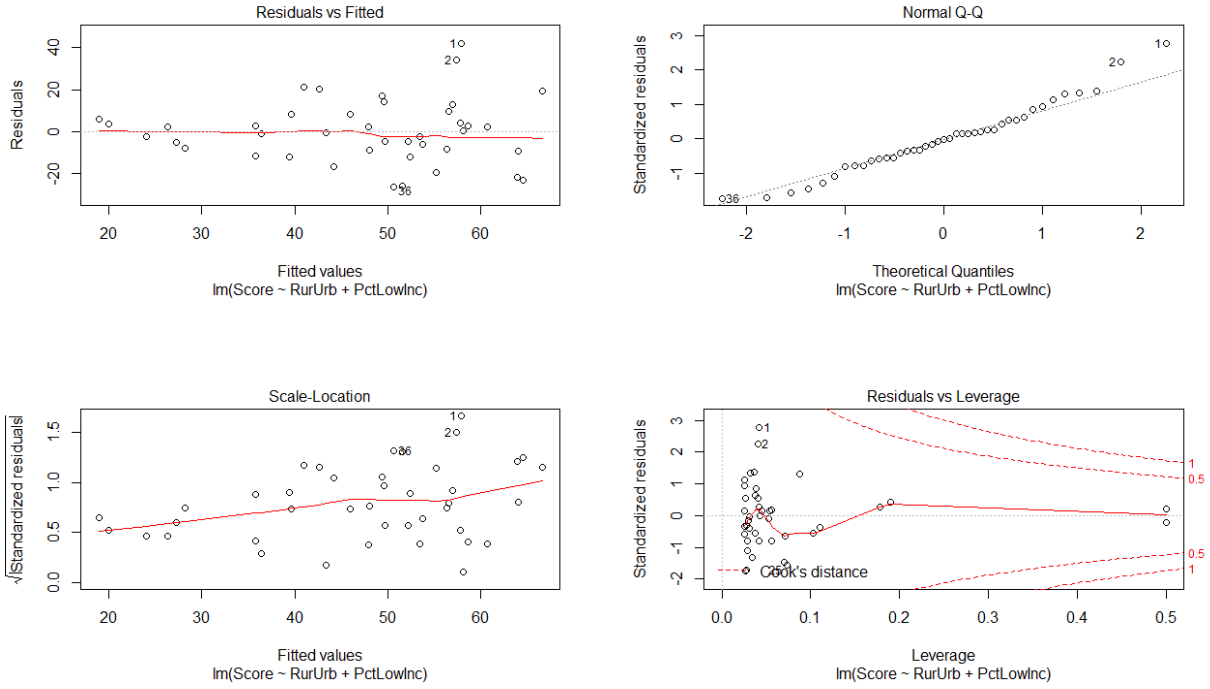

Figure 21. Combined diagnostics, Final Model 1.

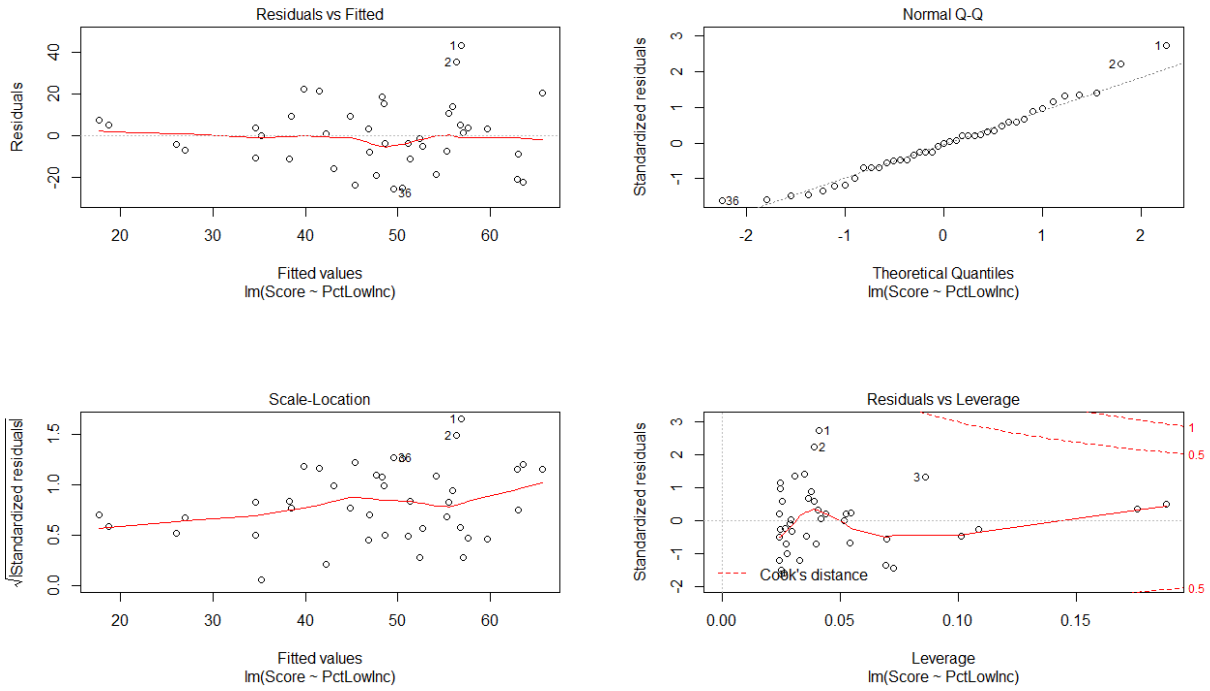

Figure 22. Combined diagnostics, Final Model 2.

deviation among the two highest quantile points, but the rest of the points aligned very close to the center diagonal. Scale-Location randomization was also confirmed for each model with points scattered above and below slightly-increasing but close-to-horizontal center trendlines. Residuals vs Leverage would show no influential points, as no point in either plot exceeded any of the Cook's Distance thresholds.

These models were applied to the Combined prediction data set to generate predicted scores for each prediction data set school. Histograms showing distributions of predicted scores for finalists can be viewed in Figure 23, and full finalist tables of prediction data schools arranged in descending order by predictions are located in Appendix Tables A.7 and A.8. Final model histogram comparisons were also similar. Predicted scores for Final Model 2 had a smaller range but was only slightly more evenly disbursed than predictions for Final Model 1.

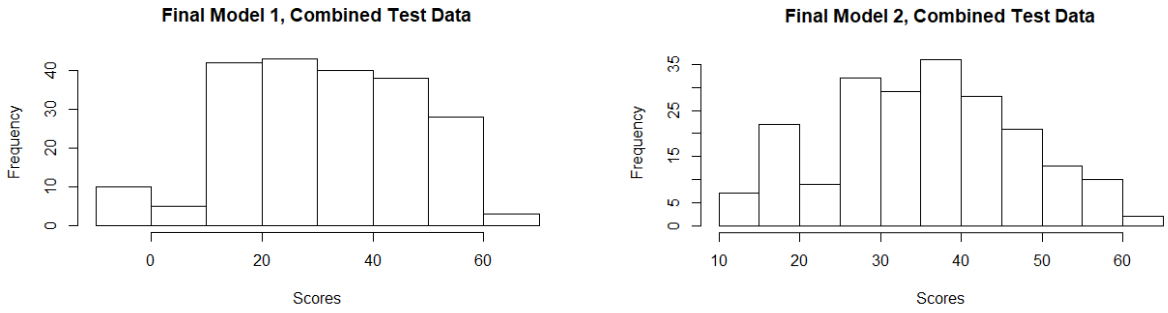

Figure 23. Combined histograms of predicted scores.

After careful analysis of output and plots, Final Model 1 was selected as the best model for estimating observations from Combined training data because of the overwhelming preference of this model that was shown in all variable selection methods and most final model comparisons. Multiple linear regression output for Final Model 1 can be viewed in Figure 24.

```
Call:
lm(formula = Score ~ RurUrb + PctLowInc, data = train.datcombined)

Residuals:
    Min      1Q  Median      3Q     Max
-26.570  -9.011  -0.447   8.182  42.101

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   -9.849     13.252  -0.743   0.4619
RurUrb        22.421     11.239   1.995   0.0533 .
PctLowInc     60.826     12.931   4.704 3.33e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 15.5 on 38 degrees of freedom
Multiple R-squared:  0.4102, Adjusted R-squared:  0.3792
F-statistic: 13.22 on 2 and 38 DF,  p-value: 4.395e-05
```

Figure 24. Multiple linear regression R output for Combined school year best model.

It followed that Combined school year prediction data score predictions would be best approximated with equation

$$Score = -9.849 + 22.421 * (RurUrb) + 60.826 * (PctLowInc).$$

For multiple linear regression model $\hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X_1 + \hat{\beta}_2 X_2$, the intercept coefficient estimate $\hat{\beta}_0 = -9.849$ was the expected score given *RurUrb* = *PctLowInc* = 0. Since *RurUrb* was a categorical predictor variable, then slope coefficient estimate $\hat{\beta}_1 = 22.421$ represented the

expected increase in *Score* for a change in *RurUrb* from 0 (rural school location) to 1 (urban school location) while all other model predictors remained constant (Grace-Martin, n.d.). That is,

$$[-9.849 + 22.421 * (1) + 60.826 * (PctLowInc)]$$

$$- [-9.849 + 22.421 * (0) + 60.826 * (PctLowInc)]$$

$$= -9.849 + 9.849 + 22.421(1) - 22.421(0) + 60.826(PctLowInc) - 60.826(PctLowInc)$$

$$= 22.421.$$

Slope coefficient estimate for *PctLowInc* $\hat{\beta}_2 = 60.826$ represented an expected increase in *Score* of $\frac{60.826}{100}$ for every $\frac{1}{100}$ increase in *PctLowInc* while all other model predictors remained constant. As both slope estimates were positive, then intercept $\hat{\beta}_0 = -9.849$ was the minimum score for this model.

As with previous best models, data visualization was performed for this model. As a multiple linear regression model with two predictors, three-dimensional plots were required. Figure 25 displays the scatterplot for the training data with predictors *RurUrb* and *PctLowInc*, their corresponding scores, and a mesh least-squares regression plane.

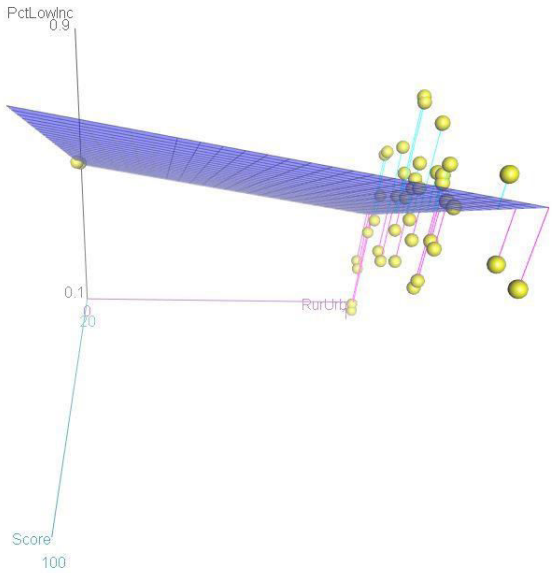

Figure 25. Combined training data: Three-dimensional scatterplot.

Model $Score = -9.849 + 22.421 * (RurUrb) + 60.826 * (PctLowInc)$ was graphed by this plane to show the fit of this model to Combined training data.

Combined prediction data visualizations included a scatterplot of predicted scores plotted by school name and a histogram of both predictors, as displayed in Figures 26 and 27, respectively.

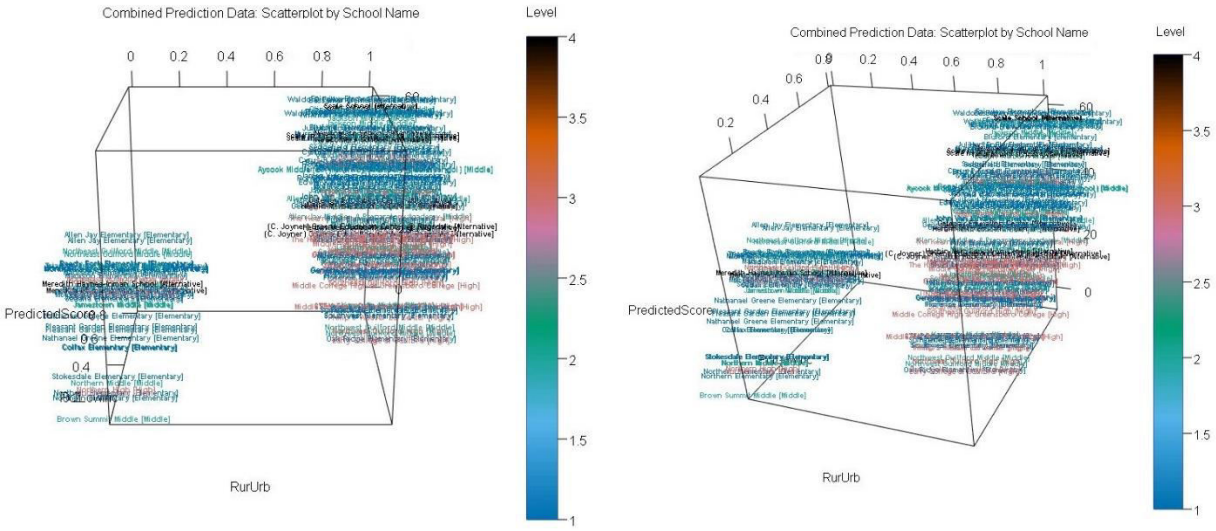

Figure 26. Combined prediction data: Three-dimensional scatterplot by school name.

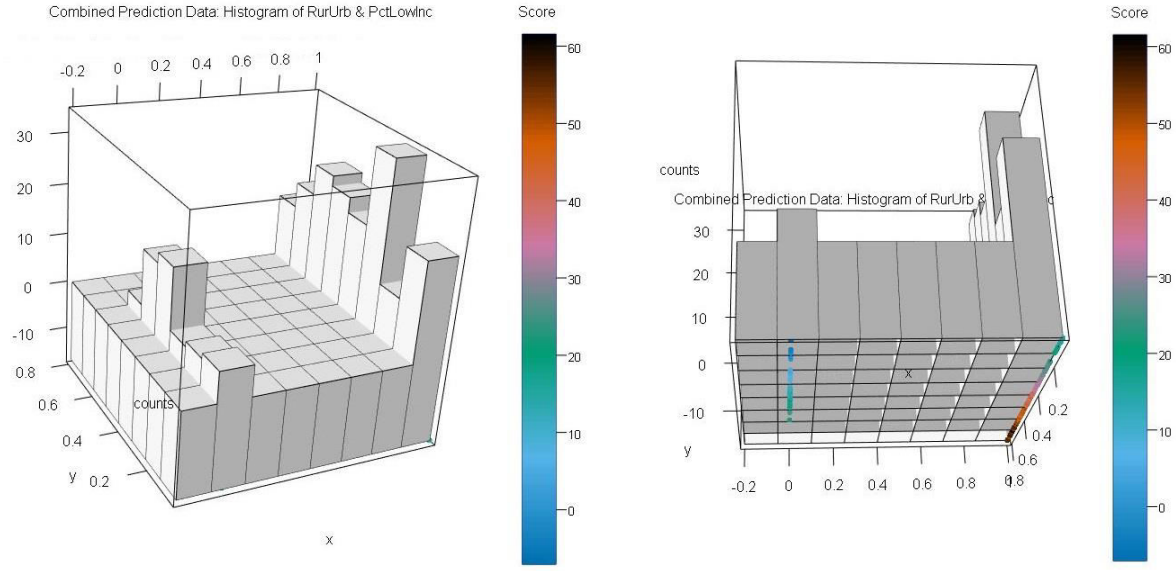

Figure 27. Combined prediction data: Three-dimensional histogram of *RurUrb* and *PctLowInc*.

The scatterplot clearly showed the separation of rural and urban schools, and school education level differences were displayed with colors as shown by the accompanying legend. Elementary, middle, and alternative schools were spread throughout the entire scatterplot, whereas the spread of high schools stopped just short of the top. The histogram exhibited a wide distribution of *PctLowInc* for urban schools while a majority of rural schools were in the 0.4-0.6 *PctLowInc* range. The bottom of the histogram showed that, as expected, schools with minimal values for *RurUrb* and *PctLowInc* received lower predicted scores, and as those values increased, predicted scores also increased. The positive association between both predictors and the response was confirmed in this histogram.

The careful selection and execution of thorough best-model selection procedures for these data sets yielded prediction data predictions tables that could be analyzed and scrutinized with great levels of confidence in their accuracy. A discussion of these results and their relation to the goals, mission, and future expansion of BackPack Beginnings is explored in the next chapter. The full R code used to obtain the previous results is provided in the Appendix.

CHAPTER 5

Discussion and Future Research

5.1 Recommendations for the BackPack Beginnings Organization

The prediction output from R clearly ordered the schools not currently serviced by BPB from highest score (greatest need for BPB services) to lowest score (least amount of need for BPB services). The top ten schools – the schools with the greatest need – were especially observed for future discussion, as shown in Tables 4, 5, and 6. Full ordered lists of prediction data schools for each school year are provided in Tables A.3, A.5 and A.7 in the Appendix section.

Table 4

Top Ten Schools, Predictions from 2016-2017 School Year Data

Rank	School	Score
1	Scale School [Alternative]	64.74735856
2	Kirkman Park Elementary [Elementary]	62.26987685
3	Otis L Hairston Sr Middle [Middle]	61.87000261
4	Bessemer Elementary [Elementary]	61.85261677
5	Fairview Elementary [Elementary]	61.5309788
6	Waldo C Falkener Sr Elementary [Elementary]	61.04417537
7	Jackson Middle [Middle]	59.44467841
8	Newcomers School [Alternative]	57.02804712
9	Murphey Traditional Academy [Elementary]	56.75856666
10	Scale in High Point (Pruette Scale) [Alternative]	56.24568448

Table 5

Top Ten Schools, Predictions from 2017-2018 School Year Data

Rank	School	Score
1	Fairview Elementary [Elementary]	60.87585242
2	Waldo C Falkener Sr Elementary [Elementary]	60.80726623
3	Bessemer Elementary [Elementary]	60.33859393
4	Bluford Elementary [Elementary]	58.82398222
5	Scale School [Alternative]	58.14383582
6	Otis L Hairston Sr Middle [Middle]	57.97237035
7	Kirkman Park Elementary [Elementary]	56.9835861
8	Jackson Middle [Middle]	55.98908633
9	Hunter Elementary [Elementary]	54.74310387
10	Julius I Foust Elementary [Elementary]	54.69166422

Table 6

Top Ten Schools, Predictions from Combined School Years Data

Rank	School	Score
1	Fairview Elementary [Elementary]	61.56081968
2	Waldo C Falkener Sr Elementary [Elementary]	61.4878282
3	Bessemer Elementary [Elementary]	60.98905313
4	Bluford Elementary [Elementary]	59.3771581
5	Scale School [Alternative]	58.65332598
6	Otis L Hairston Sr Middle [Middle]	58.4708473
7	Scale School [Alternative]	58.19104665
8	Kirkman Park Elementary [Elementary]	57.41855356
9	Kirkman Park Elementary [Elementary]	56.45749916
10	Jackson Middle [Middle]	56.36017719

Elementary schools appearing in all three Top Ten lists were Fairview Elementary, Waldo C Falkener Sr Elementary, and Kirkman Park Elementary. Bessemer Elementary and Bluford Elementary were included in 2017-2018 and Combined Top Ten lists but not the 2016-2017 list. Comparing the rankings in these three tables reveals that among elementary schools, Fairview Elementary has the greatest food insecurity need, followed by Waldo C Falkener Sr Elementary, Bessemer Elementary, Bluford Elementary, and Kirkman Park Elementary, in that order.

Clearly, most schools in these Top Ten lists were elementary schools, but other school levels were also present. Otis L Hairston Middle and Scale School (an alternative school) appeared in all three Top Ten lists, while Jackson Middle was listed in 2017-2018 and Combined Top Ten lists but not the 2016-2017 list. Among these schools, it is recommended that priority is given to Scale School, followed by Otis L Hairston Middle and then Jackson Middle.

BPB can maximize its impact by prioritizing its expansion and reaching out to schools in this order. It is recommended that BPB continues services for elementary schools, while also recognizing and addressing the needs of higher-level schools. Providing middle school students, alternative school students, and possibly high school students with food backpacks will require

much different approaches and execution methods than what is required for the preschool and elementary school students that BPB currently services. Recall the recent study (Fram & Frongillo, 2018) mentioned earlier (section 2.4: Backpack Programs) that concluded that some children who receive BPP services experience shame at the thought of the possible negative perception of their peers upon learning that they are food-insecure. As children grow into adolescence, and hence leave elementary schools to attend middle and high schools, shame and stigma worsen.

However, also recall the recommended solutions that Fram and Frongillo (2018) proposed. The first solution was learning about the actual needs of children and responding to those specific needs. The best way to do this is for BPB staff members to speak with the children themselves. In an interview conducted with Dr. Maryah Fram, one of the authors of that study, she discussed the extreme care and thoughtful preparation necessary in conducting such a focus group:

> We did something really similar to that in a pilot program here with middle school kids. And we had to be really careful about how we invited them to the focus group, and how we made sure that the people who were there all knew that the other people there were safe to talk to. And so we worked at that, and I think we did a good job of it. I had social worker interns in the schools handling that. But some of the feedback we got from the kids was – just the act of talking in that focus group was one of the most beneficial things we did, because it let them know they weren't alone. So in and of itself, that was a good thing to do that I would highly recommend. But they did come up with really good ideas for what would work for them. They did not want – like, in elementary schools, typically the bags are put in the kids' regular backpack in, like, the coat room or at the end of the

> day, or they're called to pick them up. These kids wanted a couple of central locations where they could come get it when they wanted to, so that it could be – they could control who was with them, when it was, do it at different times, so that it wouldn't be like a pattern that was noticed. But that had to do with the way their school day worked and the layout of their school. But I think you're exactly right that asking the kids in that school what would work for them is definitely the way to go. (personal communication, December 28, 2018)

Thus, if planned thoroughly and executed properly, BPB can gain valuable insight from the students themselves on how to customize FBP services for older students.

