# Analysis of Book Shelving Patterns in the Royal Palm Beach Library


## Abstract

### Problem

My initial question was posed to me by my coworker in the summer of 2023: "How much time would it take you to shelve every book in this library?" Through exploring this question, I have also branched out to wonder if other factors (ie. the time of day, category of book shelved, the amount of books shelved) impacts how quickly I shelve books.

### Approach

To count how many books were in the library, I utilized statistical stratification and representative sampling to estimate the total number of books in the library. I also needed to determine the time it takes for me to shelve books in each section of the library. I did this by marking down the time of day, the amount of books, and the section the books belonged to (I separated them by section because each book category has different shapes and sizes, which I assumed would allow me to shelve some sections quicker than others). I then timed the amount of time it took me to shelve these books. I did this for every single book I shelved from 07/13/2023 to 02/29/2024 (the date this is being written).

The categories of books I noted as significantly different from one another are as follows: Fiction, Large Print, Mystery, Science Fiction, Spanish Fiction, Spanish Non-Fiction, Non-Fiction #00-399, Non-Fiction 400-500, Non-Fiction 600-640, Non-Fiction 641, Non-Fiction 642-699, Non-Fiction 700-799, Non-Fiction 800-999, Biographies, Graphic Novels, Young Adult, Juvenile Sunshine State Readers, Juvenile Fiction, Juvenile Non-Fiction, Juvenile Biographies, Juvenile Graphic Novels, Easy-Juvenile Spanish, Beginning Readers Fiction, Beginning Readers Non-Fiction, Juvenile Specials, Board Books, VOX (Read-Aloud Books), and Easies.

### Results

I found that there is roughly 59,000 books on the shelves of the Royal Palm Beach Library. I found the time it takes for me to shelve 1 book in each category, and noticed that the time/book varied significantly between sections. By multiplying the time/book unit for each category by its corresponding estimated amount of books for that section, I was able to find the total amount of time it would take me to shelve every book in the library. This time is 11.07214 days.

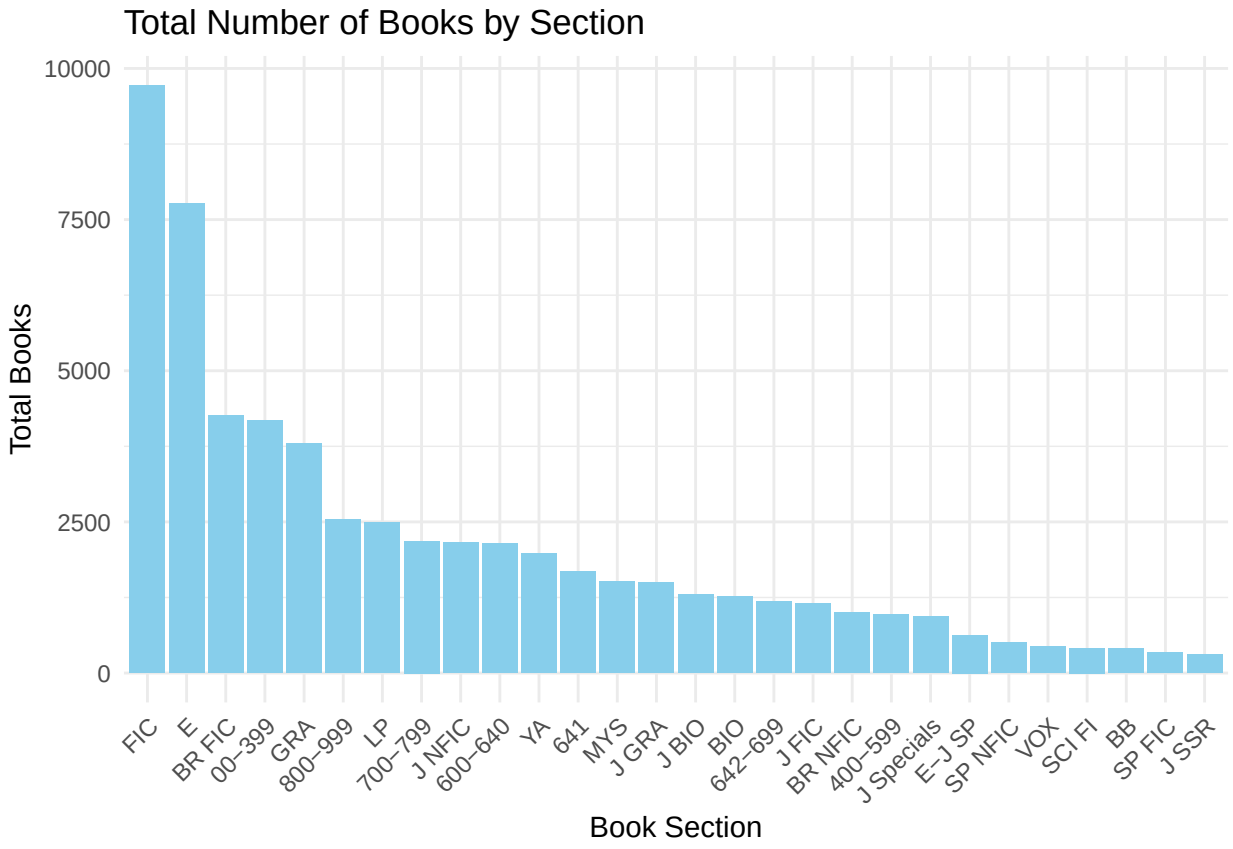
I also found that given the number of books and the section of those books, I am able to use a regression model to accurately predict the amount of time it will take for me to shelve those books. I have found that the relationship between the number + section of books and the amount of time it takes for me to shelve those books is not linear, but rather more closely follows a square root function. I believe that this is because as I grab more and more books to shelve in a single sitting, I grow tired and my efficency decreases.

