

Dream Bus: Improving Teenagers’ Accessibility of Service via Mobile Library

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1 Introduction

To better serve for each community, the Madison Library System deploys a mobile library named “Dream Bus” besides stationary libraries. The Dream Bus visits a dozen locations throughout the Madison area every weekday. Patrons could access resources like a regular library on the the Dream Bus, like browsing, checking out and returning items, placing and picking up holds, using the free WiFi, etc.

During Covid-19, the service of stationary libraries is limited whereas the Dream Bus as a mobile library provides more flexibility. This project intends to improve the service of the Dream Bus, including its stations, schedule, and items in the bus, to serve teenagers in the special time better and hopefully reach more people in the long run.

2 Circulation at Stationary Libraries Under COVID-19

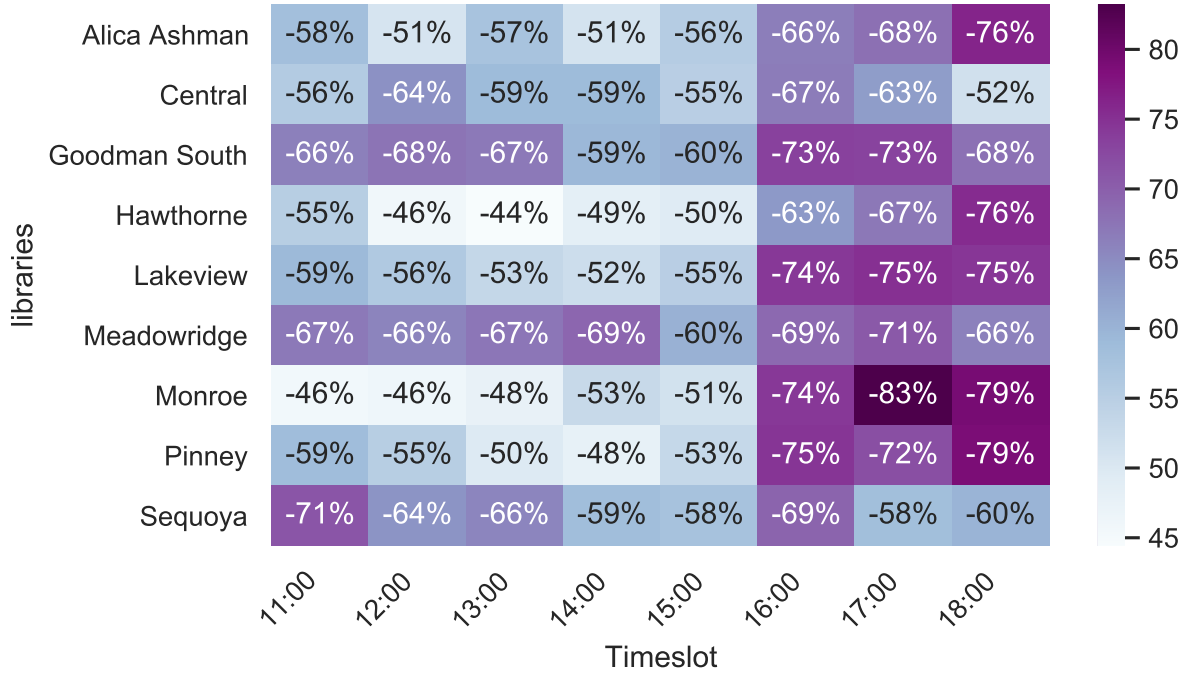


Figure 1: Circulation Drop following COVID-19 Outbreak

To demonstrate how library visitors’ flow changes during COVID-19 and identify the busy time, we generate Figure 1 the heat map about circulation drop following COVID-19 outbreak.

Each library is labeled on the y-axis, and the time is labeled on the x-axis. Across all time slots at all libraries, circulation dropped 44-83% following the COVID-19 outbreak.