The second solution was minimizing risks by creating methods to locate and offer FBP services only to students who really need them. Establishing strong working relationships with school social workers is essential to accomplish this. These social workers deal with the forms, data, and students each day that allow them to have some of the best administrator understandings of the overall food insecurity needs of their student populations.

Finally, the third suggested solution was extensively evaluating positive program outcomes and negative consequences to deduce whether BPP benefits truly outweigh its psychosocial costs. This can be achieved through periodic requests for feedback throughout the school year, but mainly through thorough follow-up sessions with school social workers, some teachers, and some students towards the end of the school year. At first, this may seem like an extremely difficult task for BPB to accomplish, and realistically, the organization may not be able to do this for every school they service every year. However, the knowledge gained after the completion of end-of-year assessments will prove invaluable, as the organization will learn of the effectiveness of current methods and what methods may be considered for future school years.

These solutions relate to this study as proposed measures for preparing BPB staff and volunteers in effectively servicing any and all schools with high food insecurity levels, regardless of education level, in future school years. Also, recall that all best-fit linear regression models chosen in this study had one predictor in common: *PctLowInc*. Thus, general ideas of food insecurity need throughout the Guilford County school system can be gathered each year by monitoring *PctLowInc* numbers. This data can be found on the website of the North Carolina State Board of Education Department of Public Instruction under the "Title I Schools Information" subheading (http://www.ncpublicschools.org/program-monitoring/titleIA/). Although these data sets are listed as "Title I Schools Information", all schools are listed, not just schools receiving Title I federal funds. This data set contains all schools in the state of North Carolina, so data rows containing schools outside the BPB service area can be deleted. The remaining data can then be custom-sorted from largest to smallest by the "% Low Income Students" column. Thus, if full data compilation and full linear regression analysis are unavailable for the most recent school year, this is the next-best recommendation for staying aware of school food insecurity needs throughout the district.

5.2 Conclusion

In conclusion, BackPack Beginnings seeks to solve the problem of child food insecurity in Guilford County, North Carolina through the Food BackPack program. Disadvantages and consequences of child food insecurity, as discovered through prior research studies, were explored. Data from the Guilford County Schools district office website and from the North Carolina State Board of Education Department of Public Instruction website were collected and consolidated. Simple and multiple linear regression methods were used to express trends from this data as mathematical models, which could then be used for prediction analysis. It was

determined that *PctLowInc* was the most relevant variable needed to predict scores for 2016-2017 and 2017-2018 data, and *RurUrb* and *PctLowInc* were the most important predictors for Combined data. Once ordered lists of predicted scores were generated, feasible solutions were suggested to BackPack Beginnings to help maximize the impact of their community outreach. These solutions included student participation in focus groups and end-of-school-year FBP program evaluations, strengthened relationships with school administrators, especially school social workers, and periodic data monitoring.

5.3 Further Research

Additional research is necessary to provide more insight and perspective to this topic. First, further research can be done to find out other food assistance programs that are also offered in potential BPB expansion schools. This is an important factor because food assistance programs provided by other local agencies decrease the need for BPB services at those schools. Thorough knowledge about other food assistance programs allows BPB resources to be more strategically placed throughout Guilford County.

Also, there may be other nonlinear regression methods that are more appropriate to use for modeling these data sets. Perhaps the best linear regression models could be compared with the best nonlinear regression models for prediction accuracy.

Finally, visualization methods could be used to show priority regions. A heat map of Guilford County could take county food deserts into consideration when assigning ranks to schools. Further research with data visualization can give a more holistic view of the child food insecurity situation in the county.

These are just a few suggestions on more detailed research and analysis possibilities. The future expansion of BackPack Beginnings has the potential to make a great impact on the county, and further research will greatly benefit food insecure children in Guilford County.

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Appendix

Table A.1

Data Set, 2016-2017 School Year, Guilford County Schools

(Internal BackPack Beginnings Data Not Included)

School	Level	Enrollment	FreeLunch	ReducedLunch	PctEDS	PctSevAbs
Parkview Village Elementary [Elementary]	1	365	344	0	0.9425	0.031073446
Clara J Peck Elementary [Elementary]	1	379	301	0	0.7942	0.034700315
Rankin Elementary [Elementary]	1	829	698	0	0.8420	0.01980198
W M Hampton Elementary [Elementary]	1	353	301	0	0.8527	0.025974026
Oak Hill Elementary [Elementary]	1	489	465	0	0.9509	0.023206751
Wiley Acel/Enrichment [Elementary]	1	341	301	0	0.8827	0.084415584
Irving Park Elementary [Elementary]	1	651	583	0	0.8955	0.015075377
Ceasar Cone Elementary [Elementary]	1	517	446	0	0.8627	0.032679739
Gillespie Park Elementary [Elementary]	1	268	240	0	0.8955	0.055555556
Montlieu Avenue Elementary [Elementary]	1	690	685	0	0.9928	0.024495677
Northwood Elementary [Elementary]	1	637	556	0	0.8728	0.046931408
Johnson Street Elementary [Elementary]	1	444	444	0	1.0000	0
David D Jones Elementary [Elementary]	1	716	672	0	0.9385	0.038632987
Peeler Open Elementary [Elementary]	1	338	321	0	0.9497	0.015873016
Washington Elementary [Elementary]	1	393	345	0	0.8779	0.066666667
Union Hill Elementary [Elementary]	1	538	499	0	0.9275	0.03187251
Jefferson Elementary [Elementary]	1	667	665	0	0.9970	0.007473842
Sternberger Elementary [Elementary]	1	381	69	20	0.2336	0
Sumner Elementary [Elementary]	1	651	616	0	0.9462	0.017886179
Jesse Wharton Elem [Elementary]	1	490	140	23	0.3327	0.004106776
The Academy at Smith [High]	3	210	113	29	0.6762	0.009803922
Alamance Elementary [Elementary]	1	515	161	37	0.3845	0.012396694
Edwin A Alderman Elementary [Elementary]	1	440	408	0	0.9273	0.004878049
Allen Jay Elementary [Elementary]	1	425	425	0	1.0000	0.018223235
Allen Jay Middle - A Preparatory Academy [Middle]	2	291	289	2	1.0000	0
Allen Middle [Middle]	2	662	645	0	0.9743	0.052790347
T Wingate Andrews High [High]	3	853	829	0	0.9719	0.094545455
Archer Elementary [Elementary]	1	425	415	0	0.9765	0.016990291
Bessemer Elementary [Elementary]	1	526	457	0	0.8688	0.076233184
Bluford Elementary [Elementary]	1	290	280	0	0.9655	0.017667845
Brightwood Elementary [Elementary]	1	635	556	0	0.8756	0.028828829

School	PctModAbs	PctMildAbs	PctNotChronAbs	RurUrb	PctAsian
Parkview Village Elementary [Elementary]	0.036723164	0.115819209	0.816384181	1	0.041
Clara J Peck Elementary [Elementary]	0.044164038	0.110410095	0.810725552	1	0.083
Rankin Elementary [Elementary]	0.02970297	0.080622348	0.869872702	1	0.141
W M Hampton Elementary [Elementary]	0.048701299	0.103896104	0.821428571	1	0.057
Oak Hill Elementary [Elementary]	0.023206751	0.103375527	0.85021097	1	0.113
Wiley Acel/Enrichment [Elementary]	0.090909091	0.191558442	0.633116883	1	0
Irving Park Elementary [Elementary]	0.016750419	0.075376884	0.89279732	1	0.118
Ceasar Cone Elementary [Elementary]	0.05664488	0.124183007	0.786492375	1	0.062
Gillespie Park Elementary [Elementary]	0.047008547	0.153846154	0.743589744	1	0.004
Montlieu Avenue Elementary [Elementary]	0.025936599	0.095100865	0.854466859	1	0.047
Northwood Elementary [Elementary]	0.039711191	0.104693141	0.80866426	1	0.114
Johnson Street Elementary [Elementary]	0.066666667	0.1	0.833333333	1	0.076
David D Jones Elementary [Elementary]	0.02526003	0.052005944	0.88410104	1	0
Peeler Open Elementary [Elementary]	0.034920635	0.085714286	0.863492063	1	0
Washington Elementary [Elementary]	0.133333333	0.177777778	0.622222222	1	0.009
Union Hill Elementary [Elementary]	0.035856574	0.099601594	0.832669323	1	0.128
Jefferson Elementary [Elementary]	0.020926756	0.064275037	0.907324365	1	0.05
Sternberger Elementary [Elementary]	0.010282776	0.023136247	0.966580977	1	0.031
Sumner Elementary [Elementary]	0.032520325	0.069918699	0.879674797	0	0.011
Jesse Wharton Elem [Elementary]	0.022587269	0.069815195	0.90349076	1	0.061
The Academy at Smith [High]	0.009803922	0.039215686	0.941176471	1	0.189
Alamance Elementary [Elementary]	0.022727273	0.076446281	0.888429752	1	0.031
Edwin A Alderman Elementary [Elementary]	0.012195122	0.06097561	0.92195122	1	0.06
Allen Jay Elementary [Elementary]	0.036446469	0.116173121	0.829157175	0	0.283
Allen Jay Middle - A Preparatory Academy [Middle]	0	0.142857143	0.857142857	1	0.03
Allen Middle [Middle]	0.036199095	0.09653092	0.814479638	1	0.109
T Wingate Andrews High [High]	0.048484848	0.116363636	0.740606061	1	0.042
Archer Elementary [Elementary]	0.029126214	0.109223301	0.844660194	1	0.193
Bessemer Elementary [Elementary]	0.085201794	0.132286996	0.706278027	1	0.013
Bluford Elementary [Elementary]	0.035335689	0.106007067	0.840989399	1	0.011
Brightwood Elementary [Elementary]	0.023423423	0.106306306	0.841441441	1	0.017

School	PctHispanic	PctBlack	PctWhite	PctOther	TitleI_NoYes	NumLowInc	PctLowInc
Parkview Village Elementary [Elementary]	0.15	0.739	0.047	0.023	1	272	0.7452
Clara J Peck Elementary [Elementary]	0.328	0.445	0.1	0.045	1	279	0.7361
Rankin Elementary [Elementary]	0.276	0.506	0.052	0.026	1	502	0.6055
W M Hampton Elementary [Elementary]	0.14	0.78	0.017	0.007	1	255	0.7224
Oak Hill Elementary [Elementary]	0.452	0.305	0.109	0.021	1	298	0.6094
Wiley Acel/Enrichment [Elementary]	0.123	0.827	0.02	0.03	1	270	0.7918
Irving Park Elementary [Elementary]	0.125	0.438	0.268	0.052	1	304	0.467
Ceasar Cone Elementary [Elementary]	0.127	0.772	0.021	0.018	1	384	0.7427
Gillespie Park Elementary [Elementary]	0.148	0.779	0.029	0.041	1	203	0.7575
Montlieu Avenue Elementary [Elementary]	0.141	0.712	0.076	0.025	1	401	0.5812
Northwood Elementary [Elementary]	0.294	0.42	0.135	0.037	1	389	0.6107
Johnson Street Elementary [Elementary]	0.239	0.496	0.158	0.031	1	225	0.5068
David D Jones Elementary [Elementary]	0.149	0.57	0.249	0.031	0	273	0.3813
Peeler Open Elementary [Elementary]	0.127	0.717	0.115	0.04	1	176	0.5207
Washington Elementary [Elementary]	0.049	0.879	0.026	0.038	1	252	0.6412
Union Hill Elementary [Elementary]	0.174	0.593	0.06	0.046	1	337	0.6264
Jefferson Elementary [Elementary]	0.18	0.437	0.274	0.058	0	255	0.3823
Sternberger Elementary [Elementary]	0.043	0.13	0.77	0.026	0	47	0.1234
Sumner Elementary [Elementary]	0.367	0.498	0.085	0.039	1	363	0.5576
Jesse Wharton Elem [Elementary]	0.105	0.251	0.53	0.053	0	126	0.2571
The Academy at Smith [High]	0.184	0.553	0.029	0.044	0	59	0.281
Alamance Elementary [Elementary]	0.072	0.202	0.628	0.067	0	140	0.2718
Edwin A Alderman Elementary [Elementary]	0.381	0.376	0.149	0.035	1	219	0.4977
Allen Jay Elementary [Elementary]	0.252	0.229	0.212	0.024	1	228	0.5365
Allen Jay Middle - A Preparatory Academy [Middle]	0.106	0.592	0.228	0.043	1	130	0.4467
Allen Middle [Middle]	0.306	0.508	0.027	0.05	1	354	0.5347
T Wingate Andrews High [High]	0.1	0.726	0.086	0.047	1	475	0.5569
Archer Elementary [Elementary]	0.286	0.449	0.026	0.045	1	226	0.5318
Bessemer Elementary [Elementary]	0.235	0.683	0.036	0.034	1	377	0.7167
Bluford Elementary [Elementary]	0.112	0.846	0.011	0.021	1	188	0.6483
Brightwood Elementary [Elementary]	0.184	0.702	0.063	0.035	1	342	0.5386

School	Level	Enrollment	FreeLunch	ReducedLunch	PctEDS
Brooks Global [Elementary]	1	409	131	29	0.3912
Brown Summit Middle [Middle]	2	238	20	20	0.1681
(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	4	79	79	0	1.0000
Claxton Elementary [Elementary]	1	609	179	36	0.3530
Colfax Elementary [Elementary]	1	637	191	35	0.3548
Dudley High [High]	3	1371	1,336	12	0.9832
Early College at Guilford [High]	3	196	0	0	0.0000
Eastern Guilford High [High]	3	1143	638	70	0.6194
Eastern Middle [Middle]	2	901	901	0	1.0000
Erwin Montessori [Elementary]	1	335	170	34	0.6090
Fairview Elementary [Elementary]	1	439	389	0	0.8861
Waldo C Falkener Sr Elementary [Elementary]	1	564	548	0	0.9716
Ferndale Middle [Middle]	2	745	664	0	0.8913
Florence Elementary [Elementary]	1	698	225	56	0.4026
Julius I Foust Elementary [Elementary]	1	369	337	0	0.9133
Cyrus P Frazier Elementary [Elementary]	1	319	316	0	0.9906
Gateway Education Center [Alternative]	4	146	47	11	0.3973
General Greene Elementary [Elementary]	1	504	151	26	0.3512
Gibsonville Elementary [Elementary]	1	486	231	45	0.5679
Grimsley High [High]	3	1687	598	49	0.3835
Guilford Elementary [Elementary]	1	630	528	0	0.8381
Otis L Hairston Sr Middle [Middle]	2	657	651	3	0.9954
Meredith Haynes-Inman School [Alternative]	4	139	73	4	0.5540
Herbin-Metz Education Center [Alternative]	4	71	36	20	0.7887
High Point Central High [High]	3	1401	823	57	0.6281
Hunter Elementary [Elementary]	1	515	462	0	0.8971
Jackson Middle [Middle]	2	492	476	0	0.9675
Jamestown Elementary [Elementary]	1	437	414	0	0.9474
Jamestown Middle [Middle]	2	1057	552	86	0.6036
James Y Joyner Elementary [Elementary]	1	305	293	0	0.9607
The Kearns Academy at High Point Central [High]	3	140	130	0	0.9286
Kernodle Middle [Middle]	2	759	152	43	0.2569
Kirkman Park Elementary [Elementary]	1	316	275	0	0.8703
Kiser Middle [Middle]	2	774	450	25	0.6137
Lincoln Academy [Middle]	2	673	275	33	0.4577
John Van Lindley Elementary [Elementary]	1	523	281	22	0.5793
Madison Elementary [Elementary]	1	227	151	20	0.7533
Middle College High at Bennett [High]	3	104	98	1	0.9519
Middle College High at Greensboro College [High]	3	117	5	3	0.0684
GTCC East Middle College High [High]	3	117	44	20	0.5470
High Point GTCC Middle College [High]	3	118	62	20	0.6949
GTCC Middle College High [High]	3	172	61	20	0.4709
Middle College High at NC A&T [High]	3	110	52	20	0.6545

School	PctSevAbs	PctModAbs	PctMildAbs
Brooks Global [Elementary]	0	0	0
Brown Summit Middle [Middle]	0	0	0.008403361
(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	0.081395349	0.011627907	0.034883721
Claxton Elementary [Elementary]	0.010186757	0.020373514	0.054329372
Colfax Elementary [Elementary]	0.003305785	0.018181818	0.079338843
Dudley High [High]	0.154138193	0.077448747	0.107820805
Early College at Guilford [High]	0	0	0
Eastern Guilford High [High]	0.070458404	0.044991511	0.100169779
Eastern Middle [Middle]	0.02991453	0.037393162	0.080128205
Erwin Montessori [Elementary]	0	0.011764706	0.019607843
Fairview Elementary [Elementary]	0.031331593	0.039164491	0.107049608
Waldo C Falkener Sr Elementary [Elementary]	0.066543438	0.036968577	0.105360444
Ferndale Middle [Middle]	0.037593985	0.058646617	0.105263158
Florence Elementary [Elementary]	0.014492754	0.01884058	0.062318841
Julius I Foust Elementary [Elementary]	0.040816327	0.029154519	0.093294461
Cyrus P Frazier Elementary [Elementary]	0.018691589	0.043613707	0.07165109
Gateway Education Center [Alternative]	0.224137931	0.068965517	0.103448276
General Greene Elementary [Elementary]	0.002024291	0.006072874	0.052631579
Gibsonville Elementary [Elementary]	0.008	0.014	0.076
Grimsley High [High]	0.059802713	0.038224414	0.081381011
Guilford Elementary [Elementary]	0.020637899	0.015009381	0.084427767
Otis L Hairston Sr Middle [Middle]	0.080314961	0.047244094	0.148031496
Meredith Haynes-Inman School [Alternative]	0.166666667	0.097222222	0.208333333
Herbin-Metz Education Center [Alternative]	0.044776119	0.074626866	0.149253731
High Point Central High [High]	0.14785142	0.056809905	0.113619811
Hunter Elementary [Elementary]	0.00877193	0.026315789	0.111842105
Jackson Middle [Middle]	0.103448276	0.056034483	0.142241379
Jamestown Elementary [Elementary]	0.028846154	0.03125	0.084134615
Jamestown Middle [Middle]	0.03946102	0.032723773	0.080846968
James Y Joyner Elementary [Elementary]	0.029315961	0.045602606	0.078175896
The Kearns Academy at High Point Central [High]	0.007633588	0.007633588	0.030534351
Kernodle Middle [Middle]	0.01285347	0.019280206	0.075835476
Kirkman Park Elementary [Elementary]	0.032142857	0.05	0.114285714
Kiser Middle [Middle]	0.051470588	0.040441176	0.099264706
Lincoln Academy [Middle]	0.010130246	0.011577424	0.037626628
John Van Lindley Elementary [Elementary]	0.020242915	0.028340081	0.078947368
Madison Elementary [Elementary]	0.004405286	0.035242291	0.079295154
Middle College High at Bennett [High]	0	0	0.12371134
Middle College High at Greensboro College [High]	0.017	0	0.069
GTCC East Middle College High [High]	0	0	0.016528926
High Point GTCC Middle College [High]	0	0.045801527	0.038167939
GTCC Middle College High [High]	0.005076142	0.010152284	0.010152284
Middle College High at NC A&T [High]	0.008130081	0.016260163	0.040650407

School	PctNotChronAbs	RurUrb	PctAsian	PctHispanic	PctBlack
Brooks Global [Elementary]	1	1	0.046	0.062	0.487
Brown Summit Middle [Middle]	0.991596639	0	0.029	0.041	0.165
(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	0.872093023	1	0.035	0.094	0.435
Claxton Elementary [Elementary]	0.915110357	1	0.076	0.067	0.255
Colfax Elementary [Elementary]	0.899173554	0	0.078	0.121	0.174
Dudley High [High]	0.660592255	1	0.026	0.096	0.832
Early College at Guilford [High]	1	1	0.427	0.035	0.075
Eastern Guilford High [High]	0.784380306	0	0.055	0.146	0.483
Eastern Middle [Middle]	0.852564103	0	0.054	0.16	0.45
Erwin Montessori [Elementary]	0.968627451	1	0.011	0.116	0.775
Fairview Elementary [Elementary]	0.822454308	1	0.084	0.228	0.606
Waldo C Falkener Sr Elementary [Elementary]	0.791127542	1	0.074	0.193	0.692
Ferndale Middle [Middle]	0.798496241	1	0.135	0.215	0.37
Florence Elementary [Elementary]	0.904347826	1	0.136	0.108	0.3
Julius I Foust Elementary [Elementary]	0.836734694	1	0.024	0.347	0.562
Cyrus P Frazier Elementary [Elementary]	0.866043614	1	0.109	0.27	0.559
Gateway Education Center [Alternative]	0.603448276	1	0.086	0.103	0.448
General Greene Elementary [Elementary]	0.939271255	1	0.018	0.072	0.311
Gibsonville Elementary [Elementary]	0.902	1	0.014	0.122	0.242
Grimsley High [High]	0.820591862	1	0.04	0.074	0.361
Guilford Elementary [Elementary]	0.879924953	1	0.017	0.21	0.561
Otis L Hairston Sr Middle [Middle]	0.724409449	1	0.056	0.18	0.728
Meredith Haynes-Inman School [Alternative]	0.527777778	0	0.053	0.147	0.307
Herbin-Metz Education Center [Alternative]	0.731343284	1	0.121	0.076	0.53
High Point Central High [High]	0.681718864	1	0.109	0.18	0.381
Hunter Elementary [Elementary]	0.853070175	1	0.033	0.482	0.374
Jackson Middle [Middle]	0.698275862	1	0.051	0.329	0.536
Jamestown Elementary [Elementary]	0.855769231	1	0.089	0.123	0.478
Jamestown Middle [Middle]	0.846968239	0	0.093	0.134	0.401
James Y Joyner Elementary [Elementary]	0.846905537	1	0.056	0.172	0.488
The Kearns Academy at High Point Central [High]	0.954198473	1	0.069	0.267	0.427
Kernodle Middle [Middle]	0.892030848	1	0.091	0.067	0.174
Kirkman Park Elementary [Elementary]	0.803571429	1	0.033	0.187	0.634
Kiser Middle [Middle]	0.808823529	1	0.022	0.103	0.398
Lincoln Academy [Middle]	0.940665702	1	0.141	0.069	0.476
John Van Lindley Elementary [Elementary]	0.872469636	1	0.016	0.166	0.271
Madison Elementary [Elementary]	0.881057269	0	0.014	0.114	0.405
Middle College High at Bennett [High]	0.87628866	1	0.01	0.069	0.871
Middle College High at Greensboro College [High]	0.914	1	0.033	0.042	0.467
GTCC East Middle College High [High]	0.983471074	1	0.043	0.112	0.586
High Point GTCC Middle College [High]	0.916030534	1	0.069	0.207	0.345
GTCC Middle College High [High]	0.974619289	1	0.082	0.132	0.319
Middle College High at NC A&T [High]	0.93495935	1	0	0.033	0.919