### Conclusion

My main findings were that there is a significant correlation between the number + section of books and the amount of time it takes for me to shelve those books. I also found the calculation of the amount of time it would take for me to shelve every book in the library to be around 11.07214 days. There are some confounding variables to these findings however, such as the fact that the library constantly throws out books to make space for new ones. My calculation of the actual amount of books in the library is only an estimate, and does not account for books that were circulating with library members. More calculations of more current estimates of the amount of books in the library would be needed to verify my initial estimation.

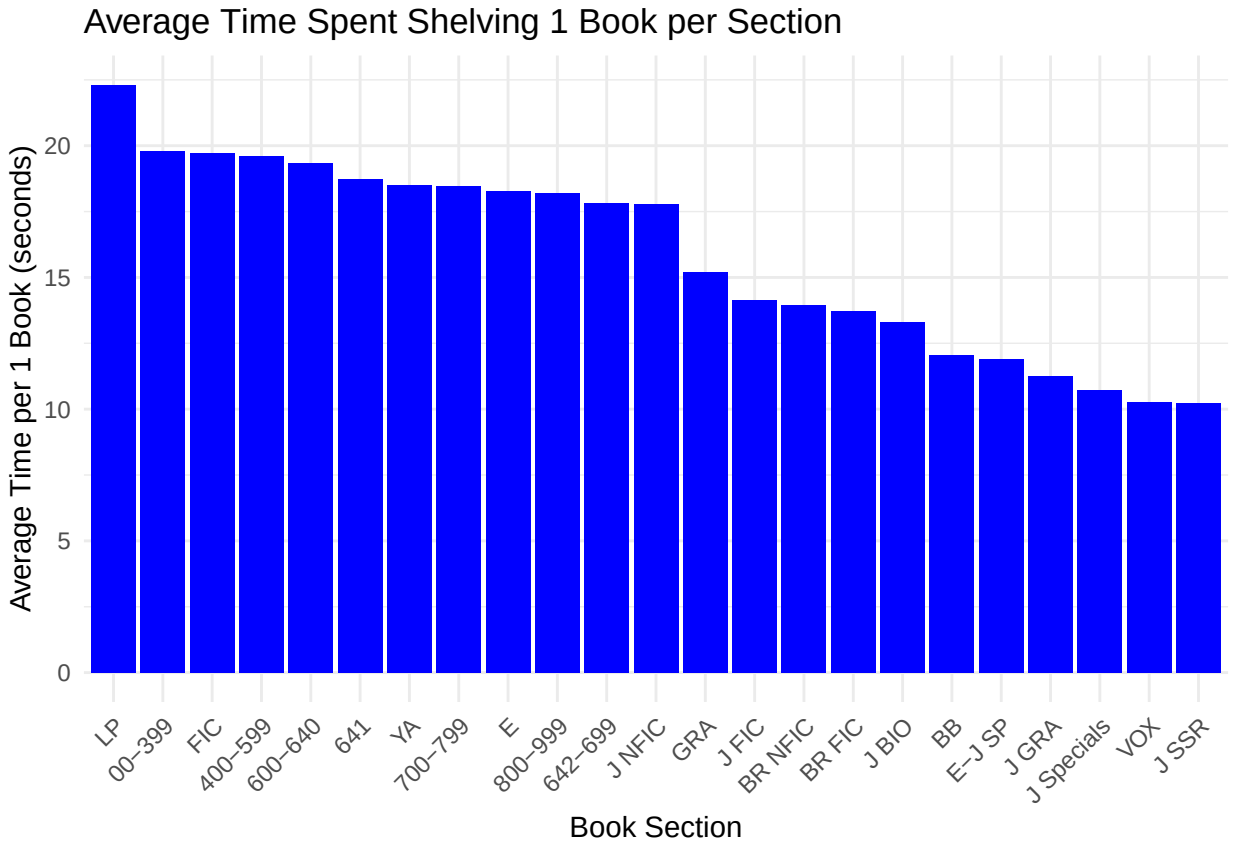