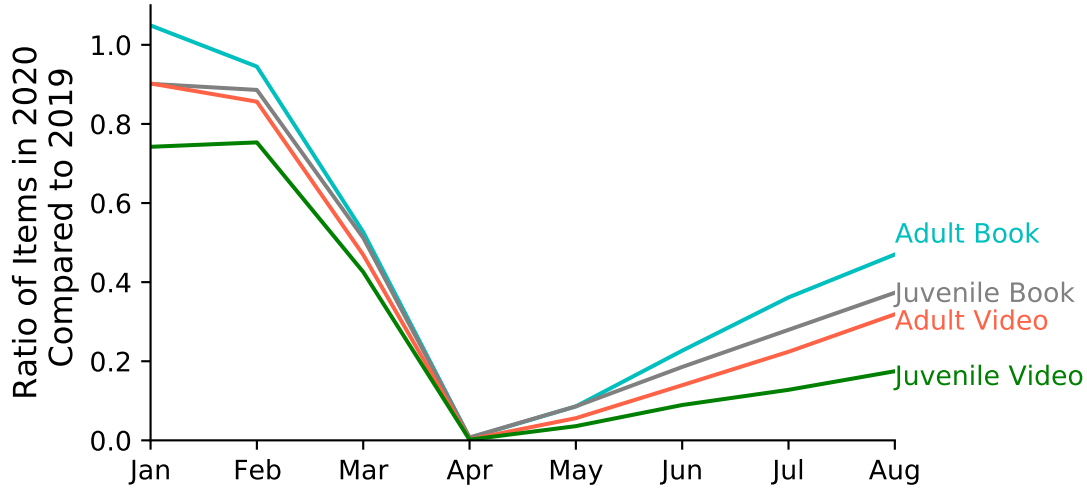


Figure 2: Circulated Time Proportion of 2020 in Different Age Group

Figure 2 demonstrates the total monthly averagely circulated time in 2020, divided by that in 2019. According to the data, the book and video for adult has decreased by 54% and 63% respectively, while for juvenile has decreased by 60% and 71%. Therefore, the book's preference is more stable than the video, and the pandemic has less influence on adults than juveniles. Thus, we need to provide more access to library resources during the pandemic via our Dream Bus.

People in pandemic subscribe to more stream media than before, thus reduce the circulation. Library was primarily used to circulate books; people interested in the video were discouraged by the pandemic. For different age groups, it could be that students studied at home rely more on the computer.

3 Dream Bus: Station & Schedule Arrangement

3.1 Current Distribution

The biggest group of patrons of the Dream Bus is juveniles. In this project, we employed the data about the percentage of teenagers in each community as the color division of our maps to show the proportion of juveniles in each community in the City of Madison. Our goal is to let teenagers go to any Dream Bus Stations near them as conveniently as possible. In Figure 3, the darker the color is, the more teenagers that community has. Based on current distributions of stationary libraries and the Dream Bus stations, we found that most communities in Madison's center have been covered by either stationary libraries or the Dream Bus stations.

However, from Figure 3, the distribution of the Dream Bus stations are not efficient enough since there are still some communities that have a large percentage of teenagers, but they are not covered by any Dream Bus stations now. Specifically, some communities in the west, some communities in the southeast, some communities in the east, and some communities in the northeast are all not covered by any Dream Bus stations. Therefore, the red points in Figure 3 will be the new stations we plan to add.

Therefore, these areas mentioned above will be what we want to improve in this project. In this project, we aim to let more teenagers go to the Dream Bus stations near them more conveniently, and disperse some patron flow from stationary libraries.

3.2 New Station Operation

Based on what we mentioned in Figure 3, we recommend adding four new Dream Bus stations in the communities that have around more than 35% of teenagers. The new stations are added in Figure 4, which are Blackhawk, Bur Oaks, Worthington Park, and Secret Places. After adding these four new stations, most communities, which have around 35% of teenagers of the total population, have been covered.