School	PctWhite	PctOther	TitleI_NoYes	NumLowInc	PctLowInc
Brooks Global [Elementary]	0.338	0.067	0	101	0.2469
Brown Summit Middle [Middle]	0.728	0.037	0	11	0.0462
(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	0.4	0.035	0	25	0.3165
Claxton Elementary [Elementary]	0.524	0.078	0	133	0.2184
Colfax Elementary [Elementary]	0.593	0.035	0	147	0.2308
Dudley High [High]	0.016	0.03	1	777	0.5667
Early College at Guilford [High]	0.432	0.03	0	9	0.0459
Eastern Guilford High [High]	0.266	0.05	0	444	0.3885
Eastern Middle [Middle]	0.282	0.053	1	374	0.4151
Erwin Montessori [Elementary]	0.079	0.019	1	138	0.4119
Fairview Elementary [Elementary]	0.054	0.028	1	313	0.713
Waldo C Falkener Sr Elementary [Elementary]	0.02	0.022	1	399	0.7074
Ferndale Middle [Middle]	0.238	0.041	1	400	0.5369
Florence Elementary [Elementary]	0.396	0.06	0	144	0.2063
Julius I Foust Elementary [Elementary]	0.024	0.042	1	230	0.6233
Cyrus P Frazier Elementary [Elementary]	0.03	0.033	1	176	0.5517
Gateway Education Center [Alternative]	0.345	0.017	0	61	0.4178
General Greene Elementary [Elementary]	0.542	0.056	0	114	0.2262
Gibsonville Elementary [Elementary]	0.573	0.05	0	171	0.3519
Grimsley High [High]	0.485	0.041	0	494	0.2928
Guilford Elementary [Elementary]	0.163	0.049	1	284	0.4508
Otis L Hairston Sr Middle [Middle]	0.018	0.018	1	471	0.7169
Meredith Haynes-Inman School [Alternative]	0.44	0.053	0	52	0.3741
Herbin-Metz Education Center [Alternative]	0.273	0	0	30	0.4225
High Point Central High [High]	0.288	0.042	1	644	0.4597
Hunter Elementary [Elementary]	0.075	0.035	1	320	0.6214
Jackson Middle [Middle]	0.037	0.047	1	339	0.689
Jamestown Elementary [Elementary]	0.254	0.056	1	192	0.4394
Jamestown Middle [Middle]	0.306	0.065	0	374	0.3538
James Y Joyner Elementary [Elementary]	0.242	0.042	1	154	0.5049
The Kearns Academy at High Point Central [High]	0.183	0.053	0	54	0.3857
Kernodle Middle [Middle]	0.605	0.063	0	102	0.1344
Kirkman Park Elementary [Elementary]	0.117	0.029	1	228	0.7215
Kiser Middle [Middle]	0.431	0.046	1	356	0.4599
Lincoln Academy [Middle]	0.263	0.051	0	186	0.2764
John Van Lindley Elementary [Elementary]	0.497	0.051	1	235	0.4493
Madison Elementary [Elementary]	0.4	0.068	1	99	0.4361
Middle College High at Bennett [High]	0.01	0.04	0	32	0.3077
Middle College High at Greensboro College [High]	0.4	0.058	0	22	0.188
GTCC East Middle College High [High]	0.19	0.069	0	32	0.2735
High Point GTCC Middle College [High]	0.302	0.078	1	50	0.4237
GTCC Middle College High [High]	0.401	0.066	0	39	0.2267
Middle College High at NC A&T [High]	0.008	0.041	0	36	0.3273

School	Level	Enrollment	FreeLunch	ReducedLunch	PctEDS	PctSevAbs	PctModAbs
UNC-G Early/Middle College [High]	3	199	66	20	0.4322	0.005128205	0
McLeansville Elementary [Elementary]	1	387	316	0	0.8165	0.025889968	0.01618123
Ronald E McNair Elementary [Elementary]	1	589	548	0	0.9304	0.014732965	0.02946593
Mendenhall Middle [Middle]	2	738	341	47	0.5257	0.028416779	0.031123139
Millis Road Elementary [Elementary]	1	492	171	32	0.4126	0.006880734	0.01146789
Monticello-Brown Summit Elem [Elementary]	1	417	238	34	0.6523	0.037234043	0.053191489
Morehead Elementary [Elementary]	1	624	377	56	0.6939	0.004694836	0.015649452
Murphey Traditional Academy [Elementary]	1	313	303	0	0.9681	0.012944984	0.012944984
Nathanael Greene Elementary [Elementary]	1	252	101	21	0.4841	0.0234375	0.03515625
Newcomers School [Alternative]	4	304	304	0	1.0000	0.030364372	0.032388664
Northeast Guilford High [High]	3	1043	661	80	0.7105	0.124401914	0.077511962
Northeast Guilford Middle [Middle]	2	725	546	64	0.8414	0.043766578	0.055702918
Northern Elementary [Elementary]	1	602	73	20	0.1545	0.004975124	0.009950249
Northern High [High]	3	1339	211	31	0.1807	0.045685279	0.036983321
Northern Middle [Middle]	2	866	176	26	0.2333	0.018779343	0.028169014
Northwest Guilford High [High]	3	2027	224	51	0.1357	0.034968431	0.033025741
Northwest Guilford Middle [Middle]	2	983	105	34	0.1414	0.010496183	0.022900763
Oak Ridge Elementary [Elementary]	1	768	57	20	0.1003	0	0.010899183
Oak View Elementary [Elementary]	1	523	499	0	0.9541	0.011904762	0.037698413
Page High [High]	3	1930	825	96	0.4772	0.059183673	0.051530612
Pearce Elementary [Elementary]	1	709	131	29	0.2257	0.006756757	0.008108108
Penn-Griffin Middle [Middle]	2	629	317	43	0.5723	0.028169014	0.033450704
Pilot Elementary [Elementary]	1	721	327	52	0.5257	0.013824885	0.019969278
Pleasant Garden Elementary [Elementary]	1	488	189	35	0.4590	0.020179372	0.035874439
Scale in High Point (Pruette Scale) [Alternative]	4	46	25	0	0.5435	0.454545455	0.136363636
Lucy Ragsdale High [High]	3	1493	656	89	0.4990	0.051771117	0.051771117
Reedy Fork Elementary [Elementary]	1	435	299	29	0.7540	0.032663317	0.010050251
Scale School [Alternative]	4	64	42	0	0.6563	0.538461538	0.08974359
Sedalia Elementary [Elementary]	1	496	253	49	0.6089	0.055555556	0.043981481
Sedgefield Elementary [Elementary]	1	556	478	0	0.8597	0.021231423	0.023354565
Shadybrook Elementary [Elementary]	1	475	247	25	0.5726	0.020642202	0.029816514
George C. Simkins, Jr Elementary [Elementary]	1	520	309	48	0.6865	0.018595041	0.022727273
Ben L Smith High [High]	3	1264	1,228	18	0.9858	0.145107794	0.06384743
Southeast Guilford High [High]	3	1365	376	91	0.3421	0.060909792	0.050115652
Southeast Guilford Middle [Middle]	2	948	339	82	0.4441	0.016824395	0.022082019
Southern Elementary [Elementary]	1	322	183	41	0.6957	0.022292994	0.031847134
Southern Guilford High [High]	3	1099	644	121	0.6961	0.054702495	0.039347409
Southern Middle [Middle]	2	726	726	0	1.0000	0.037292818	0.04281768
Southwest Elementary [Elementary]	1	819	132	61	0.2357	0	0.008130081
Southwest Guilford High [High]	3	1516	520	88	0.4011	0.05098789	0.019757808
Southwest Guilford Middle [Middle]	2	1096	412	69	0.4389	0.022401434	0.02688172
STEM Early College at NC A&T SU [High]	3	190	35	20	0.2895	0	0
Stokesdale Elementary [Elementary]	1	490	114	20	0.2735	0.003921569	0.015686275

School	PctMildAbs	PctNotChronAbs	RurUrb	PctAsian	PctHispanic
UNC-G Early/Middle College [High]	0.01025641	0.984615385	1	0.109	0.134
McLeansville Elementary [Elementary]	0.058252427	0.899676375	0	0.022	0.189
Ronald E McNair Elementary [Elementary]	0.062615101	0.893186004	1	0.116	0.136
Mendenhall Middle [Middle]	0.106901218	0.833558863	1	0.056	0.113
Millis Road Elementary [Elementary]	0.059633028	0.922018349	1	0.096	0.089
Monticello-Brown Summit Elem [Elementary]	0.135638298	0.77393617	0	0.005	0.197
Morehead Elementary [Elementary]	0.045383412	0.9342723	1	0.015	0.152
Murphey Traditional Academy [Elementary]	0.080906149	0.893203883	1	0.06	0.274
Nathanael Greene Elementary [Elementary]	0.10546875	0.8359375	0	0.004	0.066
Newcomers School [Alternative]	0.093117409	0.844129555	1	0.149	0.419
Northeast Guilford High [High]	0.133971292	0.664114833	0	0.007	0.137
Northeast Guilford Middle [Middle]	0.100795756	0.799734748	0	0.013	0.183
Northern Elementary [Elementary]	0.03814262	0.946932007	0	0.01	0.066
Northern High [High]	0.083393764	0.833937636	0	0.014	0.067
Northern Middle [Middle]	0.072769953	0.88028169	0	0.019	0.087
Northwest Guilford High [High]	0.083050024	0.848955804	1	0.05	0.058
Northwest Guilford Middle [Middle]	0.079198473	0.88740458	1	0.057	0.061
Oak Ridge Elementary [Elementary]	0.035422343	0.953678474	1	0.106	0.059
Oak View Elementary [Elementary]	0.109126984	0.841269841	1	0.079	0.218
Page High [High]	0.098979592	0.790306122	1	0.072	0.088
Pearce Elementary [Elementary]	0.063513514	0.921621622	1	0.077	0.092
Penn-Griffin Middle [Middle]	0.086267606	0.852112676	1	0.028	0.213
Pilot Elementary [Elementary]	0.075268817	0.89093702	1	0.105	0.139
Pleasant Garden Elementary [Elementary]	0.073991031	0.869955157	0	0.024	0.064
Scale in High Point (Pruette Scale) [Alternative]	0.136363636	0.272727273	1	0.143	0
Lucy Ragsdale High [High]	0.119209809	0.777247956	1	0.103	0.121
Reedy Fork Elementary [Elementary]	0.100502513	0.85678392	0	0.04	0.316
Scale School [Alternative]	0.153846154	0.217948718	1	0	0
Sedalia Elementary [Elementary]	0.113425926	0.787037037	0	0.019	0.112
Sedgefield Elementary [Elementary]	0.076433121	0.878980892	1	0.117	0.506
Shadybrook Elementary [Elementary]	0.048165138	0.901376147	1	0.071	0.163
George C. Simkins, Jr Elementary [Elementary]	0.084710744	0.873966942	1	0.026	0.206
Ben L Smith High [High]	0.116086235	0.674958541	1	0.077	0.284
Southeast Guilford High [High]	0.109483423	0.779491133	1	0.016	0.052
Southeast Guilford Middle [Middle]	0.099894848	0.861198738	1	0.015	0.091
Southern Elementary [Elementary]	0.108280255	0.837579618	0	0.013	0.287
Southern Guilford High [High]	0.07293666	0.833013436	0	0.088	0.245
Southern Middle [Middle]	0.132596685	0.787292818	0	0.079	0.279
Southwest Elementary [Elementary]	0.054587689	0.93728223	1	0.169	0.093
Southwest Guilford High [High]	0.056724028	0.872530274	1	0.105	0.091
Southwest Guilford Middle [Middle]	0.080645161	0.870071685	1	0.092	0.088
STEM Early College at NC A&T SU [High]	0.011235955	0.988764045	1	0.24	0.073
Stokesdale Elementary [Elementary]	0.088235294	0.892156863	0	0.024	0.09

School	PctBlack	PctWhite	PctOther	itleI_NoYe	NumLowInc	PctLowInc
UNC-G Early/Middle College [High]	0.426	0.282	0.05	0	40	0.201
McLeansville Elementary [Elementary]	0.327	0.421	0.041	0	148	0.3824
Ronald E McNair Elementary [Elementary]	0.633	0.079	0.037	1	282	0.4788
Mendenhall Middle [Middle]	0.403	0.374	0.054	0	257	0.3482
Millis Road Elementary [Elementary]	0.236	0.525	0.053	0	128	0.2602
Monticello-Brown Summit Elem [Elementary]	0.173	0.555	0.069	1	194	0.4652
Morehead Elementary [Elementary]	0.48	0.311	0.041	1	297	0.476
Murphey Traditional Academy [Elementary]	0.595	0.033	0.037	1	206	0.6581
Nathanael Greene Elementary [Elementary]	0.023	0.871	0.035	0	83	0.3294
Newcomers School [Alternative]	0.301	0.132	0	1	201	0.6612
Northeast Guilford High [High]	0.544	0.245	0.066	1	438	0.4199
Northeast Guilford Middle [Middle]	0.513	0.243	0.048	1	363	0.5007
Northern Elementary [Elementary]	0.086	0.785	0.053	0	69	0.1146
Northern High [High]	0.171	0.705	0.042	0	165	0.1232
Northern Middle [Middle]	0.196	0.65	0.048	0	120	0.1386
Northwest Guilford High [High]	0.072	0.791	0.029	0	135	0.0666
Northwest Guilford Middle [Middle]	0.052	0.793	0.037	0	73	0.0743
Oak Ridge Elementary [Elementary]	0.03	0.757	0.048	0	33	0.043
Oak View Elementary [Elementary]	0.436	0.208	0.059	1	252	0.4818
Page High [High]	0.404	0.395	0.042	0	609	0.3155
Pearce Elementary [Elementary]	0.096	0.686	0.049	0	92	0.1298
Penn-Griffin Middle [Middle]	0.442	0.26	0.057	1	264	0.4197
Pilot Elementary [Elementary]	0.361	0.339	0.056	0	276	0.3828
Pleasant Garden Elementary [Elementary]	0.126	0.735	0.051	0	145	0.2971
Scale in High Point (Pruette Scale) [Alternative]	0.857	0	0	0	30	0.6522
Lucy Ragsdale High [High]	0.378	0.344	0.053	0	463	0.3101
Reedy Fork Elementary [Elementary]	0.444	0.144	0.056	1	209	0.4805
Scale School [Alternative]	0.933	0.067	0	0	48	0.75
Sedalia Elementary [Elementary]	0.365	0.422	0.082	0	183	0.369
Sedgefield Elementary [Elementary]	0.317	0.038	0.021	1	334	0.6007
Shadybrook Elementary [Elementary]	0.323	0.389	0.054	0	152	0.32
George C. Simkins, Jr Elementary [Elementary]	0.596	0.123	0.049	1	213	0.4096
Ben L Smith High [High]	0.566	0.035	0.038	1	676	0.5348
Southeast Guilford High [High]	0.282	0.598	0.052	0	283	0.2073
Southeast Guilford Middle [Middle]	0.265	0.57	0.059	0	246	0.2595
Southern Elementary [Elementary]	0.052	0.58	0.068	0	128	0.3975
Southern Guilford High [High]	0.395	0.23	0.042	0	435	0.3958
Southern Middle [Middle]	0.354	0.229	0.06	1	322	0.4435
Southwest Elementary [Elementary]	0.176	0.517	0.045	0	84	0.1026
Southwest Guilford High [High]	0.354	0.415	0.036	0	369	0.2434
Southwest Guilford Middle [Middle]	0.339	0.431	0.05	0	312	0.2847
STEM Early College at NC A&T SU [High]	0.425	0.207	0.056	0	25	0.1316
Stokesdale Elementary [Elementary]	0.048	0.81	0.028	0	77	0.1571

School	Level	Enrollment	FreeLunch	ReducedLunch	PctEDS
Summerfield Elementary [Elementary]	1	638	112	20	0.2069
Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	2	618	572	0	0.9256
Triangle Lake Montessori Elem [Elementary]	1	544	310	26	0.6176
Vandalia Elementary [Elementary]	1	302	238	0	0.7881
Philip J Weaver Ed Center [High]	3	248	41	20	0.2460
Laurin Welborn Middle [Middle]	2	394	394	0	1.0000
Western Guilford Middle [Middle]	2	650	398	46	0.6831
Western Guilford High [High]	3	1284	517	59	0.4486

School	PctSevAbs	PctModAbs	PctMildAbs
Summerfield Elementary [Elementary]	0.009160305	0.007633588	0.05648855
Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	0.050877193	0.031578947	0.064912281
Triangle Lake Montessori Elem [Elementary]	0.00877193	0.028508772	0.065789474
Vandalia Elementary [Elementary]	0.012448133	0.045643154	0.082987552
Philip J Weaver Ed Center [High]	0.003891051	0.031128405	0.081712062
Laurin Welborn Middle [Middle]	0.057142857	0.066666667	0.092857143
Western Guilford Middle [Middle]	0.015025042	0.033388982	0.085141903
Western Guilford High [High]	0.067193676	0.041106719	0.099604743

School	PctNotChronAbs	RurUrb	PctAsian	PctHispanic
Summerfield Elementary [Elementary]	0.926717557	1	0.074	0.132
Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	0.852631579	1	0.069	0.113
Triangle Lake Montessori Elem [Elementary]	0.896929825	0	0.087	0.114
Vandalia Elementary [Elementary]	0.858921162	1	0.029	0.124
Philip J Weaver Ed Center [High]	0.883268482	1	0.039	0.081
Laurin Welborn Middle [Middle]	0.783333333	1	0.047	0.186
Western Guilford Middle [Middle]	0.866444073	1	0.061	0.231
Western Guilford High [High]	0.792094862	1	0.036	0.162

School	PctBlack	PctWhite	PctOther	TitleI_NoYes	NumLowInc	PctLowInc
Summerfield Elementary [Elementary]	0.072	0.688	0.034	0	83	0.1301
Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	0.658	0.111	0.049	1	332	0.5372
Triangle Lake Montessori Elem [Elementary]	0.581	0.189	0.03	1	254	0.4669
Vandalia Elementary [Elementary]	0.739	0.054	0.054	1	159	0.5265
Philip J Weaver Ed Center [High]	0.197	0.618	0.066	0	24	0.0968
Laurin Welborn Middle [Middle]	0.656	0.073	0.038	1	244	0.6193
Western Guilford Middle [Middle]	0.484	0.179	0.046	1	304	0.4677
Western Guilford High [High]	0.42	0.326	0.056	0	361	0.2812

Table A.2

Full Data Set, 2017-2018 School Year, Guilford County Schools

(Internal BackPack Beginnings Data Not Included)

School	Level	Enrollment	FreeLunch	ReducedLunch	PctEDS
Wiley Acel/Enrichment [Elementary]	1	348	287	0	0.824712644
W M Hampton Elementary [Elementary]	1	347	291	0	0.838616715
Irving Park Elementary [Elementary]	1	609	563	0	0.924466338
Clara J Peck Elementary [Elementary]	1	354	265	0	0.748587571
Ceasar Cone Elementary [Elementary]	1	487	476	0	0.977412731
Johnson Street Elementary [Elementary]	1	446	446	0	1
Union Hill Elementary [Elementary]	1	535	535	0	1
Rankin Elementary [Elementary]	1	779	750	0	0.962772786
David D Jones Elementary [Elementary]	1	707	684	0	0.967468175
Montlieu Avenue Elementary [Elementary]	1	707	620	0	0.876944837
Oak Hill Elementary [Elementary]	1	495	452	0	0.913131313
Gillespie Park Elementary [Elementary]	1	264	237	0	0.897727273
Parkview Village Elementary [Elementary]	1	369	308	0	0.834688347
Northwood Elementary [Elementary]	1	593	530	0	0.89376054
Peeler Open Elementary [Elementary]	1	321	292	4	0.92211838
Washington Elementary [Elementary]	1	385	316	0	0.820779221
Shadybrook Elementary [Elementary]	1	457	221	28	0.544857768
Sumner Elementary [Elementary]	1	619	608	0	0.982229402
Jefferson Elementary [Elementary]	1	717	667	0	0.930264993
Sternberger Elementary [Elementary]	1	410	67	20	0.212195122
Jesse Wharton Elem [Elementary]	1	483	150	34	0.380952381
The Academy at Smith [High]	3	204	115	22	0.671568627
Alamance Elementary [Elementary]	1	506	160	40	0.395256917
Edwin A Alderman Elementary [Elementary]	1	448	414	0	0.924107143
Allen Jay Elementary [Elementary]	1	468	447	0	0.955128205
Allen Jay Middle - A Preparatory Academy [Middle]	2	390	376	10	0.98974359
Allen Middle [Middle]	2	657	657	0	1
T Wingate Andrews High [High]	3	824	727	0	0.882281553
Archer Elementary [Elementary]	1	427	412	0	0.964871194
Bessemer Elementary [Elementary]	1	495	424	0	0.856565657
Bluford Elementary [Elementary]	1	282	273	3	0.978723404
Brightwood Elementary [Elementary]	1	605	539	0	0.890909091
Brooks Global [Elementary]	1	412	106	39	0.351941748
Brown Summit Middle [Middle]	2	242	21	20	0.169421488
(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	4	84	83	1	1