## Results

### #1: Total Estimated Number of Books by Section



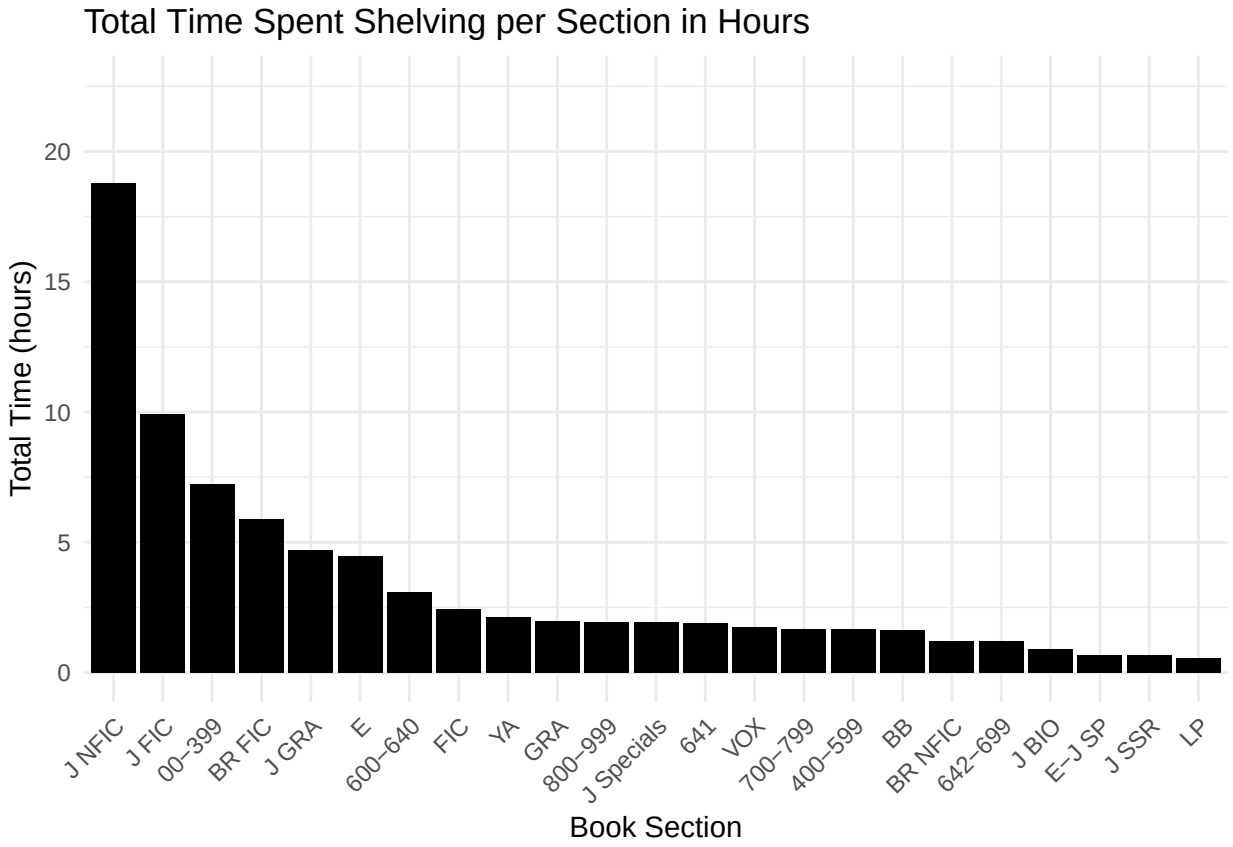
**#2: Average Amount of Time Spent Shelving 1 Book per Section**

This graph shows a visual of the average amount of time it took for me to shelve 1 book for every section in the library. Sections toward the left tend to have more books in a smaller space, making it harder to shelve new books without rearranging in some way. The opposite is true for those towards the right.



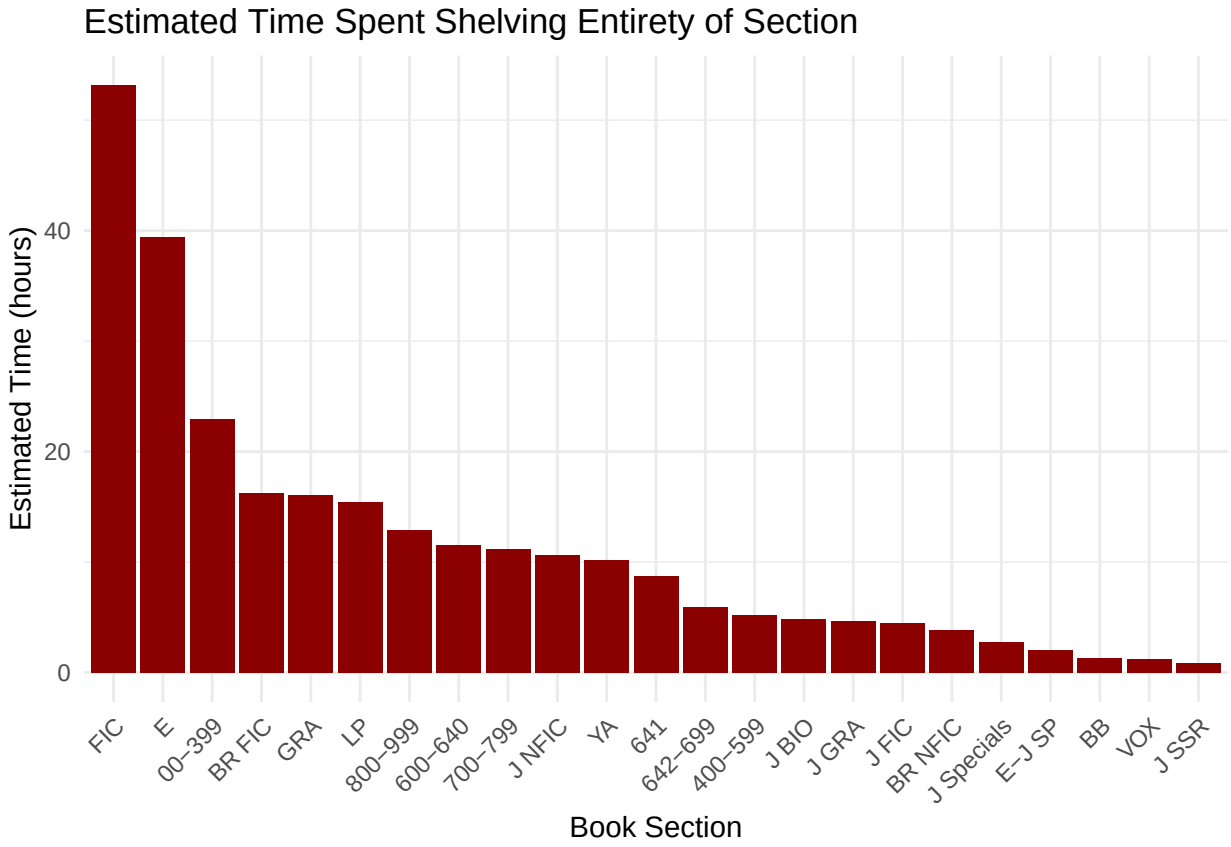
**#3: Total Amount of Time Spent Shelving in Each Section**

I have not spent my time shelving books equally in each section, as some sections have their books circulate more, requiring me to shelve them more often than others. As shown in the graph, categories in the Children's Section have taken up the majority of my shelving time.