As for the schedule, we hope the Dream Bus can have one more function of dispersing some patron follow of near libraries, so we planned to decide the time slot of the new Dream Bus stations from three

Dream Bus Stations & Library Locations

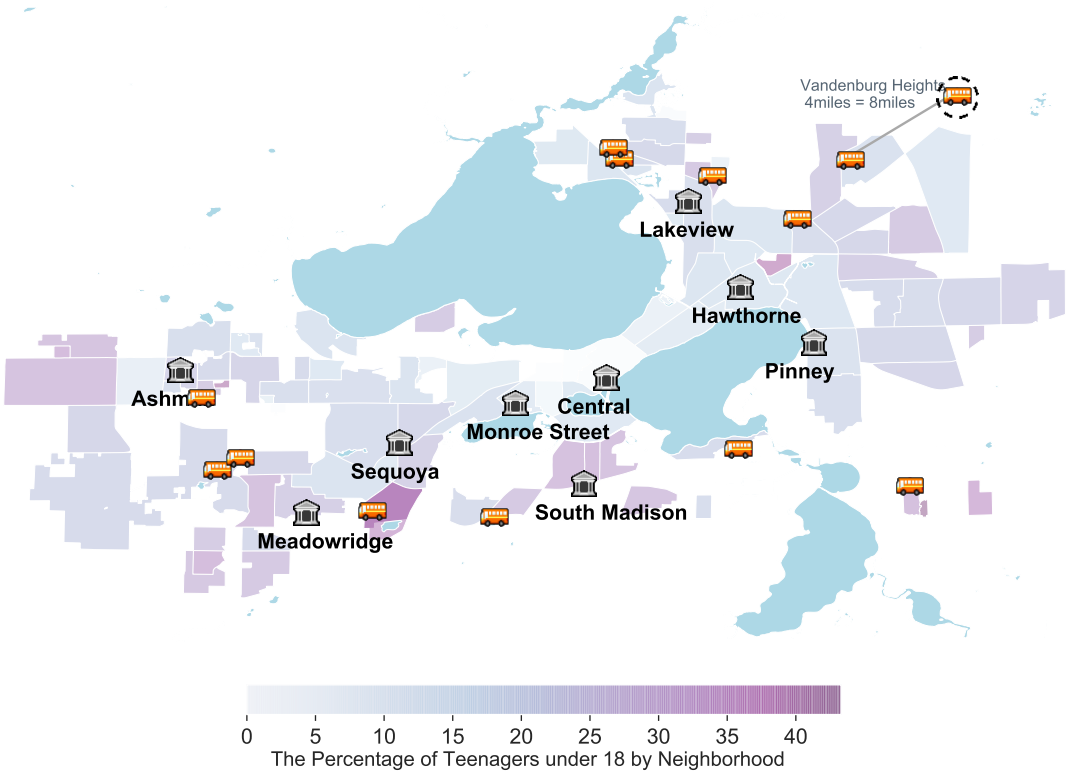


Figure 3: Dream Bus Current Stations
New Dream Bus Schedule & Routes