School	PctSevAbs	PctModAbs	PctMildAbs	PctNotChronAbs
Wiley Acel/Enrichment [Elementary]	0.12	0.074	0.166	0.64
W M Hampton Elementary [Elementary]	0.029	0.043	0.133	0.795
Irving Park Elementary [Elementary]	0.01	0.012	0.084	0.893
Clara J Peck Elementary [Elementary]	0.022	0.04	0.088	0.85
Ceasar Cone Elementary [Elementary]	0.101	0.08	0.154	0.665
Johnson Street Elementary [Elementary]	0.015	0.036	0.082	0.868
Union Hill Elementary [Elementary]	0.02	0.02	0.099	0.861
Rankin Elementary [Elementary]	0.037	0.038	0.092	0.833
David D Jones Elementary [Elementary]	0.025	0.012	0.073	0.891
Montlieu Avenue Elementary [Elementary]	0.032	0.027	0.081	0.859
Oak Hill Elementary [Elementary]	0.018	0.013	0.097	0.872
Gillespie Park Elementary [Elementary]	0.075	0.042	0.096	0.788
Parkview Village Elementary [Elementary]	0.046	0.052	0.095	0.807
Northwood Elementary [Elementary]	0.036	0.074	0.123	0.768
Peeler Open Elementary [Elementary]	0.03	0.037	0.111	0.821
Washington Elementary [Elementary]	0.019	0.026	0.081	0.874
Shadybrook Elementary [Elementary]	0.005	0.032	0.086	0.877
Sumner Elementary [Elementary]	0.021	0.041	0.078	0.861
Jefferson Elementary [Elementary]	0.01	0.021	0.05	0.919
Sternberger Elementary [Elementary]	0.005	0.007	0.04	0.948
Jesse Wharton Elem [Elementary]	0	0.012	0.06	0.924
The Academy at Smith [High]	0.005	0.01	0.069	0.916
Alamance Elementary [Elementary]	0.017	0.028	0.063	0.892
Edwin A Alderman Elementary [Elementary]	0.014	0.014	0.07	0.902
Allen Jay Elementary [Elementary]	0.02	0.035	0.126	0.819
Allen Jay Middle - A Preparatory Academy [Middle]	0.008	0.01	0.037	0.945
Allen Middle [Middle]	0.036	0.03	0.084	0.85
T Wingate Andrews High [High]	0.183	0.101	0.173	0.543
Archer Elementary [Elementary]	0.005	0.024	0.041	0.93
Bessemer Elementary [Elementary]	0.074	0.067	0.134	0.725
Bluford Elementary [Elementary]	0.037	0.04	0.092	0.831
Brightwood Elementary [Elementary]	0.026	0.046	0.075	0.853
Brooks Global [Elementary]	0	0	0.028	0.969
Brown Summit Middle [Middle]	0	0.004	0.017	0.979
(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	0.071	0.024	0.107	0.798

School	RurUrb	PctAsian	PctHispanic	PctBlack	PctWhite
Wiley Acel/Enrichment [Elementary]	1	0.003	0.14	0.803	0.017
W M Hampton Elementary [Elementary]	1	0.054	0.168	0.751	0.017
Irving Park Elementary [Elementary]	1	0.111	0.146	0.42	0.272
Clara J Peck Elementary [Elementary]	1	0.089	0.339	0.467	0.054
Ceasar Cone Elementary [Elementary]	1	0.075	0.172	0.706	0.021
Johnson Street Elementary [Elementary]	1	0.071	0.264	0.499	0.127
Union Hill Elementary [Elementary]	1	0.137	0.157	0.589	0.063
Rankin Elementary [Elementary]	1	0.132	0.249	0.546	0.045
David D Jones Elementary [Elementary]	1	0	0.155	0.573	0.23
Montlieu Avenue Elementary [Elementary]	1	0.045	0.144	0.694	0.077
Oak Hill Elementary [Elementary]	1	0.129	0.415	0.347	0.092
Gillespie Park Elementary [Elementary]	1	0.004	0.145	0.795	0.017
Parkview Village Elementary [Elementary]	1	0.043	0.134	0.745	0.043
Northwood Elementary [Elementary]	1	0.118	0.258	0.445	0.147
Peeler Open Elementary [Elementary]	1	0	0.12	0.729	0.082
Washington Elementary [Elementary]	1	0	0.059	0.901	0.015
Shadybrook Elementary [Elementary]	1	0.088	0.171	0.296	0.367
Sumner Elementary [Elementary]	0	0.01	0.319	0.518	0.106
Jefferson Elementary [Elementary]	1	0.046	0.182	0.489	0.234
Sternberger Elementary [Elementary]	1	0.023	0.033	0.123	0.799
Jesse Wharton Elem [Elementary]	1	0.066	0.105	0.247	0.531
The Academy at Smith [High]	1	0.171	0.21	0.543	0.029
Alamance Elementary [Elementary]	1	0.025	0.065	0.236	0.612
Edwin A Alderman Elementary [Elementary]	1	0.065	0.384	0.391	0.129
Allen Jay Elementary [Elementary]	0	0.282	0.284	0.223	0.19
Allen Jay Middle - A Preparatory Academy [Middle]	1	0.025	0.122	0.603	0.21
Allen Middle [Middle]	1	0.1	0.345	0.476	0.031
T Wingate Andrews High [High]	1	0.055	0.106	0.724	0.078
Archer Elementary [Elementary]	1	0.181	0.294	0.444	0.047
Bessemer Elementary [Elementary]	1	0.024	0.241	0.682	0.029
Bluford Elementary [Elementary]	1	0.011	0.116	0.837	0.018
Brightwood Elementary [Elementary]	1	0.022	0.183	0.72	0.049
Brooks Global [Elementary]	1	0.046	0.059	0.491	0.333
Brown Summit Middle [Middle]	0	0.062	0.07	0.173	0.654
(C. Joyner) Greene Education Center @ Ragsdale [A	1	0.046	0.115	0.437	0.379

School	PctOther	TitleI_NoYes	NumLowInc	PctLowInc
Wiley Acel/Enrichment [Elementary]	0.037	1	309	0.8879
W M Hampton Elementary [Elementary]	0.01	1	253	0.7291
Irving Park Elementary [Elementary]	0.051	1	301	0.4943
Clara J Peck Elementary [Elementary]	0.051	1	265	0.7486
Ceasar Cone Elementary [Elementary]	0.026	1	412	0.846
Johnson Street Elementary [Elementary]	0.04	1	245	0.5493
Union Hill Elementary [Elementary]	0.054	1	359	0.671
Rankin Elementary [Elementary]	0.029	1	560	0.7189
David D Jones Elementary [Elementary]	0.039	1	314	0.4441
Montlieu Avenue Elementary [Elementary]	0.04	1	478	0.6761
Oak Hill Elementary [Elementary]	0.017	1	322	0.6505
Gillespie Park Elementary [Elementary]	0.038	1	223	0.8447
Parkview Village Elementary [Elementary]	0.034	1	315	0.8537
Northwood Elementary [Elementary]	0.032	1	388	0.6543
Peeler Open Elementary [Elementary]	0.069	1	187	0.5826
Washington Elementary [Elementary]	0.022	1	270	0.7013
Shadybrook Elementary [Elementary]	0.078	0	179	0.3917
Sumner Elementary [Elementary]	0.047	1	368	0.5945
Jefferson Elementary [Elementary]	0.05	1	316	0.4407
Sternberger Elementary [Elementary]	0.023	0	43	0.1049
Jesse Wharton Elem [Elementary]	0.051	0	117	0.2422
The Academy at Smith [High]	0.048	0	57	0.2794
Alamance Elementary [Elementary]	0.063	0	128	0.253
Edwin A Alderman Elementary [Elementary]	0.031	1	223	0.4978
Allen Jay Elementary [Elementary]	0.02	1	281	0.6004
Allen Jay Middle - A Preparatory Academy [Middle]	0.041	0	152	0.3897
Allen Middle [Middle]	0.048	1	377	0.5738
T Wingate Andrews High [High]	0.036	1	461	0.5595
Archer Elementary [Elementary]	0.034	1	243	0.5691
Bessemer Elementary [Elementary]	0.024	1	394	0.796
Bluford Elementary [Elementary]	0.018	1	217	0.7695
Brightwood Elementary [Elementary]	0.026	1	375	0.6198
Brooks Global [Elementary]	0.071	0	93	0.2257
Brown Summit Middle [Middle]	0.041	0	11	0.0455
(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	0.023	0	32	0.381

School	Level	Enrollment	FreeLunch	ReducedLunch	PctEDS
Claxton Elementary [Elementary]	1	588	196	37	0.396258503
Colfax Elementary [Elementary]	1	636	173	37	0.330188679
Dudley High [High]	3	1344	1312	20	0.991071429
Early College at Guilford [High]	3	197	20	20	0.203045685
Eastern Guilford High [High]	3	1188	649	80	0.613636364
Eastern Middle [Middle]	2	955	946	9	1
Erwin Montessori [Elementary]	1	311	189	20	0.672025723
Fairview Elementary [Elementary]	1	406	405	1	1
Waldo C Falkener Sr Elementary [Elementary]	1	572	566	0	0.98951049
Ferndale Middle [Middle]	2	665	665	0	1
Florence Elementary [Elementary]	1	719	225	64	0.401947149
Julius I Foust Elementary [Elementary]	1	360	360	0	1
Cyrus P Frazier Elementary [Elementary]	1	344	321	0	0.933139535
Gateway Education Center [Alternative]	4	151	49	10	0.390728477
General Greene Elementary [Elementary]	1	496	149	27	0.35483871
Gibsonville Elementary [Elementary]	1	519	233	30	0.506743738
Grimsley High [High]	3	1622	626	53	0.418618989
Guilford Elementary [Elementary]	1	570	511	0	0.896491228
Otis L Hairston Sr Middle [Middle]	2	652	649	0	0.995398773
Meredith Haynes-Inman School [Alternative]	4	137	67	10	0.562043796
Herbin-Metz Education Center [Alternative]	4	67	42	20	0.925373134
High Point Central High [High]	3	1392	778	56	0.599137931
Hunter Elementary [Elementary]	1	520	510	0	0.980769231
Jackson Middle [Middle]	2	482	473	0	0.981327801
Jamestown Elementary [Elementary]	1	437	431	0	0.986270023
Jamestown Middle [Middle]	2	1048	582	85	0.636450382
James Y Joyner Elementary [Elementary]	1	316	291	0	0.920886076
The Kearns Academy at High Point Central [High]	3	131	120	5	0.954198473
Kernodle Middle [Middle]	2	776	163	31	0.25
Kirkman Park Elementary [Elementary]	1	316	305	0	0.965189873
Kiser Middle [Middle]	2	830	475	36	0.615662651
Lincoln Academy [Middle]	2	700	282	37	0.455714286
John Van Lindley Elementary [Elementary]	1	524	249	23	0.519083969
Madison Elementary [Elementary]	1	223	144	20	0.735426009
Middle College High at Bennett [High]	3	98	95	3	1
Middle College High at Greensboro College [High]	3	116	4	4	0.068965517
GTCC East Middle College High [High]	3	122	41	20	0.5
High Point GTCC Middle College [High]	3	131	59	20	0.603053435
GTCC Middle College High [High]	3	197	61	20	0.411167513
Middle College High at NC A&T [High]	3	123	47	20	0.544715447
UNC-G Early/Middle College [High]	3	196	72	26	0.5
McLeansville Elementary [Elementary]	1	333	332	0	0.996996997
Ronald E McNair Elementary [Elementary]	1	555	522	0	0.940540541

School	PctSevAbs	PctModAbs	PctMildAbs	PctNotChronAbs	RurUrb
Claxton Elementary [Elementary]	0.028	0.018	0.051	0.904	1
Colfax Elementary [Elementary]	0.013	0.021	0.094	0.872	0
Dudley High [High]	0.187	0.063	0.09	0.66	1
Early College at Guilford [High]	0.015	0.005	0.02	0.959	1
Eastern Guilford High [High]	0.088	0.031	0.088	0.793	0
Eastern Middle [Middle]	0.033	0.029	0.089	0.849	0
Erwin Montessori [Elementary]	0.004	0.004	0.045	0.947	1
Fairview Elementary [Elementary]	0.039	0.019	0.063	0.879	1
Waldo C Falkener Sr Elementary [Elementary]	0.037	0.049	0.125	0.789	1
Ferndale Middle [Middle]	0.06	0.051	0.093	0.796	1
Florence Elementary [Elementary]	0.013	0.023	0.05	0.915	1
Julius I Foust Elementary [Elementary]	0.072	0.042	0.103	0.782	1
Cyrus P Frazier Elementary [Elementary]	0.031	0.025	0.078	0.866	1
Gateway Education Center [Alternative]	0.217	0.133	0.1	0.55	1
General Greene Elementary [Elementary]	0.006	0.014	0.031	0.949	1
Gibsonville Elementary [Elementary]	0.014	0.025	0.074	0.887	1
Grimsley High [High]	0.07	0.035	0.08	0.816	1
Guilford Elementary [Elementary]	0.028	0.024	0.064	0.885	1
Otis L Hairston Sr Middle [Middle]	0.081	0.072	0.147	0.701	1
Meredith Haynes-Inman School [Alternative]	0.179	0.141	0.167	0.513	0
Herbin-Metz Education Center [Alternative]	0.103	0.026	0.077	0.795	1
High Point Central High [High]	0.13	0.05	0.115	0.705	1
Hunter Elementary [Elementary]	0.014	0.022	0.084	0.88	1
Jackson Middle [Middle]	0.078	0.074	0.114	0.735	1
Jamestown Elementary [Elementary]	0.021	0.016	0.082	0.881	1
Jamestown Middle [Middle]	0.031	0.041	0.108	0.821	0
James Y Joyner Elementary [Elementary]	0.023	0.033	0.097	0.846	1
The Kearns Academy at High Point Central [High]	0	0.008	0.016	0.975	1
Kernodle Middle [Middle]	0.023	0.01	0.076	0.89	1
Kirkman Park Elementary [Elementary]	0.034	0.058	0.134	0.773	1
Kiser Middle [Middle]	0.041	0.033	0.107	0.819	1
Lincoln Academy [Middle]	0.02	0.028	0.049	0.903	1
John Van Lindley Elementary [Elementary]	0.02	0.014	0.086	0.879	1
Madison Elementary [Elementary]	0.013	0.009	0.092	0.886	0
Middle College High at Bennett [High]	0	0	0.039	0.961	1
Middle College High at Greensboro College [High]	0	0.009	0.009	0.983	1
GTCC East Middle College High [High]	0	0.008	0.016	0.977	1
High Point GTCC Middle College [High]	0	0.007	0.037	0.955	1
GTCC Middle College High [High]	0.005	0	0.01	0.984	1
Middle College High at NC A&T [High]	0.008	0	0.008	0.983	1
UNC-G Early/Middle College [High]	0	0.005	0.01	0.985	1
McLeansville Elementary [Elementary]	0.027	0.018	0.104	0.852	0
Ronald E McNair Elementary [Elementary]	0.025	0.038	0.09	0.846	1

School	PctAsian	PctHispanic	PctBlack	PctWhite
Claxton Elementary [Elementary]	0.08	0.083	0.255	0.51
Colfax Elementary [Elementary]	0.07	0.121	0.169	0.603
Dudley High [High]	0.02	0.107	0.833	0.013
Early College at Guilford [High]	0.431	0.03	0.086	0.406
Eastern Guilford High [High]	0.051	0.13	0.505	0.258
Eastern Middle [Middle]	0.056	0.165	0.467	0.263
Erwin Montessori [Elementary]	0.008	0.107	0.813	0.063
Fairview Elementary [Elementary]	0.091	0.239	0.576	0.059
Waldo C Falkener Sr Elementary [Elementary]	0.07	0.214	0.683	0.014
Ferndale Middle [Middle]	0.117	0.238	0.422	0.188
Florence Elementary [Elementary]	0.146	0.104	0.293	0.381
Julius I Foust Elementary [Elementary]	0.025	0.364	0.532	0.033
Cyrus P Frazier Elementary [Elementary]	0.101	0.23	0.623	0.028
Gateway Education Center [Alternative]	0.085	0.102	0.441	0.356
General Greene Elementary [Elementary]	0.012	0.074	0.34	0.514
Gibsonville Elementary [Elementary]	0.018	0.117	0.22	0.574
Grimsley High [High]	0.04	0.074	0.35	0.486
Guilford Elementary [Elementary]	0.023	0.216	0.537	0.168
Otis L Hairston Sr Middle [Middle]	0.047	0.185	0.723	0.018
Meredith Haynes-Inman School [Alternative]	0.053	0.132	0.316	0.447
Herbin-Metz Education Center [Alternative]	0.095	0.068	0.527	0.243
High Point Central High [High]	0.115	0.181	0.381	0.281
Hunter Elementary [Elementary]	0.027	0.452	0.41	0.08
Jackson Middle [Middle]	0.043	0.375	0.507	0.033
Jamestown Elementary [Elementary]	0.076	0.125	0.461	0.27
Jamestown Middle [Middle]	0.103	0.139	0.402	0.294
James Y Joyner Elementary [Elementary]	0.053	0.142	0.486	0.27
The Kearns Academy at High Point Central [High]	0.031	0.31	0.442	0.147
Kernodle Middle [Middle]	0.078	0.082	0.187	0.585
Kirkman Park Elementary [Elementary]	0.035	0.208	0.607	0.107
Kiser Middle [Middle]	0.016	0.094	0.417	0.433
Lincoln Academy [Middle]	0.156	0.086	0.489	0.218
John Van Lindley Elementary [Elementary]	0.027	0.143	0.264	0.52
Madison Elementary [Elementary]	0.009	0.106	0.392	0.414
Middle College High at Bennett [High]	0.009	0.066	0.858	0.028
Middle College High at Greensboro College [High]	0.025	0.058	0.483	0.392
GTCC East Middle College High [High]	0.042	0.15	0.525	0.217
High Point GTCC Middle College [High]	0.054	0.225	0.372	0.279
GTCC Middle College High [High]	0.079	0.168	0.316	0.395
Middle College High at NC A&T [High]	0	0.081	0.871	0.016
UNC-G Early/Middle College [High]	0.098	0.151	0.429	0.263
McLeansville Elementary [Elementary]	0.028	0.19	0.364	0.361
Ronald E McNair Elementary [Elementary]	0.124	0.147	0.609	0.069

School	PctOther	TitleI_NoYes	NumLowInc	PctLowInc
Claxton Elementary [Elementary]	0.072	0	140	0.2381
Colfax Elementary [Elementary]	0.036	0	157	0.2469
Dudley High [High]	0.028	1	811	0.6034
Early College at Guilford [High]	0.046	0	8	0.0406
Eastern Guilford High [High]	0.057	0	461	0.388
Eastern Middle [Middle]	0.05	1	405	0.4241
Erwin Montessori [Elementary]	0.008	1	139	0.4469
Fairview Elementary [Elementary]	0.034	1	327	0.8054
Waldo C Falkener Sr Elementary [Elementary]	0.019	1	460	0.8042
Ferndale Middle [Middle]	0.035	1	379	0.5699
Florence Elementary [Elementary]	0.076	0	159	0.2211
Julius I Foust Elementary [Elementary]	0.047	1	251	0.6972
Cyrus P Frazier Elementary [Elementary]	0.019	1	212	0.6163
Gateway Education Center [Alternative]	0.017	0	68	0.4503
General Greene Elementary [Elementary]	0.059	0	117	0.2359
Gibsonville Elementary [Elementary]	0.071	0	174	0.3353
Grimsley High [High]	0.05	0	497	0.3064
Guilford Elementary [Elementary]	0.056	1	308	0.5404
Otis L Hairston Sr Middle [Middle]	0.026	1	492	0.7546
Meredith Haynes-Inman School [Alternative]	0.053	0	62	0.4526
Herbin-Metz Education Center [Alternative]	0.068	0	24	0.3582
High Point Central High [High]	0.042	1	654	0.4698
Hunter Elementary [Elementary]	0.032	1	363	0.6981
Jackson Middle [Middle]	0.041	1	347	0.7199
Jamestown Elementary [Elementary]	0.069	1	237	0.5423
Jamestown Middle [Middle]	0.062	0	386	0.3683
James Y Joyner Elementary [Elementary]	0.05	1	175	0.5538
The Kearns Academy at High Point Central [High]	0.07	0	42	0.3206
Kernodle Middle [Middle]	0.067	0	101	0.1302
Kirkman Park Elementary [Elementary]	0.044	1	233	0.7373
Kiser Middle [Middle]	0.039	1	377	0.4542
Lincoln Academy [Middle]	0.051	0	218	0.3114
John Van Lindley Elementary [Elementary]	0.046	1	238	0.4542
Madison Elementary [Elementary]	0.079	1	105	0.4709
Middle College High at Bennett [High]	0.038	0	34	0.3469
Middle College High at Greensboro College [High]	0.042	0	15	0.1293
GTCC East Middle College High [High]	0.067	0	34	0.2787
High Point GTCC Middle College [High]	0.07	0	45	0.3435
GTCC Middle College High [High]	0.042	0	46	0.2335
Middle College High at NC A&T [High]	0.032	0	38	0.3089
UNC-G Early/Middle College [High]	0.059	0	54	0.2755
McLeansville Elementary [Elementary]	0.058	1	136	0.4084
Ronald E McNair Elementary [Elementary]	0.052	1	326	0.5874