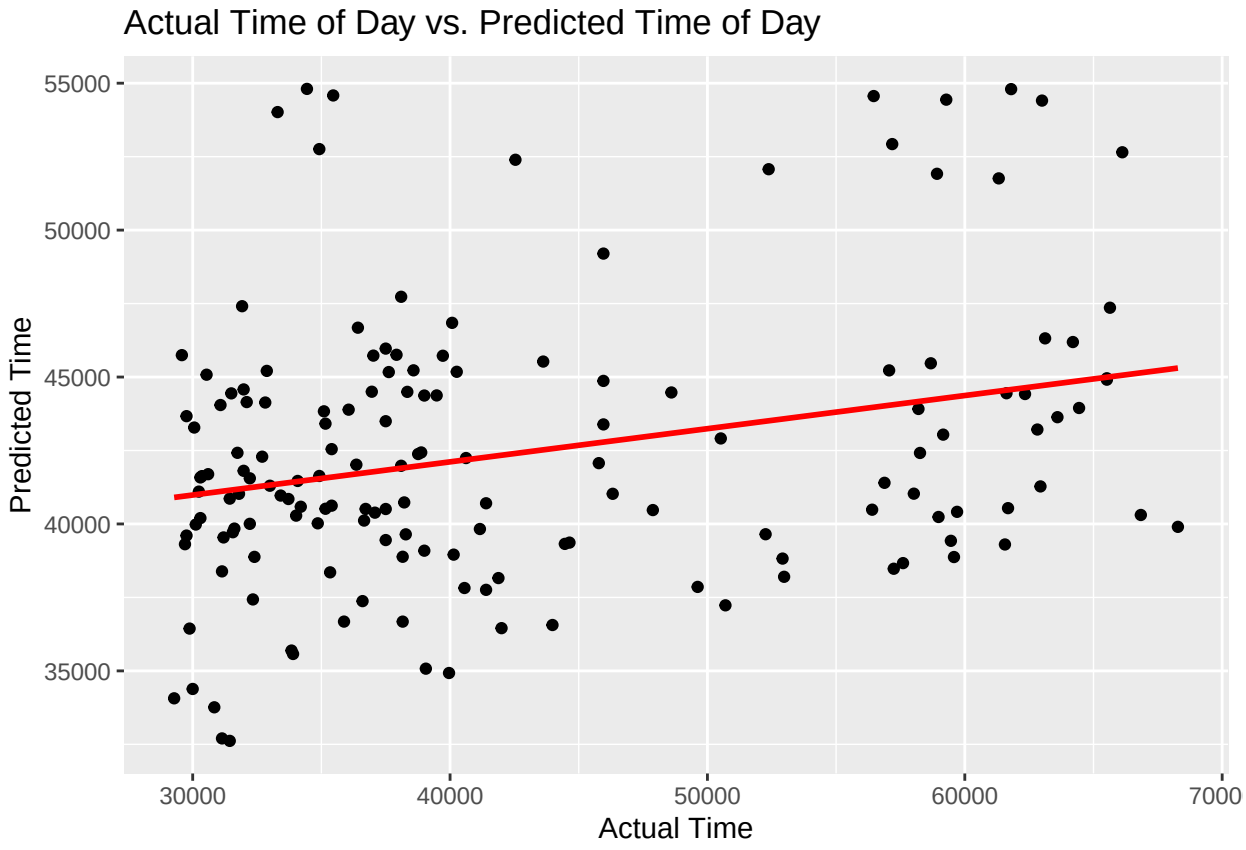
**#4: Estimated Total Amount of Time to Shelve Every Book in the Library**

I multiplied the time it takes for me to shelve 1 book for each category by the amount of estimated books in that category. This gives me the estimated amount of time it would take for me to shelve every book in that section. In total, this would take 956,632.8 seconds or 15943.88 minutes or 265.7313 hours or 11.07214 days.