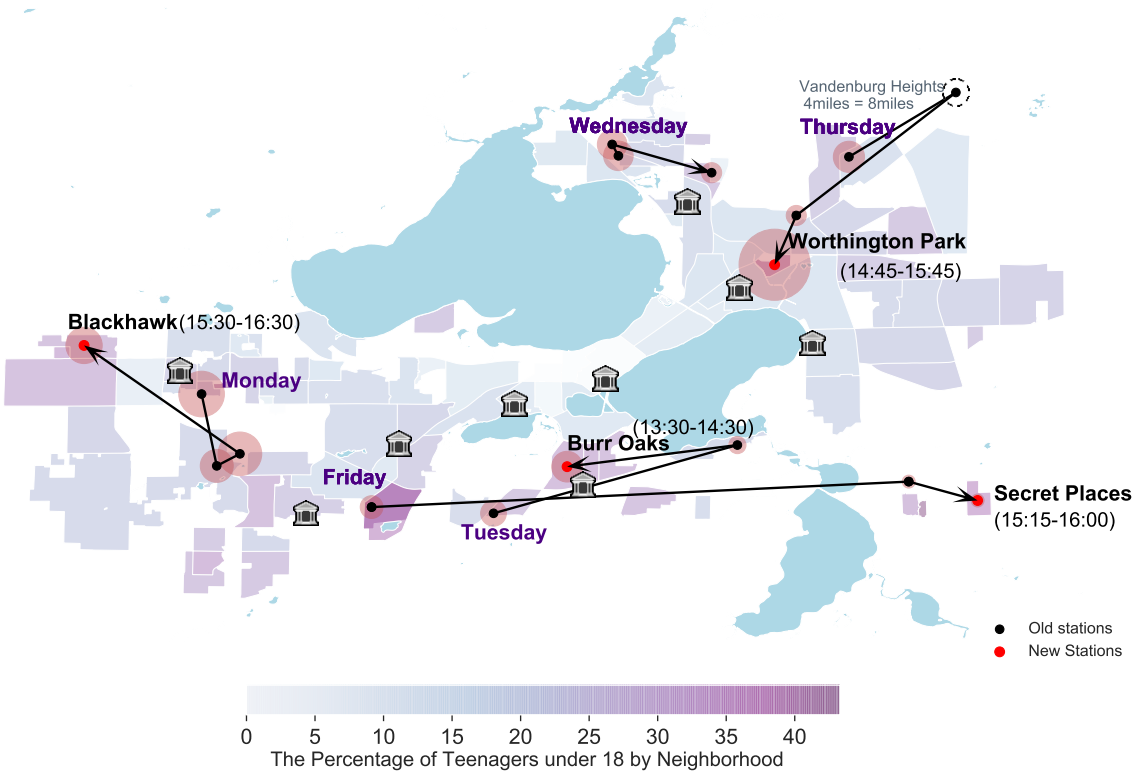


Figure 4: New Dream Bus Routes

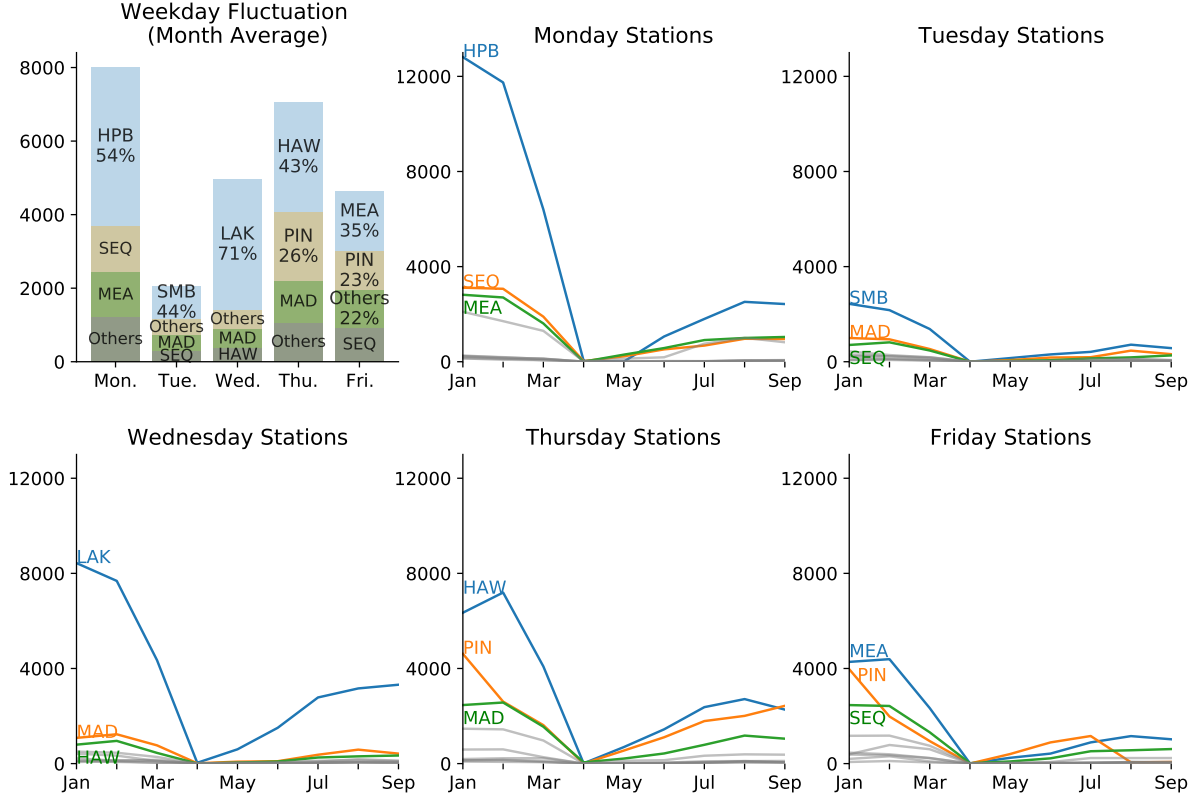


Figure 5: Station Circulation Decomposed by Stationary Libraries

aspects. The first one is the station circulation decomposed by stationary libraries, the second one is the busiest time of the near stationary library, and the last one is the patron flow around each station.