School	Level	Enrollment	FreeLunch	ReducedLunch	PctEDS
Mendenhall Middle [Middle]	2	746	365	42	0.545576408
Millis Road Elementary [Elementary]	1	453	201	42	0.536423841
Monticello-Brown Summit Elem [Elementary]	1	418	234	26	0.622009569
Morehead Elementary [Elementary]	1	653	385	44	0.656967841
Murphey Traditional Academy [Elementary]	1	309	272	6	0.899676375
Nathanael Greene Elementary [Elementary]	1	261	97	20	0.448275862
Newcomers School [Alternative]	4	478	279	4	0.592050209
Northeast Guilford High [High]	3	1057	608	87	0.657521287
Northeast Guilford Middle [Middle]	2	764	693	13	0.92408377
Northern Elementary [Elementary]	1	600	74	20	0.156666667
Northern High [High]	3	1389	189	34	0.160547156
Northern Middle [Middle]	2	858	186	35	0.257575758
Northwest Guilford High [High]	3	2068	203	46	0.12040619
Northwest Guilford Middle [Middle]	2	1056	101	37	0.130681818
Oak Ridge Elementary [Elementary]	1	750	54	25	0.105333333
Oak View Elementary [Elementary]	1	536	515	0	0.960820896
Page High [High]	3	1972	760	75	0.423427992
Pearce Elementary [Elementary]	1	744	137	26	0.219086022
Penn-Griffin Middle [Middle]	2	588	319	51	0.629251701
Pilot Elementary [Elementary]	1	673	339	31	0.549777117
Pleasant Garden Elementary [Elementary]	1	461	184	29	0.462039046
Scale in High Point (Pruette Scale) [Alternative]	4	45	17	0	0.377777778
Lucy Ragsdale High [High]	3	1490	622	103	0.486577181
Reedy Fork Elementary [Elementary]	1	412	291	44	0.813106796
Scale School [Alternative]	4	66	35	0	0.53030303
Sedalia Elementary [Elementary]	1	469	258	37	0.628997868
Sedgefield Elementary [Elementary]	1	516	514	0	0.996124031
George C. Simkins, Jr Elementary [Elementary]	1	505	354	59	0.817821782
Ben L Smith High [High]	3	1236	1189	0	0.96197411
Southeast Guilford High [High]	3	1307	364	83	0.342004591
Southeast Guilford Middle [Middle]	2	964	340	81	0.436721992
Southern Elementary [Elementary]	1	331	166	43	0.63141994
Southern Guilford High [High]	3	1049	644	96	0.705433746
Southern Middle [Middle]	2	738	738	0	1
Southwest Elementary [Elementary]	1	865	146	57	0.234682081
Southwest Guilford High [High]	3	1580	548	75	0.394303797
Southwest Guilford Middle [Middle]	2	1127	464	80	0.482697427
STEM Early College at NC A&T SU [High]	3	178	38	20	0.325842697
Stokesdale Elementary [Elementary]	1	537	95	20	0.2141527
Summerfield Elementary [Elementary]	1	656	113	23	0.207317073
Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	2	579	567	12	1
Triangle Lake Montessori Elem [Elementary]	1	536	297	43	0.634328358
Vandalia Elementary [Elementary]	1	273	231	0	0.846153846
Philip J Weaver Ed Center [High]	3	258	35	20	0.213178295
Laurin Welborn Middle [Middle]	2	427	348	0	0.81498829
Western Guilford Middle [Middle]	2	1265	436	57	0.38972332
Western Guilford High [High]	3	608	506	57	0.925986842

School	PctSevAbs	PctModAbs	PctMildAbs	PctNotChronAbs
Mendenhall Middle [Middle]	0.052	0.046	0.104	0.798
Millis Road Elementary [Elementary]	0.011	0.017	0.042	0.929
Monticello-Brown Summit Elem [Elementary]	0.024	0.022	0.111	0.843
Morehead Elementary [Elementary]	0.009	0.013	0.038	0.941
Murphey Traditional Academy [Elementary]	0.022	0.022	0.088	0.869
Nathanael Greene Elementary [Elementary]	0.039	0.035	0.055	0.871
Newcomers School [Alternative]	0.021	0.025	0.089	0.864
Northeast Guilford High [High]	0.111	0.074	0.15	0.665
Northeast Guilford Middle [Middle]	0.05	0.028	0.101	0.821
Northern Elementary [Elementary]	0.005	0.014	0.03	0.951
Northern High [High]	0.031	0.027	0.082	0.86
Northern Middle [Middle]	0.02	0.02	0.081	0.879
Northwest Guilford High [High]	0.017	0.025	0.058	0.9
Northwest Guilford Middle [Middle]	0.014	0.02	0.048	0.917
Oak Ridge Elementary [Elementary]	0	0	0.025	0.972
Oak View Elementary [Elementary]	0.019	0.021	0.129	0.83
Page High [High]	0.101	0.053	0.093	0.752
Pearce Elementary [Elementary]	0	0.02	0.049	0.927
Penn-Griffin Middle [Middle]	0.017	0.022	0.073	0.887
Pilot Elementary [Elementary]	0.024	0.023	0.069	0.884
Pleasant Garden Elementary [Elementary]	0.023	0.03	0.058	0.889
Scale in High Point (Pruette Scale) [Alternative]	0.485	0.182	0.091	0.242
Lucy Ragsdale High [High]	0.06	0.041	0.101	0.798
Reedy Fork Elementary [Elementary]	0.037	0.042	0.104	0.817
Scale School [Alternative]	0.596	0.018	0.158	0.228
Sedalia Elementary [Elementary]	0.059	0.023	0.073	0.845
Sedgefield Elementary [Elementary]	0.042	0.029	0.08	0.849
George C. Simkins, Jr Elementary [Elementary]	0.013	0.026	0.077	0.883
Ben L Smith High [High]	0.116	0.072	0.115	0.697
Southeast Guilford High [High]	0.061	0.043	0.096	0.8
Southeast Guilford Middle [Middle]	0.021	0.026	0.078	0.874
Southern Elementary [Elementary]	0.017	0.01	0.116	0.857
Southern Guilford High [High]	0.093	0.057	0.112	0.738
Southern Middle [Middle]	0.057	0.043	0.149	0.751
Southwest Elementary [Elementary]	0	0.003	0.033	0.962
Southwest Guilford High [High]	0.028	0.022	0.054	0.896
Southwest Guilford Middle [Middle]	0.028	0.039	0.087	0.845
STEM Early College at NC A&T SU [High]	0	0	0	1
Stokesdale Elementary [Elementary]	0.006	0.011	0.082	0.901
Summerfield Elementary [Elementary]	0	0.005	0.04	0.954
Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	0.067	0.037	0.101	0.795
Triangle Lake Montessori Elem [Elementary]	0.014	0.011	0.068	0.907
Vandalia Elementary [Elementary]	0.021	0.017	0.089	0.872
Philip J Weaver Ed Center [High]	0.01	0.017	0.112	0.861
Laurin Welborn Middle [Middle]	0.056	0.047	0.14	0.757
Western Guilford Middle [Middle]	0.025	0.041	0.093	0.841
Western Guilford High [High]	0.071	0.049	0.108	0.771

School	RurUrb	PctAsian	PctHispanic	PctBlack	PctWhite
Mendenhall Middle [Middle]	1	0.052	0.128	0.409	0.351
Millis Road Elementary [Elementary]	1	0.088	0.098	0.234	0.53
Monticello-Brown Summit Elem [Elementary]	0	0.003	0.2	0.178	0.567
Morehead Elementary [Elementary]	1	0.019	0.132	0.516	0.3
Murphey Traditional Academy [Elementary]	1	0.081	0.225	0.606	0.039
Nathanael Greene Elementary [Elementary]	0	0.004	0.061	0.031	0.851
Newcomers School [Alternative]	1	0.165	0.41	0.353	0.068
Northeast Guilford High [High]	0	0.016	0.167	0.54	0.219
Northeast Guilford Middle [Middle]	0	0.006	0.177	0.571	0.198
Northern Elementary [Elementary]	0	0.008	0.079	0.092	0.782
Northern High [High]	0	0.02	0.074	0.165	0.699
Northern Middle [Middle]	0	0.02	0.103	0.195	0.641
Northwest Guilford High [High]	1	0.053	0.062	0.077	0.777
Northwest Guilford Middle [Middle]	1	0.062	0.053	0.061	0.774
Oak Ridge Elementary [Elementary]	1	0.119	0.064	0.024	0.746
Oak View Elementary [Elementary]	1	0.073	0.221	0.465	0.179
Page High [High]	1	0.072	0.102	0.399	0.383
Pearce Elementary [Elementary]	1	0.092	0.087	0.103	0.656
Penn-Griffin Middle [Middle]	1	0.022	0.223	0.45	0.255
Pilot Elementary [Elementary]	1	0.109	0.15	0.363	0.326
Pleasant Garden Elementary [Elementary]	0	0.018	0.08	0.112	0.735
Scale in High Point (Pruette Scale) [Alternative]	1	0	0	1	0
Lucy Ragsdale High [High]	1	0.11	0.133	0.375	0.326
Reedy Fork Elementary [Elementary]	0	0.038	0.278	0.502	0.134
Scale School [Alternative]	1	0	0	0.857	0.071
Sedalia Elementary [Elementary]	0	0.021	0.116	0.416	0.374
Sedgefield Elementary [Elementary]	1	0.101	0.485	0.349	0.041
George C. Simkins, Jr Elementary [Elementary]	1	0.027	0.214	0.595	0.118
Ben L Smith High [High]	1	0.09	0.314	0.508	0.041
Southeast Guilford High [High]	1	0.016	0.066	0.275	0.589
Southeast Guilford Middle [Middle]	1	0.022	0.09	0.275	0.556
Southern Elementary [Elementary]	0	0.013	0.32	0.057	0.542
Southern Guilford High [High]	0	0.088	0.258	0.371	0.234
Southern Middle [Middle]	0	0.078	0.299	0.358	0.214
Southwest Elementary [Elementary]	1	0.199	0.093	0.16	0.496
Southwest Guilford High [High]	1	0.095	0.101	0.34	0.421
Southwest Guilford Middle [Middle]	1	0.095	0.101	0.375	0.387
STEM Early College at NC A&T SU [High]	1	0.23	0.08	0.422	0.219
Stokesdale Elementary [Elementary]	0	0.021	0.091	0.045	0.813
Summerfield Elementary [Elementary]	1	0.112	0.12	0.078	0.635
Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	1	0.059	0.11	0.703	0.09
Triangle Lake Montessori Elem [Elementary]	0	0.095	0.115	0.583	0.182
Vandalia Elementary [Elementary]	1	0.0147	0.145	0.722	0.05
Philip J Weaver Ed Center [High]	1	0.046	0.075	0.195	0.622
Laurin Welborn Middle [Middle]	1	0.069	0.184	0.617	0.084
Western Guilford Middle [Middle]	1	0.053	0.273	0.457	0.163
Western Guilford High [High]	1	0.039	0.178	0.41	0.319

School	PctOther	TitleI_NoYes	NumLowInc	PctLowInc
Mendenhall Middle [Middle]	0.059	0	281	0.3767
Millis Road Elementary [Elementary]	0.05	0	128	0.2826
Monticello-Brown Summit Elem [Elementary]	0.052	1	199	0.4761
Morehead Elementary [Elementary]	0.032	1	328	0.5023
Murphey Traditional Academy [Elementary]	0.049	1	202	0.6537
Nathanael Greene Elementary [Elementary]	0.054	0	69	0.2644
Newcomers School [Alternative]	0.004	1	306	0.6402
Northeast Guilford High [High]	0.059	1	475	0.4494
Northeast Guilford Middle [Middle]	0.048	1	412	0.5393
Northern Elementary [Elementary]	0.04	0	61	0.1017
Northern High [High]	0.042	0	159	0.1145
Northern Middle [Middle]	0.0421	0	122	0.1422
Northwest Guilford High [High]	0.032	0	133	0.0643
Northwest Guilford Middle [Middle]	0.05	0	62	0.0587
Oak Ridge Elementary [Elementary]	0.046	0	34	0.0453
Oak View Elementary [Elementary]	0.061	1	308	0.5746
Page High [High]	0.044	0	676	0.3428
Pearce Elementary [Elementary]	0.061	0	90	0.121
Penn-Griffin Middle [Middle]	0.05	1	247	0.4201
Pilot Elementary [Elementary]	0.053	0	254	0.3774
Pleasant Garden Elementary [Elementary]	0.055	0	133	0.2885
Scale in High Point (Pruette Scale) [Alternative]	0	1	29	0.6444
Lucy Ragsdale High [High]	0.056	0	480	0.3221
Reedy Fork Elementary [Elementary]	0.047	1	201	0.4879
Scale School [Alternative]	0.071	1	50	0.7576
Sedalia Elementary [Elementary]	0.072	0	184	0.3923
Sedgefield Elementary [Elementary]	0.024	1	320	0.6202
George C. Simkins, Jr Elementary [Elementary]	0.046	1	227	0.4495
Ben L Smith High [High]	0.047	1	714	0.5777
Southeast Guilford High [High]	0.055	0	254	0.1943
Southeast Guilford Middle [Middle]	0.057	0	248	0.2573
Southern Elementary [Elementary]	0.067	1	140	0.423
Southern Guilford High [High]	0.05	1	425	0.4051
Southern Middle [Middle]	0.051	1	367	0.4973
Southwest Elementary [Elementary]	0.052	0	96	0.111
Southwest Guilford High [High]	0.043	0	394	0.2494
Southwest Guilford Middle [Middle]	0.042	0	322	0.2857
STEM Early College at NC A&T SU [High]	0.048	0	23	0.1292
Stokesdale Elementary [Elementary]	0.03	0	86	0.1601
Summerfield Elementary [Elementary]	0.056	0	79	0.1204
Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	0.038	1	313	0.5406
Triangle Lake Montessori Elem [Elementary]	0.025	1	260	0.4851
Vandalia Elementary [Elementary]	0.066	1	167	0.6117
Philip J Weaver Ed Center [High]	0.062	0	27	0.1047
Laurin Welborn Middle [Middle]	0.046	1	283	0.6628
Western Guilford Middle [Middle]	0.053	1	375	0.4753
Western Guilford High [High]	0.053	0	289	0.2964

Appendix

R Script Code

```
library(readxl)
library(randomForest)
library(car)
library(plot3D)
library(plot3Drgl)

set.seed(79971319)
p <- 6 # number of predictors

# Read data sets
gcs1617 <- read_excel("C:/Users/oldir/Desktop/ISEN 794 - Masters Supervised Research (NRT Research)/External Data/Guilford County Schools Data for R.xlsx", sheet = "2016-2017 Condensed")
View(gcs1617)

train.dat1617 <- gcs1617[1:20,]
prediction.dat1617 <- gcs1617[-(1:20),]
n1 <- nrow(train.dat1617)