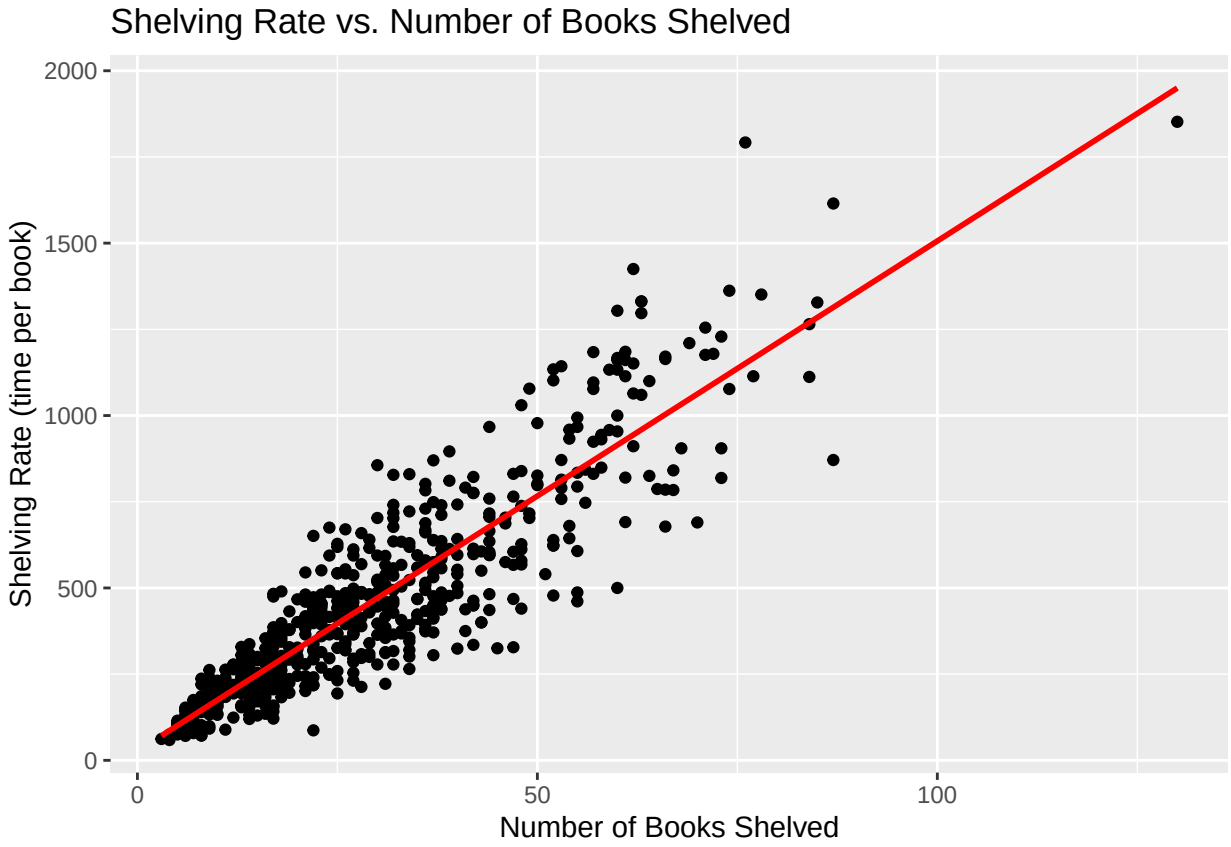
**#5: Failed Attempt at Predicting the Time I Shelved a Book**

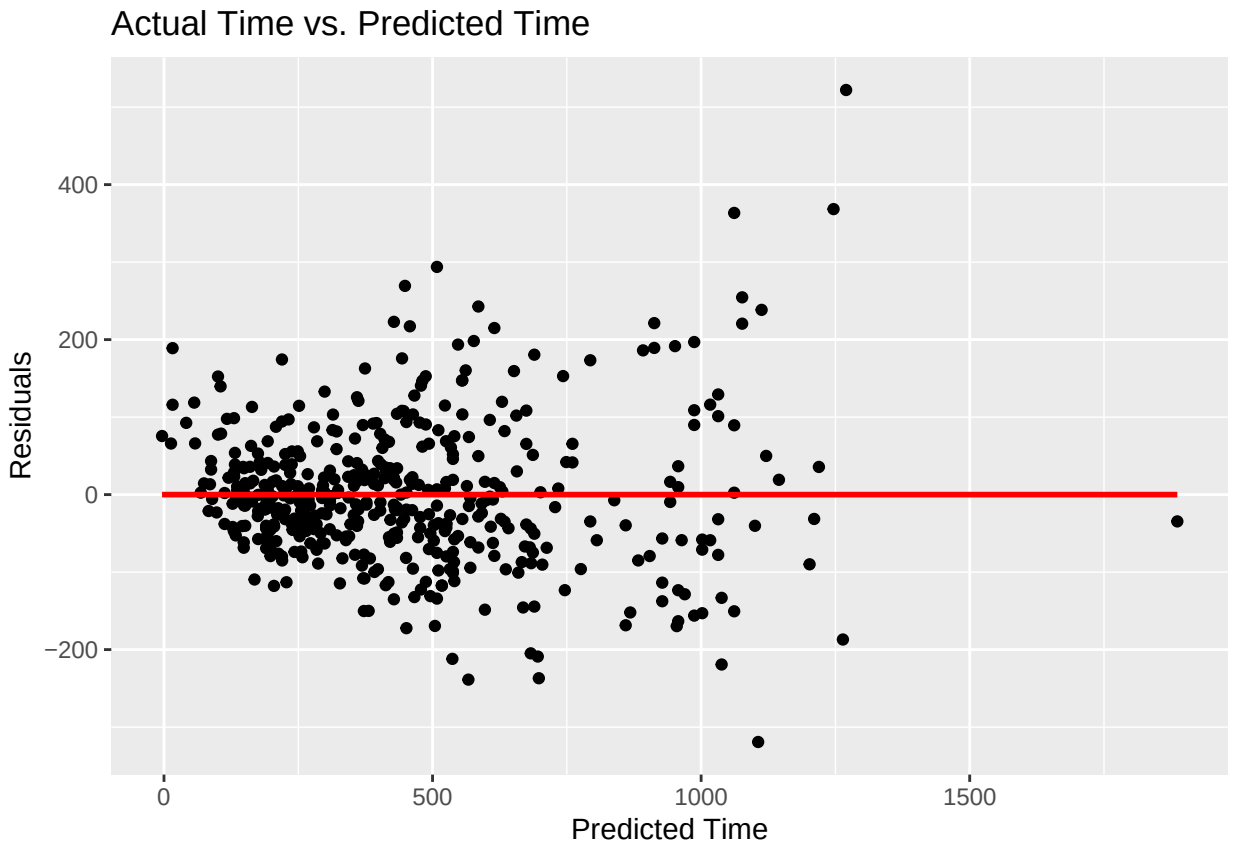
I was curious to see if I was quicker at shelving specific sections during different times of the day (ie. I shelve books in the children's section quicker in the morning, but books in the adult fiction section quicker in the afternoon). After several forms of regression testing, I found that there is no correlation between the amount of books shelved + the time it took me to shelve those books and the time of day. This is shown by the horribly inaccurate regression line with an r^2 of 0.11.