3.3 Analysis of Stationary Libraries near New Dream Bus Stations

To select the items to place on the Dream Bus, we would like to predict readers' preference at each station. To infer this, we identify the stationary libraries frequently used by people in each area. Our goal is to find which stationary library is the most likely substituted by one of new Dream Bus routes, and then we will add the new time slots based on the busiest time of this stationary library.

In Figure 5, we demonstrate each library's contribution to the regions where the station stays in the graph. Each line in the chart represents one library in Madison, and we mark the line in color to indicate that the sum of those libraries' contribution is beyond 75%. It identified the replacement of the bus station for stationary libraries. We would take those essential libraries to come up with the new item arrangement recommendation.

To better understand Figure 5, taking the Monday stations as an example, the blue line represents the circulation of Ashman Library this year at the Monday stations, while the orange line represents that of Sequoia and the green line represents that of Meadowridge. If we sum up the circulation of these three libraries, it will take up more than 75% of the total circulation in the region of Monday stations. Ashman Library is in at the top of the subplot of Monday stations, which means that communities near Monday routes mostly like to go to Ashman Library. Therefore, we plan to revise the time of new Dream Station on Monday at the busiest time range of Ashman Library so that it allows some people to go to the Dream Bus stations at the busiest time of stationary library. With the same way, we checked other three new station routes.

Through Figure 5 below, we decided to confirm the time slots of new Dream Bus stations through readers' preference at each station on each day. Specifically, Blackhawk station on Monday is determined by Ashman library, Burr Oaks on Tuesday station is determined by South Madison Library, and Worthington Park station on Thursday is determined by near Hawthorne Library. We also notice the weekday's fluctuation and find there are two peaks on Monday and Thursday. Therefore, we expect there

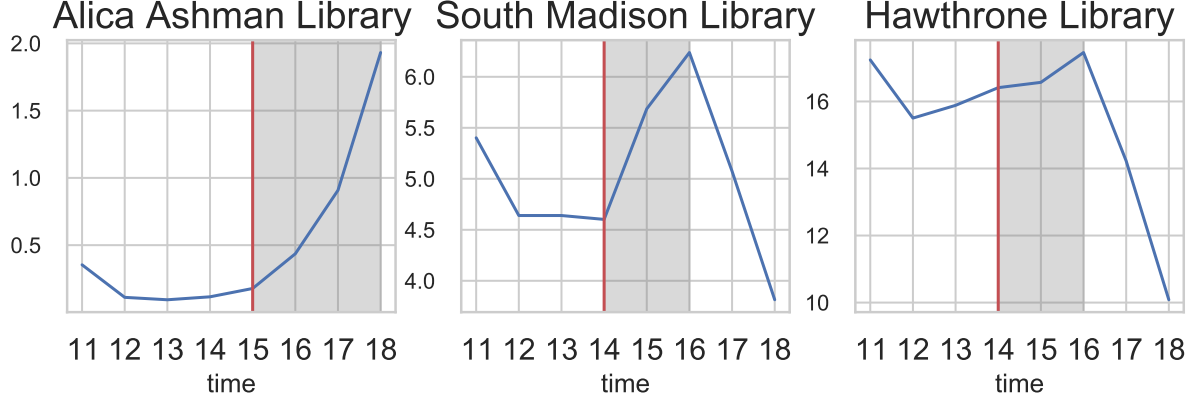


Figure 6: Library Comparison

is a potential chance for a small shuffle on Tuesday or Friday.