```

```
gcs1718 <- read_excel("C:/Users/oldir/Desktop/ISEN 794 -
Masters Supervised Research (NRT Research)/External
Data/Guilford County Schools Data for R.xlsx", sheet =
"2017-2018 Condensed")
View(gcs1718)

train.dat1718 <- gcs1718[1:21,]
prediction.dat1718 <- gcs1718[-(1:21),]
n2 <- nrow(train.dat1718)


gcscombined <- read_excel("C:/Users/oldir/Desktop/ISEN 794
- Masters Supervised Research (NRT Research)/External
Data/Guilford County Schools Data for R.xlsx", sheet =
"Combined Condensed")
View(gcscombined)

train.datcombined <- gcscombined[1:41,]
prediction.datcombined <- gcscombined[-(1:41),]
n3 <- nrow(train.datcombined)


# Current trend analysis
```

```
train.FBPTotal <- NULL
train.PctEDS <- NULL
train.PctSevAbs <- NULL
train.PctMinority <- NULL
train.TitleI_NoYes <- NULL
train.PctLowInc <- NULL

for (i in 1:n2) {
  train.FBPTotal[i] <- sum(c(train.dat1718[i,]$FBPTotal,

gcs1617[pmatch(train.dat1718[i,]$School,

gcs1617$School),]$FBPTotal))
  train.PctEDS[i] <- mean(c(train.dat1718[i,]$PctEDS,

gcs1617[pmatch(train.dat1718[i,]$School,

gcs1617$School),]$PctEDS))
  train.PctSevAbs[i] <- mean(c(train.dat1718[i,]$PctSevAbs,

gcs1617[pmatch(train.dat1718[i,]$School,

gcs1617$School),]$PctSevAbs))
```

```
  train.PctMinority[i] <-
mean(c(train.dat1718[i,]$PctMinority,

gcs1617[pmatch(train.dat1718[i,]$School,

gcs1617$School),]$PctMinority))
  train.TitleI_NoYes[i] <-
mean(c(train.dat1718[i,]$TitleI_NoYes,

gcs1617[pmatch(train.dat1718[i,]$School,

gcs1617$School),]$TitleI_NoYes))
  train.PctLowInc[i] <- mean(c(train.dat1718[i,]$PctLowInc,

gcs1617[pmatch(train.dat1718[i,]$School,

gcs1617$School),]$PctLowInc))
}



train.FBPtable <- data.frame(School = train.dat1718$School,
SumFBPTotal = train.FBPTotal, AvgPctEDS = train.PctEDS,
```

```
  AvgPctSevAbs = train.PctSevAbs, RurUrb =
  train.dat1718$RurUrb, AvgPctMinority = train.PctMinority,
  AvgTitleI_NoYes = train.TitleI_NoYes, AvgPctLowInc =
  train.PctLowInc)
➢ train.FBPtable <- train.FBPtable[order(-
  train.FBPtable$SumFBPTotal),]
➢
➢ scatter2D(train.FBPtable$AvgPctMinority,
  train.FBPtable$SumFBPTotal, colvar =
  train.FBPtable$SumFBPTotal, xlab = "AvgPctMinority", ylab =
  "SumFBPTotal", pch = 16, bty ="n", type ="p", clab =
  "FBPTotal")
➢ scatter2D(train.FBPtable$AvgPctLowInc,
  train.FBPtable$SumFBPTotal, colvar =
  train.FBPtable$SumFBPTotal, xlab = "AvgPctLowInc", ylab =
  "SumFBPTotal", pch = 16, bty ="n", type ="p", clab =
  "FBPTotal")
➢
➢ row.names(train.FBPtable) <- NULL
➢ train.FBPtable$SumFBPTotal <- NULL
➢ train.FBPtable
➢ write.table(train.FBPtable, file = "TrendAnalysis.csv",
  sep=",", row.names = FALSE)
```

```
➢
➢
➢
➢
➢ # 2016-2017 data analysis
➢ # Full model with all main predictors
➢ fullmodel1 <- lm(Score ~
  PctEDS+PctSevAbs+RurUrb+PctMinority+TitleI_NoYes+PctLowInc,
  data = train.dat1617)
➢
➢ # Diagnostic check for full model
➢ par(mfrow = c(2,2))
➢ plot(fullmodel1)
➢ round(cor(train.dat1617[,-1]), 2)
➢ vif(fullmodel1)
➢
➢ # Remove PctMinority due to collinearity
➢ fullmodel1a <- update(fullmodel1, .~. -PctMinority)
➢ vif(fullmodel1a)
➢ plot(fullmodel1a)
➢
➢ # Backward variable selection process
➢ summary(fullmodel1a)
```

```
summary(update(fullmodel1a, .~. -TitleI_NoYes))
summary(update(fullmodel1a, .~. -TitleI_NoYes-PctEDS))
summary(update(fullmodel1a, .~. -TitleI_NoYes-PctEDS-
PctSevAbs))
summary(update(fullmodel1a, .~. -TitleI_NoYes-PctEDS-
PctSevAbs-RurUrb))

# Backward Selection with second-order "corrected" Akaike
Information Criterion (AICc)
step(fullmodel1a, direction = "backward", k = 2*(n1/(n1-p-
1)))

# Forward variable selection process
nullmodel1 <- lm(Score ~ 1, data = train.dat1617)
summary(nullmodel1)

summary(update(nullmodel1, .~. +PctEDS))
summary(update(nullmodel1, .~. +PctSevAbs))
summary(update(nullmodel1, .~. +RurUrb))
summary(update(nullmodel1, .~. +TitleI_NoYes))
summary(update(nullmodel1, .~. +PctLowInc)) #include

summary(update(nullmodel1, .~. +PctLowInc+PctEDS))
```

```
summary(update(nullmodel1, .~. +PctLowInc+PctSevAbs))
summary(update(nullmodel1, .~. +PctLowInc+RurUrb))
summary(update(nullmodel1, .~. +PctLowInc+TitleI_NoYes))

# Forward Selection with AICc
step(nullmodel1, scope = list(lower = nullmodel1, upper =
fullmodel1a), direction = "forward", k = 2*(n1/(n1-p-1)))

# Stepwise Selection with AICc (considering all
combinations of interaction effects)
step(fullmodel1a, scope = list(lower = nullmodel1, upper =
~PctEDS*PctSevAbs*RurUrb*TitleI_NoYes*PctLowInc), k =
2*(n1/(n1-p-1)), direction = "both")

# Final 2016-2017 model
finalmodel1617 <- lm(Score ~ PctLowInc, data =
train.dat1617)

# Diagnostic checks for final 2016-2017 model
plot(finalmodel1617)
par(mfrow = c(1,1))
summary(finalmodel1617)
```

```
# Predictions for final model
pred1617 <- predict.lm(finalmodel1617, newdata =
prediction.dat1617)
pred1617a <- data.frame(School = prediction.dat1617[,1],
PredictedScore = pred1617)
(pred1617a <- pred1617a[order(-pred1617a$PredictedScore),])
hist(pred1617a$PredictedScore, main="Final Model, 2016-2017
Prediction Data", xlab="Scores")
write.table(pred1617a, file = "Predictions1617.csv",
sep=",", row.names = FALSE)

# 2016-2017 data visualization
pred1617_best <- pred1617a[order(pred1617a$School),]
predictiondat1617order <-
prediction.dat1617[order(prediction.dat1617$School),]
finalcols1617 <- c("Level", "PctLowInc")
predictiondat1617order2 <-
predictiondat1617order[finalcols1617]
finaldata1617 <- cbind(pred1617_best,
predictiondat1617order2)
finaldata1617 <- finaldata1617[order(-
finaldata1617$PredictedScore),]
```

```
➢ # 2D training data scatterplot
➢ scatter2D(train.dat1617$PctLowInc, train.dat1617$Score,
  colvar = train.dat1617$Score, main = "2016-2017 Training
  Data Scatterplot", xlab = "PctLowInc", ylab = "Score", pch
  = 16, bty ="n", type ="p", clab = "Score")
➢ abline(finalmodel1617, col = "red")
➢
➢ # 2D prediction data scatterplot of predictions
➢ with(finaldata1617, text2D(PctLowInc, PredictedScore,
➢                           labels = School, colvar = Level,
➢                           xlab = "PctLowInc", ylab =
  "PredictedScore",
➢                           main = c("2016-2017 Prediction
  Data:", "Scatterplot by School Name"), cex = 0.6,
➢                           clab = "Level", adj = 0.5, font
  = 2))
➢
➢ # Histogram of PctLowInc
➢ hist(finaldata1617$PctLowInc, main="2016-2017 Prediction
  Data:\nHistogram of PctLowInc", xlab="PctLowInc")
➢ ##########################################################
  ####################################
➢
```

```
➢
➢
➢
➢ # 2017-2018 data analysis
➢ # Full model with all main predictors
➢ fullmodel2 <- lm(Score ~
  PctEDS+PctSevAbs+RurUrb+PctMinority+TitleI_NoYes+PctLowInc,
  data = train.dat1718)
➢
➢ # Diagnostic check for full model
➢ par(mfrow = c(2,2))
➢ plot(fullmodel2)
➢ round(cor(train.dat1718[,-1]), 2)
➢ vif(fullmodel2)
➢
➢ # Remove PctMinority due to collinearity
➢ fullmodel2a <- update(fullmodel2, .~. -PctMinority)
➢ vif(fullmodel2a)
➢ plot(fullmodel2a)
➢
➢ # Backward variable selection process
➢ summary(fullmodel2a)
➢ summary(update(fullmodel2a, .~. -PctEDS))
```

```
summary(update(fullmodel2a, .~. -PctEDS-PctLowInc))
summary(update(fullmodel2a, .~. -PctEDS-PctLowInc-RurUrb))
summary(update(fullmodel2a, .~. -PctEDS-PctLowInc-RurUrb-
TitleI_NoYes))

# Backward Selection with AICc
step(fullmodel2a, direction = "backward", k = 2*(n2/(n2-p-
1)))

# Forward variable selection process
nullmodel2 <- lm(Score ~ 1, data = train.dat1718)
summary(nullmodel2)

summary(update(nullmodel2, .~. +PctEDS))
summary(update(nullmodel2, .~. +PctSevAbs))
summary(update(nullmodel2, .~. +RurUrb))
summary(update(nullmodel2, .~. +TitleI_NoYes))
summary(update(nullmodel2, .~. +PctLowInc)) #include

summary(update(nullmodel2, .~. +PctLowInc+PctEDS))
summary(update(nullmodel2, .~. +PctLowInc+PctSevAbs))
summary(update(nullmodel2, .~. +PctLowInc+RurUrb))
summary(update(nullmodel2, .~. +PctLowInc+TitleI_NoYes))
```

```
➢
➢ # Forward Selection with AICc
➢ step(nullmodel2, scope = list(lower = nullmodel2, upper =
  fullmodel2), direction = "forward", k = 2*(n2/(n2-p-1)))
➢
➢ # Stepwise Selection with AICc (considering all
  combinations of interaction effects)
➢ step(fullmodel2a, scope = list(lower = nullmodel2, upper =
  ~PctEDS*PctSevAbs*RurUrb*TitleI_NoYes*PctLowInc), k =
  2*(n2/(n2-p-1)), direction = "both")
➢
➢ # Random Forest analysis (starting with full model)
➢ print(randomForest(Score ~
  PctEDS+PctSevAbs+RurUrb+TitleI_NoYes+PctLowInc, data =
  train.dat1718))
➢ print(randomForest(Score ~ PctSevAbs + TitleI_NoYes, data =
  train.dat1718))
➢ print(randomForest(Score ~ PctLowInc, data =
  train.dat1718))
➢ print(randomForest(Score ~ PctSevAbs, data =
  train.dat1718))
➢
➢
```

```
# Final 2017-2018 models
finalmodel1718_1 <- lm(Score ~ PctSevAbs + TitleI_NoYes,
data = train.dat1718)
finalmodel1718_2 <- lm(Score ~ PctLowInc, data =
train.dat1718)
finalmodel1718_3 <- lm(Score ~ PctSevAbs, data =
train.dat1718)

# Diagnostic checks for final 2017-2018 models
plot(finalmodel1718_1)
plot(finalmodel1718_2)
plot(finalmodel1718_3)
par(mfrow = c(1,1))

# Linear regression output for full model and final 2017-
2018 models
summary(fullmodel2a)
summary(finalmodel1718_1)
summary(finalmodel1718_2)
summary(finalmodel1718_3)

# Predictions for final models
```

```
pred1718_1 <- predict.lm(finalmodel1718_1, newdata =
prediction.dat1718)
pred1718_1a <- data.frame(School = prediction.dat1718[,1],
PredictedScore = pred1718_1)
(pred1718_1a <- pred1718_1a[order(-
pred1718_1a$PredictedScore),])
hist(pred1718_1a$PredictedScore, main="Final Model 1, 2017-
2018 Prediction Data", xlab="Scores")
write.table(pred1718_1a, file = "Predictions1718_1.csv",
sep=",", row.names = FALSE)

pred1718_2 <- predict.lm(finalmodel1718_2, newdata =
prediction.dat1718)
pred1718_2a <- data.frame(School = prediction.dat1718[,1],
PredictedScore = pred1718_2)
(pred1718_2a <- pred1718_2a[order(-
pred1718_2a$PredictedScore),])
hist(pred1718_2a$PredictedScore, main="Final Model 2, 2017-
2018 Prediction Data", xlab="Scores")
write.table(pred1718_2a, file = "Predictions1718_2.csv",
sep=",", row.names = FALSE)
```

```
pred1718_3 <- predict.lm(finalmodel1718_3, newdata =
prediction.dat1718)
pred1718_3a <- data.frame(School = prediction.dat1718[,1],
PredictedScore = pred1718_3)
(pred1718_3a <- pred1718_3a[order(-
pred1718_3a$PredictedScore),])
hist(pred1718_3a$PredictedScore, main="Final Model 3, 2017-
2018 Prediction Data", xlab="Scores")
write.table(pred1718_3a, file = "Predictions1718_3.csv",
sep=",", row.names = FALSE)

# The choice of best linear regression model for 2017-2018
training data:
# Score ~ PctLowInc
bestmodel1718 <- finalmodel1718_2

# 2017-2018 data visualization
pred1718_best <- pred1718_2a[order(pred1718_2a$School),]
predictiondat1718order <-
prediction.dat1718[order(prediction.dat1718$School),]
finalcols1718 <- c("Level", "PctLowInc")
predictiondat1718order2 <-
predictiondat1718order[finalcols1718]
```

```
finaldata1718 <- cbind(pred1718_best,
predictiondat1718order2)
finaldata1718 <- finaldata1718[order(-
finaldata1718$PredictedScore),]

# 2D training data scatterplot
scatter2D(train.dat1718$PctLowInc, train.dat1718$Score,
colvar = train.dat1718$Score, main = "2017-2018 Training
Data Scatterplot", xlab = "PctLowInc", ylab = "Score", pch
= 16, bty ="n", type ="p", clab = "Score")
abline(bestmodel1718, col = "red")

# 2D prediction data scatterplot of predictions
with(finaldata1718, text2D(PctLowInc, PredictedScore,
                           labels = School, colvar = Level,
                           xlab = "PctLowInc", ylab =
"PredictedScore",
                           main = c("2017-2018 Prediction
Data:", "Scatterplot by School Name"), cex = 0.6,
                           clab = "Level", adj = 0.5, font
= 2))

# Histogram of PctLowInc
```

```
hist(finaldata1718$PctLowInc, main="2017-2018 Prediction
Data:\nHistogram of PctLowInc", xlab="PctLowInc")
##################################################################
####################################
#
#
#
# Combined data analysis
# Full model with all main predictors
fullmodel3 <- lm(Score ~
PctEDS+PctSevAbs+RurUrb+PctMinority+TitleI_NoYes+PctLowInc,
data = train.datcombined)
#
# Diagnostic check for full model
par(mfrow = c(2,2))
plot(fullmodel3)
round(cor(train.datcombined[,-1]), 2)
vif(fullmodel3)
#
# Backward variable selection process
summary(fullmodel3)
summary(update(fullmodel3, .~. -PctEDS))
summary(update(fullmodel3, .~. -PctEDS-PctSevAbs))
```

```
summary(update(fullmodel3, .~. -PctEDS-PctMinority-
TitleI_NoYes))
summary(update(fullmodel3, .~. -PctEDS-PctMinority-
TitleI_NoYes-PctSevAbs))

# Backward Selection with AICc
step(fullmodel3, direction = "backward", k = 2*(n3/(n3-p-
1)))

# Forward variable selection process
nullmodel3 <- lm(Score ~ 1, data = train.datcombined)
summary(nullmodel3)

summary(update(nullmodel3, .~. +PctEDS))
summary(update(nullmodel3, .~. +PctSevAbs))
summary(update(nullmodel3, .~. +RurUrb))
summary(update(nullmodel3, .~. +PctMinority))
summary(update(nullmodel3, .~. +TitleI_NoYes))
summary(update(nullmodel3, .~. +PctLowInc)) # include

summary(update(nullmodel3, .~. +PctLowInc+PctEDS))
summary(update(nullmodel3, .~. +PctLowInc+PctSevAbs))
summary(update(nullmodel3, .~. +PctLowInc+RurUrb)) #include
```

```
summary(update(nullmodel3, .~. +PctLowInc+PctMinority))
summary(update(nullmodel3, .~. +PctLowInc+TitleI_NoYes))

summary(update(nullmodel3, .~. +PctLowInc+RurUrb+PctEDS))
summary(update(nullmodel3, .~.
+PctLowInc+RurUrb+PctSevAbs))
summary(update(nullmodel3, .~.
+PctLowInc+RurUrb+PctMinority))
summary(update(nullmodel3, .~.
+PctLowInc+RurUrb+TitleI_NoYes))

# Forward Selection with AICc
step(nullmodel3, scope = list(lower = nullmodel3, upper =
fullmodel3), direction = "forward", k = 2*(n3/(n3-p-1)))

# Stepwise Selection with AICc (considering all
combinations of interaction effects)
step(fullmodel3, scope = list(lower = nullmodel3, upper =
~PctEDS*PctSevAbs*RurUrb*PctMinority*TitleI_NoYes*PctLowInc
), k = 2*(n3/(n3-p-1)), direction = "both")

# Final Combined models
```

```
finalmodelcombined_1 <- lm(Score ~ RurUrb+PctLowInc, data =
train.datcombined)
finalmodelcombined_2 <- lm(Score ~ PctLowInc, data =
train.datcombined)

# Diagnostic checks for final Combined models
plot(finalmodelcombined_1)
plot(finalmodelcombined_2)
par(mfrow = c(1,1))

# Random Forest analysis (starting with full model)
print(randomForest(Score ~
PctEDS+PctSevAbs+RurUrb+PctMinority+TitleI_NoYes+PctLowInc,
data = train.datcombined))
print(randomForest(Score ~ RurUrb+PctLowInc, data =
train.datcombined))
print(randomForest(Score ~ PctLowInc, data =
train.datcombined))

# Linear regression output for full model and final
Combined models
summary(fullmodel3)
summary(finalmodelcombined_1)
```

```
summary(finalmodelcombined_2)

# Predictions for final models
predcombined_1 <- predict.lm(finalmodelcombined_1, newdata
= prediction.datcombined)
predcombined_1a <- data.frame(School =
prediction.datcombined[,1], PredictedScore =
predcombined_1)
(predcombined_1a <- predcombined_1a[order(-
predcombined_1a$PredictedScore),])
hist(predcombined_1a$PredictedScore, main="Final Model 1,
Combined Prediction Data", xlab="Scores")
write.table(predcombined_1a, file =
"PredictionsCombined_1.csv", sep=",", row.names = FALSE)

predcombined_2 <- predict.lm(finalmodelcombined_2, newdata
= prediction.datcombined)
predcombined_2a <- data.frame(School =
prediction.datcombined[,1], PredictedScore =
predcombined_2)
(predcombined_2a <- predcombined_2a[order(-
predcombined_2a$PredictedScore),])
```

```
hist(predcombined_2a$PredictedScore, main="Final Model 2,
Combined Prediction Data", xlab="Scores")
write.table(predcombined_2a, file =
"PredictionsCombined_2.csv", sep=",", row.names = FALSE)

# The choice of best linear regression model for Combined
training data:
# Score ~ RurUrb + PctLowInc
lmtraincombined <- finalmodelcombined_1

# Combined data visualization
predcombined_best <-
predcombined_1a[order(predcombined_1a$School),]
predictiondatcombinedorder <-
prediction.datcombined[order(prediction.datcombined$School)
,]
finalcolscombined <- c("Level", "RurUrb", "PctLowInc")
predictiondatcombinedorder2 <-
predictiondatcombinedorder[finalcolscombined]
finaldatacombined <- cbind(predcombined_best,
predictiondatcombinedorder2)
finaldatacombined <- finaldatacombined[order(-
finaldatacombined$PredictedScore),]
```

```
➢
➢
➢ # 3D interactive training data scatterplot
➢ scatter3d(train.datcombined$RurUrb,
  train.datcombined$PctLowInc, train.datcombined$Score, xlab
  = "RurUrb", ylab = "PctLowInc", zlab = "Score")
➢
➢ # Prediction data 3D scatterplot of predictions
➢ with(finaldatacombined, text3D(RurUrb, PctLowInc,
  PredictedScore,
➢                            labels = School, colvar = Level,
➢                            col = gg.col(100), theta = 60,
  phi = 20,
➢                            xlab = "RurUrb", ylab =
  "PctLowInc", zlab = "PredictedScore",
➢                            main = "Combined Prediction
  Data: Scatterplot by School Name", cex = 0.6,
➢                            bty = "g", ticktype =
  "detailed", d = 2,
➢                            clab = "Level", adj = 0.5, font
  = 2))
➢ plotrgl() # make plot interactive
➢
```

```
➢ ##########################################################
  ####################################
➢ # Function for plotting "fancy" 3D histograms
➢ hist3D_fancy<- function(x, y, break.func = c("Sturges",
  "scott", "FD"), breaks = NULL,
➢                          colvar = NULL, col="white",
  clab=NULL, phi = 5, theta = 25, ...){
➢
➢   # Compute the number of classes for a histogram
➢   break.func <- break.func [1]
➢   if(is.null(breaks)){
➢     x.breaks <- switch(break.func,
➢                        Sturges = nclass.Sturges(x),
➢                        scott = nclass.scott(x),
➢                        FD = nclass.FD(x))
➢     y.breaks <- switch(break.func,
➢                        Sturges = nclass.Sturges(y),
➢                        scott = nclass.scott(y),
➢                        FD = nclass.FD(y))
➢   } else x.breaks <- y.breaks <- breaks
➢
➢   # Cut x and y variables in bins for counting
➢   x.bin <- seq(min(x)-0.2, max(x), length.out = x.breaks)
```

```
    y.bin <- seq(min(y), max(y), length.out = y.breaks)
    xy <- table(cut(x, x.bin), cut(y, y.bin))
    z <- xy

    xmid <- 0.5*(x.bin[-1] + x.bin[-length(x.bin)])
    ymid <- 0.5*(y.bin[-1] + y.bin[-length(y.bin)])

    oldmar <- par("mar")
    par (mar = par("mar") + c(0, 0, 0, 2))
    hist3D(x = xmid, y = ymid, z = xy, ...,
           zlim = c(-max(z)/2, max(z)), zlab = "counts", bty=
  "g",
           phi = phi, theta = theta,
           shade = 0.2, col = col, border = "black",
           d = 1, ticktype = "detailed")

    scatter3D(x, y,
              z = rep(-max(z)/2, length.out = length(x)),
              colvar = colvar, col = gg.col(100),
              add = TRUE, pch = 18, clab = clab,
              colkey = list(length = 0.5, width = 0.5,
                            dist = 0.05, cex.axis = 0.8,
  cex.clab = 0.8)
```

```
  )
  par(mar = oldmar)
}

# Prediction data 3D histogram
hist3D_fancy(finaldatacombined$RurUrb,
finaldatacombined$PctLowInc, colvar =
finaldatacombined$PredictedScore, clab = "Score", main =
c("Combined Prediction Data: Histogram of RurUrb &
PctLowInc"))
plotrgl() # make plot interactive
############################################################
####################################
```

Table A.3

Prediction Data Schools, Ordered by Predicted Need;

Best Model, 2016-2017 School Year

Rank	School	Score
1	Scale School [Alternative]	64.74735856
2	Kirkman Park Elementary [Elementary]	62.26987685
3	Otis L Hairston Sr Middle [Middle]	61.87000261
4	Bessemer Elementary [Elementary]	61.85261677
5	Fairview Elementary [Elementary]	61.5309788
6	Waldo C Falkener Sr Elementary [Elementary]	61.04417537
7	Jackson Middle [Middle]	59.44467841
8	Newcomers School [Alternative]	57.02804712
9	Murphey Traditional Academy [Elementary]	56.75856666
10	Scale in High Point (Pruette Scale) [Alternative]	56.24568448
11	Bluford Elementary [Elementary]	55.90666067
12	Julius I Foust Elementary [Elementary]	53.73343109
13	Hunter Elementary [Elementary]	53.56826565
14	Laurin Welborn Middle [Middle]	53.38571436
15	Sedgefield Elementary [Elementary]	51.76883156
16	Dudley High [High]	48.81323935
17	T Wingate Andrews High [High]	47.96133335
18	Cyrus P Frazier Elementary [Elementary]	47.5093016
19	Brightwood Elementary [Elementary]	46.37052931
20	Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	46.24882845
21	Ferndale Middle [Middle]	46.2227497
22	Allen Jay Elementary [Elementary]	46.18797802
23	Ben L Smith High [High]	46.04019841
24	Allen Middle [Middle]	46.0315055
25	Archer Elementary [Elementary]	45.77941087
26	Vandalia Elementary [Elementary]	45.3186862
27	James Y Joyner Elementary [Elementary]	43.44101585
28	Northeast Guilford Middle [Middle]	43.07591328
29	Edwin A Alderman Elementary [Elementary]	42.81512573
30	Oak View Elementary [Elementary]	41.43295172
31	Reedy Fork Elementary [Elementary]	41.31994379
32	Ronald E McNair Elementary [Elementary]	41.17216418
33	Morehead Elementary [Elementary]	40.92876246
34	Western Guilford Middle [Middle]	40.20725025
35	Triangle Lake Montessori Elem [Elementary]	40.1377069
36	Monticello-Brown Summit Elem [Elementary]	39.98992729
37	Kiser Middle [Middle]	39.52920262
38	High Point Central High [High]	39.51181678

Rank	School	Score
39	Guilford Elementary [Elementary]	38.73814706
40	John Van Lindley Elementary [Elementary]	38.60775328
41	Allen Jay Middle - A Preparatory Academy [Middle]	38.38173741
42	Southern Middle [Middle]	38.10356402
43	Jamestown Elementary [Elementary]	37.74715437
44	Madison Elementary [Elementary]	37.46028807
45	High Point GTCC Middle College [High]	36.3823662
46	Herbin-Metz Education Center [Alternative]	36.27805118
47	Northeast Guilford High [High]	36.05203531
48	Penn-Griffin Middle [Middle]	36.03464947
49	Gateway Education Center [Alternative]	35.86948402
50	Eastern Middle [Middle]	35.63477523
51	Erwin Montessori [Elementary]	35.35660184
52	George C. Simkins, Jr Elementary [Elementary]	35.15666472
53	Southern Elementary [Elementary]	34.10482161
54	Southern Guilford High [High]	33.957042
55	Eastern Guilford High [High]	33.32245897
56	The Kearns Academy at High Point Central [High]	33.07905725
57	Pilot Elementary [Elementary]	32.82696262
58	McLeansville Elementary [Elementary]	32.79219095
59	Meredith Haynes-Inman School [Alternative]	32.07067873
60	Sedalia Elementary [Elementary]	31.6273399
61	Jamestown Middle [Middle]	30.30601632
62	Gibsonville Elementary [Elementary]	30.14085087
63	Mendenhall Middle [Middle]	29.8192129
64	Nathanael Greene Elementary [Elementary]	28.18494426
65	Middle College High at NC A&T [High]	28.00239298
66	Shadybrook Elementary [Elementary]	27.36780994
67	(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	27.0635578
68	Page High [High]	26.97662862
69	Lucy Ragsdale High [High]	26.50721103
70	Middle College High at Bennett [High]	26.29858099
71	Pleasant Garden Elementary [Elementary]	25.37713165
72	Grimsley High [High]	25.00333617
73	Southwest Guilford Middle [Middle]	24.29920979
74	Western Guilford High [High]	23.99495765
75	The Academy at Smith [High]	23.97757181
76	Lincoln Academy [Middle]	23.57769757
77	GTCC East Middle College High [High]	23.32560294
78	Alamance Elementary [Elementary]	23.17782333
79	Millis Road Elementary [Elementary]	22.16944481
80	Southeast Guilford Middle [Middle]	22.10859438
81	Brooks Global [Elementary]	21.01328668