**#6: Regression Model to Predict Time Taken to Shelve Books**

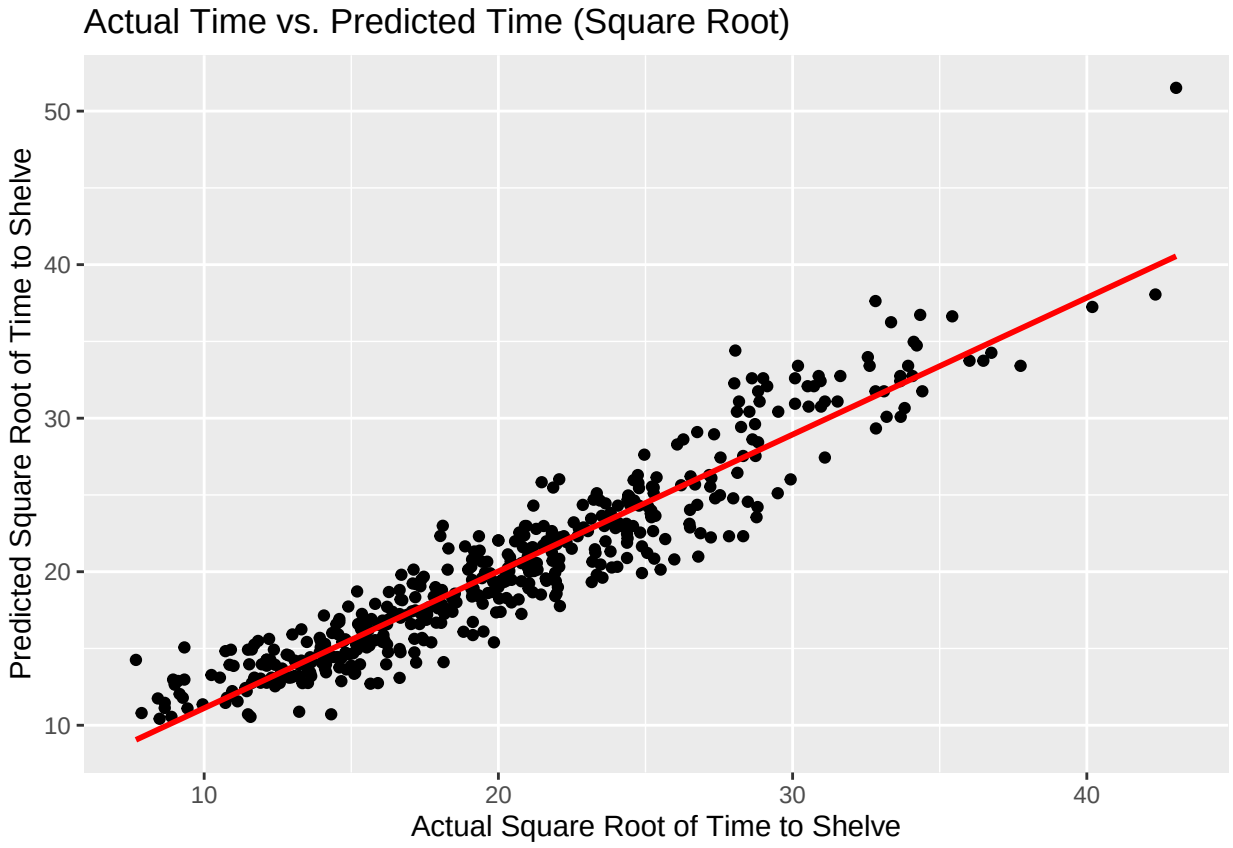
I used a regression model to have it predict the amount of time it took for me to shelve books by only giving it the amount of books I shelved and the section of books they belonged to. With this, I found that it was accurately able to predict it, with an r^2 of 0.8925. However, I noticed in the residual plot that the data points had a funnel shape, which clued me in to look into different forms of representing the time data.