Secondly, we analyzed the busy time of these three selected stationary libraries. Figure 6 shows that Alica Ashman Library starts to become very busy after 15:00, South Madison Library has a huge flow increasing after 14:00, and the patron flow Hawthorne Library also increases between 14:00 and 16:00. Then we confirm the time range of these new stations in the busiest time range of these stationary libraries.

3.4 Time Operation

Finally, we especially want to see whether there is a high patron flow around these new stations. During the COVID-19 pandemic, it is very necessary to control the flow at each station. Also, if the patron flow is high, it is necessary to extend the stopping time at that station.

Refer to Figure 4, we use the data of patron added from January to September to see how many visitors flow around each Dream Bus station in the regular schedule. The areas of these red circles are proportioned by the number of patron flow around that specific station. The bigger it is, the more people have the needs for the library. From Figure 4, if we compare the patron flow by each station, the biggest area is Worthington Park, which means the communities here are more willing to go to the library. Therefore, the Dream Bus station here should be busier than others. If we compare the patron flow by each day, the bigger area of the circle is from Monday and Thursday, especially on Monday, the four stations are all comparable bigger than others.

In conclusion, in order to control the social distance on Monday and Thursday and these high-flow stations like Worthington Park, we decided to extend the stopping time of new stations on Monday and Thursday up to one hour. Specifically, the stopping time of Blackhawk on Monday is at 15:30-16:30, the stopping time of Burr Oaks on Tuesday is at 13:30-14:30, the stopping time of Worthington Park on Thursday is at 14:45-15:45, and the stopping time of Secret Places on Friday is at 15:15-16:00. All of the new information was shown in Figure 4.

3.5 More Efficient New Routes

Based on the new Dream Bus stations and new time schedule, Figure 4 visualizes the new Dream Bus routes. The red points are new recommended stations, and the black points are unchanged Dream bus routes. We also annotated the names and time slots of the new recommended stations, and the arrows show how the Dream Bus works every day.

To test our model, from Figure 7, there are the the top ten communities of top 50 teenager-oriented communities with the largest distance reduction. These communities only need to walk less than one kilometer to their nearest Dream Bus Station. Because on the X-axis, the neighborhoods are arranged from left to right in terms of the distance reduction. We can see that the distance to the Dream Bus Station was significantly reduced in all the 10 communities. In conclusion, we ensure that adding four new stations is an efficient way to improve the convenience of teenagers to go to the Dream Bus. Therefore, we think it is valuable to recommend Madison Library System to add these four Dream Bus Stations.