Rank	School	Score
82	Southwest Guilford High [High]	20.70903454
83	Colfax Elementary [Elementary]	19.61372683
84	GTCC Middle College High [High]	19.25731718
85	General Greene Elementary [Elementary]	19.21385259
86	Claxton Elementary [Elementary]	18.53580496
87	Southeast Guilford High [High]	17.57089104
88	Florence Elementary [Elementary]	17.48396185
89	UNC-G Early/Middle College [High]	17.02323718
90	Middle College High at Greensboro College [High]	15.89315781
91	Stokesdale Elementary [Elementary]	13.20704606
92	Northern Middle [Middle]	11.59885617
93	Kernodle Middle [Middle]	11.23375361
94	STEM Early College at NC A&T SU [High]	10.99035189
95	Summerfield Elementary [Elementary]	10.85995812
96	Pearce Elementary [Elementary]	10.83387937
97	Northern High [High]	10.26014676
98	Northern Elementary [Elementary]	9.512555786
99	Southwest Elementary [Elementary]	8.469405592
100	Philip J Weaver Ed Center [High]	7.965216332
101	Northwest Guilford Middle [Middle]	6.009309718
102	Northwest Guilford High [High]	5.33995501
103	Brown Summit Middle [Middle]	3.56659968
104	Early College at Guilford [High]	3.540520926
105	Oak Ridge Elementary [Elementary]	3.288426295

Table A.4

Prediction Data Schools, Ordered by Predicted Need;

Final Model 1, 2017-2018 School Year

Rank	School	Score
1	Scale School [Alternative]	207.5934564
2	Scale in High Point (Pruette Scale) [Alternative]	177.0162432
3	Dudley High [High]	94.92606695
4	T Wingate Andrews High [High]	93.82418539
5	Gateway Education Center [Alternative]	85.49237794
6	High Point Central High [High]	79.22425473
7	Ben L Smith High [High]	75.36766927
8	Meredith Haynes-Inman School [Alternative]	75.02450312
9	Northeast Guilford High [High]	73.99031732
10	Southern Guilford High [High]	69.0318503
11	Otis L Hairston Sr Middle [Middle]	65.72620562
12	Jackson Middle [Middle]	64.89979445
13	Bessemer Elementary [Elementary]	63.79791289
14	Julius I Foust Elementary [Elementary]	63.24697211
15	Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	61.86962016
16	Ferndale Middle [Middle]	59.94132743
17	Southern Middle [Middle]	59.11491626
18	Laurin Welborn Middle [Middle]	58.83944587
19	Northeast Guilford Middle [Middle]	57.18662353
20	Sedgefield Elementary [Elementary]	54.98286041
21	Kiser Middle [Middle]	54.70739002
22	Fairview Elementary [Elementary]	54.15644924
23	Herbin-Metz Education Center [Alternative]	54.08875348
24	Bluford Elementary [Elementary]	53.60550846
25	Waldo C Falkener Sr Elementary [Elementary]	53.60550846
26	Reedy Fork Elementary [Elementary]	53.60550846
27	Page High [High]	53.5378127
28	Allen Middle [Middle]	53.33003807
29	Kirkman Park Elementary [Elementary]	52.77909729
30	Eastern Middle [Middle]	52.5036269
31	Cyrus P Frazier Elementary [Elementary]	51.95268612
32	Guilford Elementary [Elementary]	51.12627495
33	McLeansville Elementary [Elementary]	50.85080456
34	Brightwood Elementary [Elementary]	50.57533417
35	Ronald E McNair Elementary [Elementary]	50.29986378
36	Western Guilford Middle [Middle]	50.29986378
37	Monticello-Brown Summit Elem [Elementary]	50.02439339
38	Eastern Guilford High [High]	49.95669763

Rank	School	Score
39	James Y Joyner Elementary [Elementary]	49.748923
40	Murphey Traditional Academy [Elementary]	49.47345261
41	Jamestown Elementary [Elementary]	49.19798222
42	Newcomers School [Alternative]	49.19798222
43	Vandalia Elementary [Elementary]	49.19798222
44	Allen Jay Elementary [Elementary]	48.92251183
45	John Van Lindley Elementary [Elementary]	48.92251183
46	Oak View Elementary [Elementary]	48.64704144
47	Penn-Griffin Middle [Middle]	48.09610066
48	Southern Elementary [Elementary]	48.09610066
49	Edwin A Alderman Elementary [Elementary]	47.26968949
50	Hunter Elementary [Elementary]	47.26968949
51	Triangle Lake Montessori Elem [Elementary]	47.26968949
52	Madison Elementary [Elementary]	46.9942191
53	George C. Simkins, Jr Elementary [Elementary]	46.9942191
54	Morehead Elementary [Elementary]	45.89233754
55	(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	45.27370101
56	Western Guilford High [High]	45.27370101
57	Grimsley High [High]	44.99823062
58	Archer Elementary [Elementary]	44.79045598
59	Erwin Montessori [Elementary]	44.51498559
60	Southeast Guilford High [High]	42.51899711
61	Lucy Ragsdale High [High]	42.24352672
62	Sedalia Elementary [Elementary]	41.96805633
63	Mendenhall Middle [Middle]	40.0397636
64	Nathanael Greene Elementary [Elementary]	36.45864853
65	Jamestown Middle [Middle]	34.25488541
66	Northern High [High]	34.25488541
67	Claxton Elementary [Elementary]	33.42847424
68	Southwest Guilford High [High]	33.42847424
69	Southwest Guilford Middle [Middle]	33.42847424
70	Pilot Elementary [Elementary]	32.32659268
71	Kernodle Middle [Middle]	32.05112229
72	Pleasant Garden Elementary [Elementary]	32.05112229
73	Southeast Guilford Middle [Middle]	31.50018151
74	Lincoln Academy [Middle]	31.22471112
75	Northern Middle [Middle]	31.22471112
76	Alamance Elementary [Elementary]	30.39829995
77	Northwest Guilford High [High]	30.39829995
78	Early College at Guilford [High]	29.84735917
79	Gibsonville Elementary [Elementary]	29.57188878
80	Northwest Guilford Middle [Middle]	29.57188878
81	Colfax Elementary [Elementary]	29.29641839

Rank	School	Score
82	Florence Elementary [Elementary]	29.29641839
83	Millis Road Elementary [Elementary]	28.74547761
84	Philip J Weaver Ed Center [High]	28.47000722
85	Allen Jay Middle - A Preparatory Academy [Middle]	27.91906644
86	Middle College High at NC A&T [High]	27.91906644
87	General Greene Elementary [Elementary]	27.36812566
88	Stokesdale Elementary [Elementary]	27.36812566
89	The Academy at Smith [High]	27.09265527
90	GTCC Middle College High [High]	27.09265527
91	Northern Elementary [Elementary]	27.09265527
92	Brooks Global [Elementary]	25.71530332
93	Brown Summit Middle [Middle]	25.71530332
94	The Kearns Academy at High Point Central [High]	25.71530332
95	Middle College High at Bennett [High]	25.71530332
96	Middle College High at Greensboro College [High]	25.71530332
97	GTCC East Middle College High [High]	25.71530332
98	High Point GTCC Middle College [High]	25.71530332
99	UNC-G Early/Middle College [High]	25.71530332
100	Oak Ridge Elementary [Elementary]	25.71530332
101	Pearce Elementary [Elementary]	25.71530332
102	Southwest Elementary [Elementary]	25.71530332
103	STEM Early College at NC A&T SU [High]	25.71530332
104	Summerfield Elementary [Elementary]	25.71530332

Table A.5

Prediction Data Schools, Ordered by Predicted Need;

Final Model 2, 2017-2018 School Year

Rank	School	Score
1	Fairview Elementary [Elementary]	60.87585242
2	Waldo C Falkener Sr Elementary [Elementary]	60.80726623
3	Bessemer Elementary [Elementary]	60.33859393
4	Bluford Elementary [Elementary]	58.82398222
5	Scale School [Alternative]	58.14383582
6	Otis L Hairston Sr Middle [Middle]	57.97237035
7	Kirkman Park Elementary [Elementary]	56.9835861
8	Jackson Middle [Middle]	55.98908633
9	Hunter Elementary [Elementary]	54.74310387
10	Julius I Foust Elementary [Elementary]	54.69166422
11	Laurin Welborn Middle [Middle]	52.72552675
12	Murphey Traditional Academy [Elementary]	52.20541481
13	Scale in High Point (Pruette Scale) [Alternative]	51.67387183
14	Newcomers School [Alternative]	51.43382016
15	Sedgefield Elementary [Elementary]	50.29071698
16	Brightwood Elementary [Elementary]	50.26785492
17	Cyrus P Frazier Elementary [Elementary]	50.06781186
18	Vandalia Elementary [Elementary]	49.80489813
19	Dudley High [High]	49.33051031
20	Allen Jay Elementary [Elementary]	49.15904483
21	Ronald E McNair Elementary [Elementary]	48.41602777
22	Ben L Smith High [High]	47.86162272
23	Oak View Elementary [Elementary]	47.68444173
24	Allen Middle [Middle]	47.6387176
25	Ferndale Middle [Middle]	47.41581248
26	Archer Elementary [Elementary]	47.37008836
27	T Wingate Andrews High [High]	46.82139883
28	James Y Joyner Elementary [Elementary]	46.49561442
29	Jamestown Elementary [Elementary]	45.8383301
30	Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	45.74116633
31	Guilford Elementary [Elementary]	45.72973529
32	Northeast Guilford Middle [Middle]	45.66686462
33	Morehead Elementary [Elementary]	43.55212374
34	Edwin A Alderman Elementary [Elementary]	43.29492552
35	Southern Middle [Middle]	43.26634794
36	Reedy Fork Elementary [Elementary]	42.72908945
37	Triangle Lake Montessori Elem [Elementary]	42.569055
38	Monticello-Brown Summit Elem [Elementary]	42.05465857

Rank	School	Score
39	Western Guilford Middle [Middle]	42.00893444
40	Madison Elementary [Elementary]	41.75745175
41	High Point Central High [High]	41.69458107
42	Kiser Middle [Middle]	40.80296059
43	John Van Lindley Elementary [Elementary]	40.80296059
44	Meredith Haynes-Inman School [Alternative]	40.71151234
45	Gateway Education Center [Alternative]	40.58005547
46	George C. Simkins, Jr Elementary [Elementary]	40.53433134
47	Northeast Guilford High [High]	40.52861583
48	Erwin Montessori [Elementary]	40.38572793
49	Eastern Middle [Middle]	39.08259031
50	Southern Elementary [Elementary]	39.01971963
51	Penn-Griffin Middle [Middle]	38.85396967
52	McLeansville Elementary [Elementary]	38.18525431
53	Southern Guilford High [High]	37.99664228
54	Sedalia Elementary [Elementary]	37.26505625
55	Allen Jay Middle - A Preparatory Academy [Middle]	37.11645284
56	Eastern Guilford High [High]	37.01928907
57	(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	36.61920295
58	Pilot Elementary [Elementary]	36.41344438
59	Mendenhall Middle [Middle]	36.37343577
60	Jamestown Middle [Middle]	35.89333243
61	Herbin-Metz Education Center [Alternative]	35.31606533
62	Middle College High at Bennett [High]	34.67021203
63	High Point GTCC Middle College [High]	34.47588449
64	Page High [High]	34.43587588
65	Gibsonville Elementary [Elementary]	34.00721219
66	Lucy Ragsdale High [High]	33.25276409
67	The Kearns Academy at High Point Central [High]	33.16703135
68	Lincoln Academy [Middle]	32.64120389
69	Middle College High at NC A&T [High]	32.49831599
70	Grimsley High [High]	32.35542809
71	Western Guilford High [High]	31.7838765
72	Pleasant Garden Elementary [Elementary]	31.33235075
73	Southwest Guilford Middle [Middle]	31.1723163
74	Millis Road Elementary [Elementary]	30.99513531
75	The Academy at Smith [High]	30.8122388
76	GTCC East Middle College High [High]	30.77223019
77	UNC-G Early/Middle College [High]	30.58933368
78	Nathanael Greene Elementary [Elementary]	29.95491142
79	Southeast Guilford Middle [Middle]	29.54910979
80	Alamance Elementary [Elementary]	29.3033426
81	Southwest Guilford High [High]	29.09758403

Rank	School	Score
82	Colfax Elementary [Elementary]	28.95469613
83	Claxton Elementary [Elementary]	28.45173074
84	General Greene Elementary [Elementary]	28.32598939
85	GTCC Middle College High [High]	28.188817
86	Brooks Global [Elementary]	27.74300676
87	Florence Elementary [Elementary]	27.48009303
88	Southeast Guilford High [High]	25.94833477
89	Stokesdale Elementary [Elementary]	23.99362834
90	Northern Middle [Middle]	22.97055099
91	Kernodle Middle [Middle]	22.28468908
92	Middle College High at Greensboro College [High]	22.23324944
93	STEM Early College at NC A&T SU [High]	22.22753392
94	Pearce Elementary [Elementary]	21.75886162
95	Summerfield Elementary [Elementary]	21.72456852
96	Northern High [High]	21.38735309
97	Southwest Elementary [Elementary]	21.18731003
98	Philip J Weaver Ed Center [High]	20.82723253
99	Northern Elementary [Elementary]	20.65576705
100	Northwest Guilford High [High]	18.5181641
101	Northwest Guilford Middle [Middle]	18.19809521
102	Brown Summit Middle [Middle]	17.44364712
103	Oak Ridge Elementary [Elementary]	17.43221608
104	Early College at Guilford [High]	17.16358684

Table A.6

Prediction Data Schools, Ordered by Predicted Need;

Final Model 3, 2017-2018 School Year

Rank	School	Score
1	Scale School [Alternative]	250.2414601
2	Scale in High Point (Pruette Scale) [Alternative]	210.7701705
3	Gateway Education Center [Alternative]	115.4701198
4	Dudley High [High]	104.8022036
5	T Wingate Andrews High [High]	103.3798148
6	Meredith Haynes-Inman School [Alternative]	101.957426
7	High Point Central High [High]	84.53316301
8	Ben L Smith High [High]	79.55480216
9	Northeast Guilford High [High]	77.77681614
10	Herbin-Metz Education Center [Alternative]	74.9320385
11	Page High [High]	74.2208441
12	Southern Guilford High [High]	71.37606646
13	Eastern Guilford High [High]	69.59808044
14	Otis L Hairston Sr Middle [Middle]	67.10890001
15	Jackson Middle [Middle]	66.0421084
16	Bessemer Elementary [Elementary]	64.61971959
17	Julius I Foust Elementary [Elementary]	63.90852518
18	(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	63.55292797
19	Western Guilford High [High]	63.55292797
20	Grimsley High [High]	63.19733077
21	Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	62.13053916
22	Southeast Guilford High [High]	59.99695593
23	Ferndale Middle [Middle]	59.64135873
24	Lucy Ragsdale High [High]	59.64135873
25	Sedalia Elementary [Elementary]	59.28576153
26	Southern Middle [Middle]	58.57456712
27	Laurin Welborn Middle [Middle]	58.21896991
28	Mendenhall Middle [Middle]	56.7965811
29	Northeast Guilford Middle [Middle]	56.08538669
30	Sedgefield Elementary [Elementary]	53.24060906
31	Kiser Middle [Middle]	52.88501185
32	Fairview Elementary [Elementary]	52.17381744
33	Nathanael Greene Elementary [Elementary]	52.17381744
34	Bluford Elementary [Elementary]	51.46262304
35	Waldo C Falkener Sr Elementary [Elementary]	51.46262304
36	Reedy Fork Elementary [Elementary]	51.46262304
37	Allen Middle [Middle]	51.10702583
38	Kirkman Park Elementary [Elementary]	50.39583142

Rank	School	Score
39	Eastern Middle [Middle]	50.04023422
40	Cyrus P Frazier Elementary [Elementary]	49.32903981
41	Jamestown Middle [Middle]	49.32903981
42	Northern High [High]	49.32903981
43	Claxton Elementary [Elementary]	48.2622482
44	Guilford Elementary [Elementary]	48.2622482
45	Southwest Guilford High [High]	48.2622482
46	Southwest Guilford Middle [Middle]	48.2622482
47	McLeansville Elementary [Elementary]	47.906651
48	Brightwood Elementary [Elementary]	47.55105379
49	Ronald E McNair Elementary [Elementary]	47.19545659
50	Western Guilford Middle [Middle]	47.19545659
51	Monticello-Brown Summit Elem [Elementary]	46.83985938
52	Pilot Elementary [Elementary]	46.83985938
53	James Y Joyner Elementary [Elementary]	46.48426218
54	Kernodle Middle [Middle]	46.48426218
55	Pleasant Garden Elementary [Elementary]	46.48426218
56	Murphey Traditional Academy [Elementary]	46.12866498
57	Jamestown Elementary [Elementary]	45.77306777
58	Newcomers School [Alternative]	45.77306777
59	Southeast Guilford Middle [Middle]	45.77306777
60	Vandalia Elementary [Elementary]	45.77306777
61	Allen Jay Elementary [Elementary]	45.41747057
62	Lincoln Academy [Middle]	45.41747057
63	John Van Lindley Elementary [Elementary]	45.41747057
64	Northern Middle [Middle]	45.41747057
65	Oak View Elementary [Elementary]	45.06187336
66	Alamance Elementary [Elementary]	44.35067895
67	Northwest Guilford High [High]	44.35067895
68	Penn-Griffin Middle [Middle]	44.35067895
69	Southern Elementary [Elementary]	44.35067895
70	Early College at Guilford [High]	43.63948455
71	Edwin A Alderman Elementary [Elementary]	43.28388734
72	Gibsonville Elementary [Elementary]	43.28388734
73	Hunter Elementary [Elementary]	43.28388734
74	Northwest Guilford Middle [Middle]	43.28388734
75	Triangle Lake Montessori Elem [Elementary]	43.28388734
76	Colfax Elementary [Elementary]	42.92829014
77	Florence Elementary [Elementary]	42.92829014
78	Madison Elementary [Elementary]	42.92829014
79	George C. Simkins, Jr Elementary [Elementary]	42.92829014
80	Millis Road Elementary [Elementary]	42.21709573
81	Philip J Weaver Ed Center [High]	41.86149853

Rank	School	Score
82	Morehead Elementary [Elementary]	41.50590132
83	Allen Jay Middle - A Preparatory Academy [Middle]	41.15030412
84	Middle College High at NC A&T [High]	41.15030412
85	General Greene Elementary [Elementary]	40.43910971
86	Stokesdale Elementary [Elementary]	40.43910971
87	The Academy at Smith [High]	40.08351251
88	Archer Elementary [Elementary]	40.08351251
89	GTCC Middle College High [High]	40.08351251
90	Northern Elementary [Elementary]	40.08351251
91	Erwin Montessori [Elementary]	39.7279153
92	Brooks Global [Elementary]	38.30552649
93	Brown Summit Middle [Middle]	38.30552649
94	The Kearns Academy at High Point Central [High]	38.30552649
95	Middle College High at Bennett [High]	38.30552649
96	Middle College High at Greensboro College [High]	38.30552649
97	GTCC East Middle College High [High]	38.30552649
98	High Point GTCC Middle College [High]	38.30552649
99	UNC-G Early/Middle College [High]	38.30552649
100	Oak Ridge Elementary [Elementary]	38.30552649
101	Pearce Elementary [Elementary]	38.30552649
102	Southwest Elementary [Elementary]	38.30552649
103	STEM Early College at NC A&T SU [High]	38.30552649
104	Summerfield Elementary [Elementary]	38.30552649

Table A.7

Prediction Data Schools, Ordered by Predicted Need;

Final Model 1, Combined School Years

Rank	School	Score
1	Fairview Elementary [Elementary]	61.56081968
2	Waldo C Falkener Sr Elementary [Elementary]	61.4878282
3	Bessemer Elementary [Elementary]	60.98905313
4	Bluford Elementary [Elementary]	59.3771581
5	Scale School [Alternative]	58.65332598
6	Otis L Hairston Sr Middle [Middle]	58.4708473
7	Scale School [Alternative]	58.19104665
8	Kirkman Park Elementary [Elementary]	57.41855356
9	Kirkman Park Elementary [Elementary]	56.45749916
10	Jackson Middle [Middle]	56.36017719
11	Otis L Hairston Sr Middle [Middle]	56.17769851
12	Bessemer Elementary [Elementary]	56.16553327
13	Fairview Elementary [Elementary]	55.94047622
14	Waldo C Falkener Sr Elementary [Elementary]	55.59984935
15	Hunter Elementary [Elementary]	55.03416543
16	Julius I Foust Elementary [Elementary]	54.97942182
17	Jackson Middle [Middle]	54.48064675
18	Laurin Welborn Middle [Middle]	52.88699958
19	Newcomers School [Alternative]	52.78967762
20	Murphey Traditional Academy [Elementary]	52.60111631
21	Murphey Traditional Academy [Elementary]	52.33348091
22	Scale in High Point (Pruette Scale) [Alternative]	52.24224157
23	Bluford Elementary [Elementary]	52.00501928
24	Scale in High Point (Pruette Scale) [Alternative]	51.76779699
25	Newcomers School [Alternative]	51.51232684
26	Julius I Foust Elementary [Elementary]	50.48436358
27	Hunter Elementary [Elementary]	50.36879375
28	Sedgefield Elementary [Elementary]	50.29580228
29	Brightwood Elementary [Elementary]	50.27147179
30	Laurin Welborn Middle [Middle]	50.24105867
31	Cyrus P Frazier Elementary [Elementary]	50.05857999
32	Vandalia Elementary [Elementary]	49.77877934
33	Dudley High [High]	49.27392165
34	Sedgefield Elementary [Elementary]	49.10969084
35	Ronald E McNair Elementary [Elementary]	48.30070201
36	Ben L Smith High [High]	47.7106876
37	Oak View Elementary [Elementary]	47.52212629
38	Allen Middle [Middle]	47.47346531