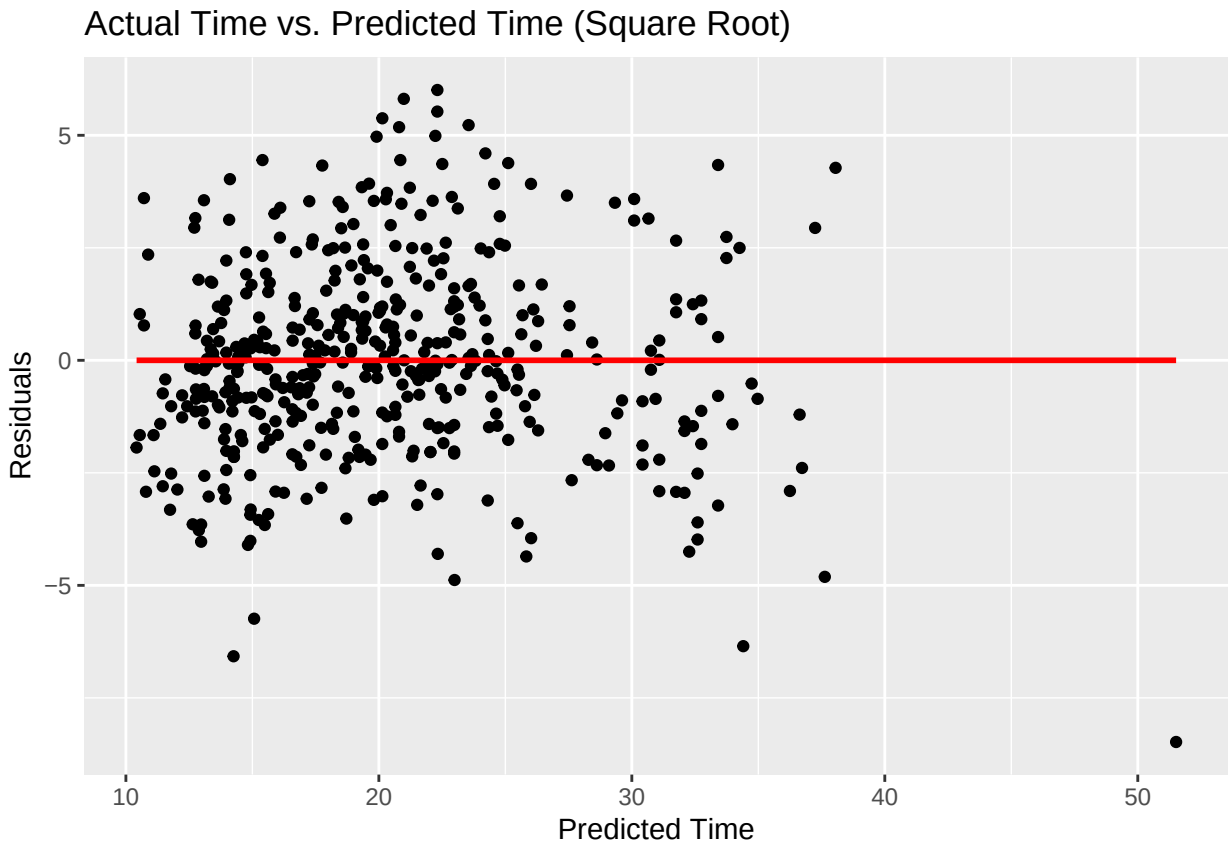



Actual Time vs. Predicted Time
Residuals
400
200
0
−200
0
500
1000
1500
Predicted Time

**#7: Square Root Regression Model to Predict Time Taken to Shelve Books**

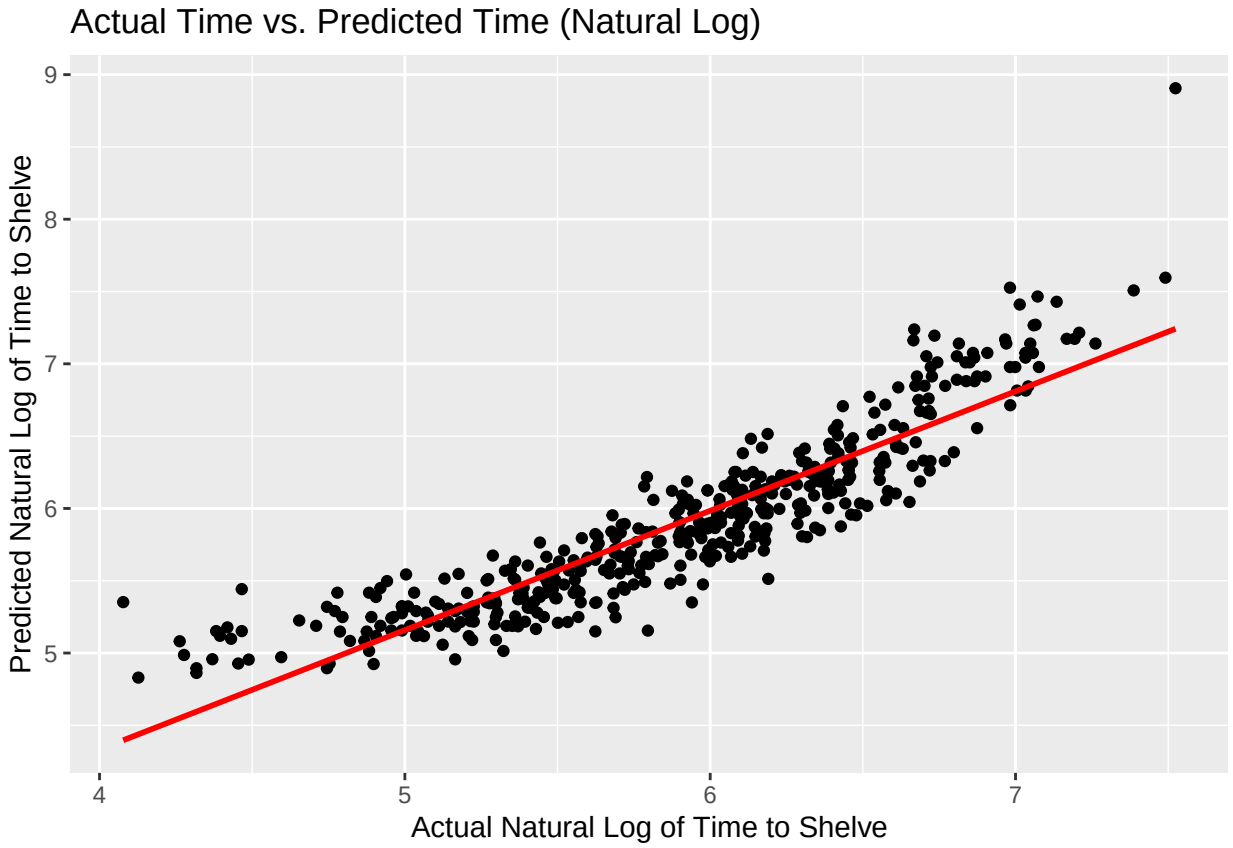
I used the same regression model as #5, except I asked it to predict the square root of the time that it took for me to shelve the books. By using this model, I found that the pattern in the residual plot went away, indicating that this is a good model. Furthermore, I found that the r^2 was higher for this model, being 0.9439279.