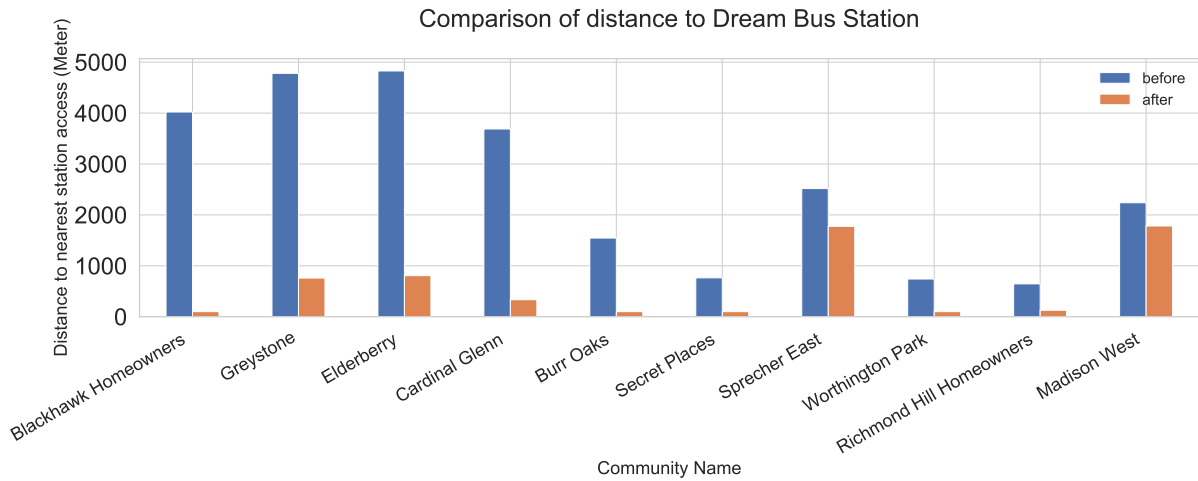


Figure 7: Testing Model

Dream Bus Recommend Winter Schedule

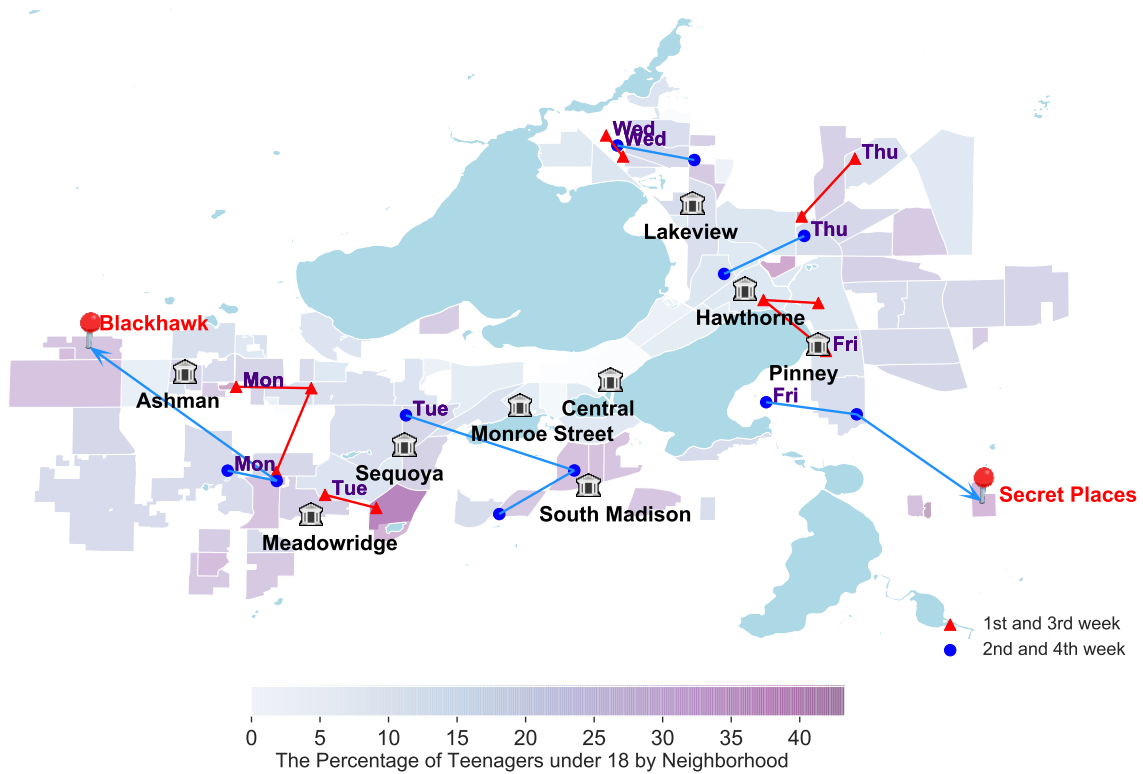


Figure 8: Winter Schedule

4 Dream Bus Winter Schedule

In November, the Dream Bus website updated that due to COVID-19 and impending winter weather, the Dream Bus will offer limited service in November and December by partnering with MSCR sites and community centers to make bi-monthly book drops at 23 community locations., which is different from the previous one. This is just a temporary schedule for winter, but we still check the locations of each station in the new winter schedule so that to make some adjustments to the recommendation we did before. The winter schedule is divided by 1st-3rd week and 2nd-4th week. In Figure 8, the red points represent the stations of the 1st-3rd week, and the blue points represent the station of the 2nd-4th week. We also show the routes of each day in different weeks.