Rank	School	Score
39	Ferndale Middle [Middle]	47.23624302
40	Archer Elementary [Elementary]	47.18758204
41	Dudley High [High]	47.04159909
42	T Wingate Andrews High [High]	46.60365025
43	T Wingate Andrews High [High]	46.44550206
44	James Y Joyner Elementary [Elementary]	46.25694075
45	Cyrus P Frazier Elementary [Elementary]	46.12920567
46	Jamestown Elementary [Elementary]	45.55743913
47	Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	45.45403454
48	Guilford Elementary [Elementary]	45.4418693
49	Brightwood Elementary [Elementary]	45.33238209
50	Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	45.24722537
51	Ferndale Middle [Middle]	45.2289775
52	Ben L Smith High [High]	45.10124242
53	Allen Middle [Middle]	45.0951598
54	Archer Elementary [Elementary]	44.91876374
55	Vandalia Elementary [Elementary]	44.59638473
56	James Y Joyner Elementary [Elementary]	43.28253821
57	Morehead Elementary [Elementary]	43.12439002
58	Edwin A Alderman Elementary [Elementary]	42.85067199
59	Edwin A Alderman Elementary [Elementary]	42.84458937
60	Oak View Elementary [Elementary]	41.87745234
61	Ronald E McNair Elementary [Elementary]	41.69497366
62	Morehead Elementary [Elementary]	41.52466022
63	Western Guilford Middle [Middle]	41.48208186
64	High Point Central High [High]	41.14753761
65	Western Guilford Middle [Middle]	41.01980253
66	Kiser Middle [Middle]	40.54535796
67	High Point Central High [High]	40.53319271
68	Kiser Middle [Middle]	40.19864846
69	John Van Lindley Elementary [Elementary]	40.19864846
70	Guilford Elementary [Elementary]	39.99183928
71	Gateway Education Center [Alternative]	39.96142617
72	George C. Simkins, Jr Elementary [Elementary]	39.91276519
73	John Van Lindley Elementary [Elementary]	39.90059994
74	Erwin Montessori [Elementary]	39.75461699
75	Allen Jay Middle - A Preparatory Academy [Middle]	39.74245175
76	Jamestown Elementary [Elementary]	39.29842028
77	High Point GTCC Middle College [High]	38.34344851
78	Herbin-Metz Education Center [Alternative]	38.27045703
79	Penn-Griffin Middle [Middle]	38.12447409
80	Penn-Griffin Middle [Middle]	38.1001436
81	Gateway Education Center [Alternative]	37.98457376

Rank	School	Score
82	Erwin Montessori [Elementary]	37.62569902
83	George C. Simkins, Jr Elementary [Elementary]	37.48579869
84	Allen Jay Middle - A Preparatory Academy [Middle]	36.27535676
85	The Kearns Academy at High Point Central [High]	36.03205185
86	Pilot Elementary [Elementary]	35.85565579
87	(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	35.74616858
88	Pilot Elementary [Elementary]	35.52719416
89	Mendenhall Middle [Middle]	35.4846158
90	Herbin-Metz Education Center [Alternative]	34.35933058
91	Gibsonville Elementary [Elementary]	33.97612535
92	Mendenhall Middle [Middle]	33.75106831
93	Middle College High at Bennett [High]	33.67199421
94	High Point GTCC Middle College [High]	33.46518503
95	Page High [High]	33.42260667
96	Gibsonville Elementary [Elementary]	32.96640997
97	Middle College High at NC A&T [High]	32.47980014
98	Lucy Ragsdale High [High]	32.16350376
99	The Kearns Academy at High Point Central [High]	32.07226442
100	Shadybrook Elementary [Elementary]	32.03576868
101	(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	31.82287688
102	Page High [High]	31.76205065
103	Lincoln Academy [Middle]	31.51266312
104	Lucy Ragsdale High [High]	31.43358902
105	Middle College High at NC A&T [High]	31.36059755
106	Middle College High at Bennett [High]	31.28760608
107	Grimsley High [High]	31.20853198
108	Western Guilford High [High]	30.6002697
109	Grimsley High [High]	30.38129528
110	Southwest Guilford Middle [Middle]	29.94942906
111	Southwest Guilford Middle [Middle]	29.88860284
112	Millis Road Elementary [Elementary]	29.76086776
113	Western Guilford High [High]	29.67571104
114	The Academy at Smith [High]	29.66354579
115	The Academy at Smith [High]	29.56622383
116	GTCC East Middle College High [High]	29.52364547
117	Lincoln Academy [Middle]	29.38374515
118	UNC-G Early/Middle College [High]	29.32900154
119	GTCC East Middle College High [High]	29.20734909
120	Alamance Elementary [Elementary]	29.1039445
121	Millis Road Elementary [Elementary]	28.39836025
122	Southeast Guilford Middle [Middle]	28.3557819
123	Southeast Guilford Middle [Middle]	28.22196419
124	Alamance Elementary [Elementary]	27.96041141

Rank	School	Score
125	Southwest Guilford High [High]	27.74143699
126	Brooks Global [Elementary]	27.58937142
127	Southwest Guilford High [High]	27.37647963
128	Claxton Elementary [Elementary]	27.05410062
129	General Greene Elementary [Elementary]	26.92028292
130	GTCC Middle College High [High]	26.77429997
131	Allen Jay Elementary [Elementary]	26.6708142
132	GTCC Middle College High [High]	26.36068162
133	General Greene Elementary [Elementary]	26.33026851
134	Brooks Global [Elementary]	26.29985539
135	Florence Elementary [Elementary]	26.02005475
136	Claxton Elementary [Elementary]	25.85582393
137	Southeast Guilford High [High]	25.1806528
138	Florence Elementary [Elementary]	25.11982657
139	UNC-G Early/Middle College [High]	24.79744757
140	Southeast Guilford High [High]	24.38991184
141	Middle College High at Greensboro College [High]	24.0067066
142	Northeast Guilford Middle [Middle]	22.95433168
143	Allen Jay Elementary [Elementary]	22.78401824
144	Kernodle Middle [Middle]	20.74642079
145	Northeast Guilford Middle [Middle]	20.60643928
146	STEM Early College at NC A&T SU [High]	20.57610735
147	Kernodle Middle [Middle]	20.49095064
148	Summerfield Elementary [Elementary]	20.48486801
149	Pearce Elementary [Elementary]	20.46662014
150	Middle College High at Greensboro College [High]	20.43620703
151	STEM Early College at NC A&T SU [High]	20.43012441
152	Southern Middle [Middle]	20.39963011
153	Pearce Elementary [Elementary]	19.93134934
154	Summerfield Elementary [Elementary]	19.8948536
155	Reedy Fork Elementary [Elementary]	19.82786357
156	Triangle Lake Montessori Elem [Elementary]	19.65755013
157	Reedy Fork Elementary [Elementary]	19.37774948
158	Southwest Elementary [Elementary]	19.32308706
159	Monticello-Brown Summit Elem [Elementary]	19.11011408
160	Philip J Weaver Ed Center [High]	18.93988183
161	Southwest Elementary [Elementary]	18.81214675
162	Madison Elementary [Elementary]	18.79381769
163	Triangle Lake Montessori Elem [Elementary]	18.55051278
164	Philip J Weaver Ed Center [High]	18.45935463
165	Monticello-Brown Summit Elem [Elementary]	18.44710819
166	Meredith Haynes-Inman School [Alternative]	17.68069772
167	Northeast Guilford High [High]	17.48605379

Rank	School	Score
168	Southern Middle [Middle]	17.12717905
169	Northwest Guilford Middle [Middle]	17.0907645
170	Madison Elementary [Elementary]	16.67706496
171	Northwest Guilford High [High]	16.62240254
172	Northwest Guilford High [High]	16.48250222
173	Northwest Guilford Middle [Middle]	16.14187534
174	Eastern Middle [Middle]	15.94715023
175	Southern Elementary [Elementary]	15.88024138
176	Northeast Guilford High [High]	15.69168007
177	Eastern Middle [Middle]	15.39971418
178	Early College at Guilford [High]	15.36329963
179	Oak Ridge Elementary [Elementary]	15.32680389
180	Oak Ridge Elementary [Elementary]	15.18690357
181	Early College at Guilford [High]	15.04092062
182	McLeansville Elementary [Elementary]	14.99217845
183	Southern Guilford High [High]	14.7914519
184	Southern Elementary [Elementary]	14.32917257
185	Southern Guilford High [High]	14.22576798
186	Sedalia Elementary [Elementary]	14.01287618
187	Eastern Guilford High [High]	13.78173652
188	Eastern Guilford High [High]	13.7513234
189	McLeansville Elementary [Elementary]	13.41069653
190	Meredith Haynes-Inman School [Alternative]	12.90583884
191	Sedalia Elementary [Elementary]	12.59562508
192	Jamestown Middle [Middle]	12.55304672
193	Jamestown Middle [Middle]	11.67106641
194	Nathanael Greene Elementary [Elementary]	10.18690645
195	Pleasant Garden Elementary [Elementary]	8.222219293
196	Pleasant Garden Elementary [Elementary]	7.699113734
197	Nathanael Greene Elementary [Elementary]	6.233201643
198	Colfax Elementary [Elementary]	5.168742656
199	Colfax Elementary [Elementary]	4.189440387
200	Stokesdale Elementary [Elementary]	-0.11097392
201	Stokesdale Elementary [Elementary]	-0.2934526
202	Northern Middle [Middle]	-1.1997634
203	Northern Middle [Middle]	-1.41873782
204	Northern High [High]	-2.35546173
205	Northern Elementary [Elementary]	-2.87856729
206	Northern High [High]	-2.88464991
207	Northern Elementary [Elementary]	-3.66322563
208	Brown Summit Middle [Middle]	-7.03908127
209	Brown Summit Middle [Middle]	-7.08165963

Table A.8

Prediction Data Schools, Ordered by Predicted Need;

Final Model 2, Combined School Years

Rank	School	Score
1	Fairview Elementary [Elementary]	60.5612893
2	Waldo C Falkener Sr Elementary [Elementary]	60.4877731
3	Bessemer Elementary [Elementary]	59.98541243
4	Bluford Elementary [Elementary]	58.36192978
5	Scale School [Alternative]	57.63289417
6	Otis L Hairston Sr Middle [Middle]	57.44910368
7	Scale School [Alternative]	57.1672916
8	Kirkman Park Elementary [Elementary]	56.3892452
9	Kirkman Park Elementary [Elementary]	55.42128196
10	Jackson Middle [Middle]	55.32326036
11	Otis L Hairston Sr Middle [Middle]	55.13946987
12	Bessemer Elementary [Elementary]	55.12721717
13	Fairview Elementary [Elementary]	54.90054224
14	Waldo C Falkener Sr Elementary [Elementary]	54.55746666
15	Hunter Elementary [Elementary]	53.98771614
16	Julius I Foust Elementary [Elementary]	53.932579
17	Jackson Middle [Middle]	53.43021833
18	Laurin Welborn Middle [Middle]	51.82511472
19	Newcomers School [Alternative]	51.72709313
20	Murphey Traditional Academy [Elementary]	51.53717629
21	Murphey Traditional Academy [Elementary]	51.26761691
22	Scale in High Point (Pruette Scale) [Alternative]	51.17572166
23	Bluford Elementary [Elementary]	50.93679403
24	Scale in High Point (Pruette Scale) [Alternative]	50.69786639
25	Newcomers School [Alternative]	50.44055971
26	Julius I Foust Elementary [Elementary]	49.40520662
27	Hunter Elementary [Elementary]	49.28880598
28	Sedgefield Elementary [Elementary]	49.21528978
29	Brightwood Elementary [Elementary]	49.19078438
30	Laurin Welborn Middle [Middle]	49.16015264
31	Cyrus P Frazier Elementary [Elementary]	48.97636215
32	Vandalia Elementary [Elementary]	48.69455006
33	Dudley High [High]	48.18606304
34	Sedgefield Elementary [Elementary]	48.0206516
35	Allen Jay Elementary [Elementary]	48.00227256
36	Ronald E McNair Elementary [Elementary]	47.2058471
37	Ben L Smith High [High]	46.61159119
38	Oak View Elementary [Elementary]	46.42167435

Rank	School	Score
39	Allen Middle [Middle]	46.37266355
40	Ferndale Middle [Middle]	46.13373592
41	Archer Elementary [Elementary]	46.08472512
42	Dudley High [High]	45.93769273
43	T Wingate Andrews High [High]	45.49659556
44	T Wingate Andrews High [High]	45.33731047
45	James Y Joyner Elementary [Elementary]	45.14739363
46	Cyrus P Frazier Elementary [Elementary]	45.01874029
47	Jamestown Elementary [Elementary]	44.44286342
48	Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	44.33871548
49	Guilford Elementary [Elementary]	44.32646278
50	Northeast Guilford Middle [Middle]	44.25907293
51	Brightwood Elementary [Elementary]	44.21618848
52	Aycock Middle (Dr. Melvin C. Swann Jr. Middle School) [Middle]	44.13041959
53	Ferndale Middle [Middle]	44.11204054
54	Allen Jay Elementary [Elementary]	44.08753514
55	Ben L Smith High [High]	43.9833872
56	Allen Middle [Middle]	43.97726085
57	Archer Elementary [Elementary]	43.79959671
58	Vandalia Elementary [Elementary]	43.47490018
59	James Y Joyner Elementary [Elementary]	42.15160866
60	Morehead Elementary [Elementary]	41.99232357
61	Northeast Guilford Middle [Middle]	41.89430197
62	Edwin A Alderman Elementary [Elementary]	41.71663783
63	Edwin A Alderman Elementary [Elementary]	41.71051149
64	Southern Middle [Middle]	41.68600609
65	Reedy Fork Elementary [Elementary]	41.11012922
66	Triangle Lake Montessori Elem [Elementary]	40.93859143
67	Oak View Elementary [Elementary]	40.73642189
68	Reedy Fork Elementary [Elementary]	40.65677935
69	Ronald E McNair Elementary [Elementary]	40.55263141
70	Monticello-Brown Summit Elem [Elementary]	40.38721997
71	Morehead Elementary [Elementary]	40.38109362
72	Western Guilford Middle [Middle]	40.33820917
73	Madison Elementary [Elementary]	40.06864978
74	High Point Central High [High]	40.00125994
75	Western Guilford Middle [Middle]	39.8726066
76	Triangle Lake Montessori Elem [Elementary]	39.8235958
77	Monticello-Brown Summit Elem [Elementary]	39.71944786
78	Kiser Middle [Middle]	39.39475132
79	High Point Central High [High]	39.38249863
80	Kiser Middle [Middle]	39.0455494
81	John Van Lindley Elementary [Elementary]	39.0455494

Rank	School	Score
82	Meredith Haynes-Inman School [Alternative]	38.9475278
83	Guilford Elementary [Elementary]	38.83725351
84	Gateway Education Center [Alternative]	38.80662176
85	George C. Simkins, Jr Elementary [Elementary]	38.75761096
86	Northeast Guilford High [High]	38.75148461
87	John Van Lindley Elementary [Elementary]	38.74535826
88	Erwin Montessori [Elementary]	38.59832587
89	Allen Jay Middle - A Preparatory Academy [Middle]	38.58607317
90	Southern Middle [Middle]	38.39002999
91	Jamestown Elementary [Elementary]	38.13884965
92	Madison Elementary [Elementary]	37.93668011
93	Eastern Middle [Middle]	37.20151816
94	High Point GTCC Middle College [High]	37.17701276
95	Southern Elementary [Elementary]	37.13412831
96	Herbin-Metz Education Center [Alternative]	37.10349656
97	Penn-Griffin Middle [Middle]	36.95646417
98	Northeast Guilford High [High]	36.94421147
99	Penn-Griffin Middle [Middle]	36.93195877
100	Gateway Education Center [Alternative]	36.81555813
101	Eastern Middle [Middle]	36.65014669
102	Erwin Montessori [Elementary]	36.4541035
103	George C. Simkins, Jr Elementary [Elementary]	36.31319746
104	McLeansville Elementary [Elementary]	36.23968127
105	Southern Guilford High [High]	36.03751173
106	Southern Elementary [Elementary]	35.57190916
107	Southern Guilford High [High]	35.46776121
108	Sedalia Elementary [Elementary]	35.25333898
109	Allen Jay Middle - A Preparatory Academy [Middle]	35.09405388
110	Eastern Guilford High [High]	35.02053769
111	Eastern Guilford High [High]	34.98990594
112	The Kearns Academy at High Point Central [High]	34.8489999
113	Pilot Elementary [Elementary]	34.67133576
114	McLeansville Elementary [Elementary]	34.64683036
115	(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	34.56106147
116	Pilot Elementary [Elementary]	34.34051288
117	Mendenhall Middle [Middle]	34.29762843
118	Meredith Haynes-Inman School [Alternative]	34.13834334
119	Sedalia Elementary [Elementary]	33.82589951
120	Jamestown Middle [Middle]	33.78301506
121	Herbin-Metz Education Center [Alternative]	33.16425375
122	Jamestown Middle [Middle]	32.89469437
123	Gibsonville Elementary [Elementary]	32.77829372
124	Mendenhall Middle [Middle]	32.55161879

Rank	School	Score
125	Middle College High at Bennett [High]	32.47197624
126	High Point GTCC Middle College [High]	32.26368036
127	Page High [High]	32.22079591
128	Gibsonville Elementary [Elementary]	31.76131969
129	Nathanael Greene Elementary [Elementary]	31.39986506
130	Middle College High at NC A&T [High]	31.27121172
131	Lucy Ragsdale High [High]	30.95264153
132	The Kearns Academy at High Point Central [High]	30.86074629
133	Shadybrook Elementary [Elementary]	30.82398819
134	(C. Joyner) Greene Education Center @ Ragsdale [Alternative]	30.60956596
135	Page High [High]	30.54830246
136	Lincoln Academy [Middle]	30.29712212
137	Lucy Ragsdale High [High]	30.21747958
138	Middle College High at NC A&T [High]	30.14396338
139	Middle College High at Bennett [High]	30.07044719
140	Grimsley High [High]	29.99080464
141	Pleasant Garden Elementary [Elementary]	29.42105413
142	Western Guilford High [High]	29.37816968
143	Grimsley High [High]	29.15762109
144	Pleasant Garden Elementary [Elementary]	28.89418806
145	Southwest Guilford Middle [Middle]	28.72265027
146	Southwest Guilford Middle [Middle]	28.66138677
147	Millis Road Elementary [Elementary]	28.53273343
148	Western Guilford High [High]	28.44696454
149	The Academy at Smith [High]	28.43471184
150	The Academy at Smith [High]	28.33669024
151	GTCC East Middle College High [High]	28.2938058
152	Lincoln Academy [Middle]	28.15289975
153	UNC-G Early/Middle College [High]	28.09776261
154	GTCC East Middle College High [High]	27.97523561
155	Alamance Elementary [Elementary]	27.87108767
156	Nathanael Greene Elementary [Elementary]	27.4177378
157	Millis Road Elementary [Elementary]	27.16043111
158	Southeast Guilford Middle [Middle]	27.11754667
159	Southeast Guilford Middle [Middle]	26.98276697
160	Alamance Elementary [Elementary]	26.71933394
161	Southwest Guilford High [High]	26.49878535
162	Brooks Global [Elementary]	26.34562661
163	Colfax Elementary [Elementary]	26.34562661
164	Southwest Guilford High [High]	26.13120438
165	Claxton Elementary [Elementary]	25.80650785
166	General Greene Elementary [Elementary]	25.67172815
167	GTCC Middle College High [High]	25.52469576

Rank	School	Score
168	Colfax Elementary [Elementary]	25.35928432
169	GTCC Middle College High [High]	25.10810399
170	General Greene Elementary [Elementary]	25.07747224
171	Brooks Global [Elementary]	25.04684049
172	Florence Elementary [Elementary]	24.76502841
173	Claxton Elementary [Elementary]	24.59961697
174	Southeast Guilford High [High]	23.91959216
175	Florence Elementary [Elementary]	23.85832866
176	UNC-G Early/Middle College [High]	23.53363213
177	Southeast Guilford High [High]	23.12316671
178	Middle College High at Greensboro College [High]	22.73720668
179	Stokesdale Elementary [Elementary]	21.02795513
180	Stokesdale Elementary [Elementary]	20.84416465
181	Northern Middle [Middle]	19.93133855
182	Northern Middle [Middle]	19.71078996
183	Kernodle Middle [Middle]	19.45348328
184	STEM Early College at NC A&T SU [High]	19.28194549
185	Kernodle Middle [Middle]	19.19617659
186	Summerfield Elementary [Elementary]	19.19005025
187	Pearce Elementary [Elementary]	19.1716712
188	Middle College High at Greensboro College [High]	19.14103945
189	STEM Early College at NC A&T SU [High]	19.1349131
190	Northern High [High]	18.76733212
191	Pearce Elementary [Elementary]	18.63255243
192	Summerfield Elementary [Elementary]	18.59579433
193	Northern Elementary [Elementary]	18.24046605
194	Northern High [High]	18.2343397
195	Southwest Elementary [Elementary]	18.01991747
196	Philip J Weaver Ed Center [High]	17.63395744
197	Southwest Elementary [Elementary]	17.5053041
198	Northern Elementary [Elementary]	17.45016695
199	Philip J Weaver Ed Center [High]	17.14997582
200	Northwest Guilford Middle [Middle]	15.77154715
201	Northwest Guilford High [High]	15.29981823
202	Northwest Guilford High [High]	15.15891219
203	Northwest Guilford Middle [Middle]	14.81583661
204	Brown Summit Middle [Middle]	14.05004291
205	Early College at Guilford [High]	14.03166386
206	Brown Summit Middle [Middle]	14.00715846
207	Oak Ridge Elementary [Elementary]	13.99490576
208	Oak Ridge Elementary [Elementary]	13.85399972
209	Early College at Guilford [High]	13.70696733