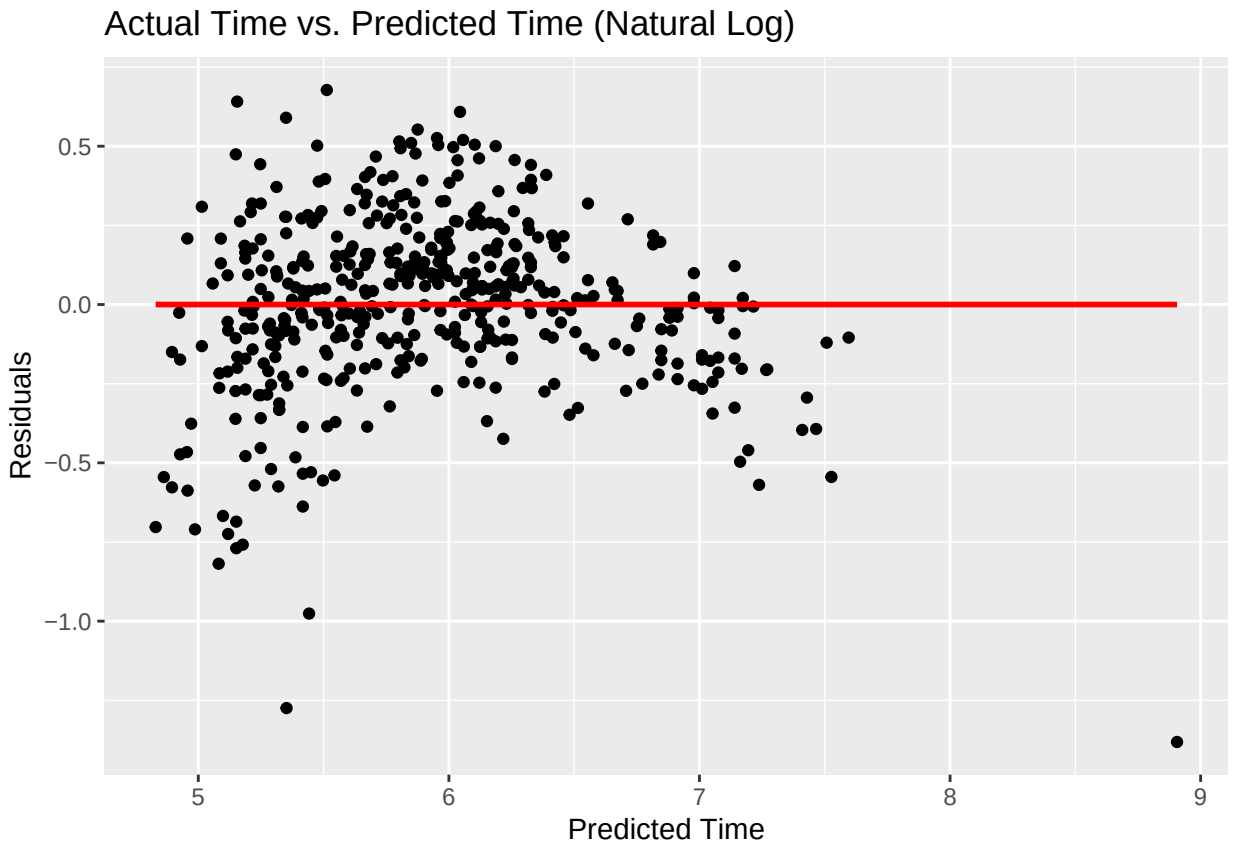



Actual Time vs. Predicted Time (Square Root)
Residuals
5
0
−5
10
20
30
40
50
Predicted Time

**#8: Natural Log Regression Model to Predict Time Taken to Shelve Books**

I also tested to see if taking the natural log of time was a better fit for my data than taking the square root. Noted by the obvious pattern in the residual graph and the lowered r^2 value of 0.9086446, it was not.




Actual Time vs. Predicted Time (Natural Log)
Residuals
0.5
0.0
−0.5
−1.0
5
6
7
8
9
Predicted Time

## Discussion

With my results, I can conclude that the time it takes to shelve books in the Royal Palm Beach Library is influenced by both the number of books and the specific section they belong to. I also discovered that the relationship between the number and section of books and the time it takes to shelve them is not linear. A regression model, particularly one using the square root transformation of time, provided a better fit, with an improved R-squared value of 0.9439279 compared to a linear model.

While the regression models proved successful, attempting to predict the time of day based on the number of books and time taken to shelve them did not yield meaningful results. The lack of correlation suggests that the time of day does not significantly impact the shelving efficiency.

It's essential to acknowledge potential limitations in the study, such as the assumption of consistent shelving patterns over time and the estimated count of books. The calculation of the total time needed to shelve all books assumes a constant rate, not accounting for factors like fatigue or changing shelving conditions. Further research and refined estimates may improve the accuracy of predictions and account for additional factors affecting shelving efficiency.

In the future, I could use these regression models to predict how long it will take me to shelve a particular number of books in a section before I shelve it. This will allow me to optimize my time and ensure that I have enough time to shelve what I want to in my allotted shifts.