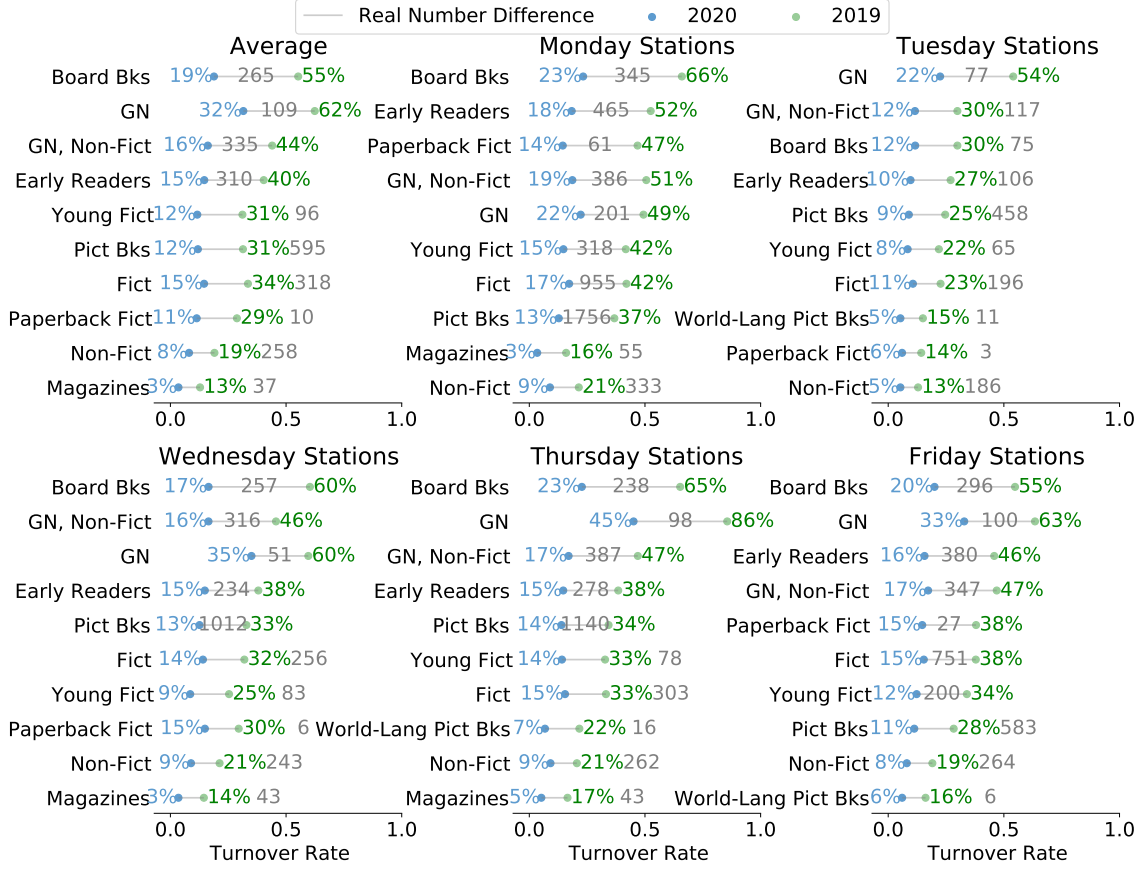


Figure 9: The Turnover Rate Fluctuation Between 2019 and 2020

In the previous recommendation, we recommend four new Dream Bus stations, but now two of them, which are located near South Madison Library and Hawthorne Library, have been covered by the current winter schedule. Therefore, we only keep the other two recommended new stations in the winter schedule. If the Library backs to the regular schedule next year, the previous four stations will still recommend.

In order to have a balanced distribution of stations on each day, we add Balckhaw station to the Monday route of the 2nd-4th week and Secret Places station to the Friday route of the 2nd-4th week. Therefore, most communities with more teenagers could be covered in this winter schedule.

Therefore, after adding the recommended stations, most routes from the winter schedule have a fair number of stations either in the 1st-3rd week or 2nd-4th week except Tuesday. However, we don't recommend adding one more station on Tuesday because the stations on Tuesday are enough to cover most communities around this route now. Adding one more station may increase the operation cost.

In addition, this is just a short-term recommendation for winter. The recommendation for long-term plan will still follow the regular schedule before.

5 Dream Bus: Item Operation

5.1 Item Operation Overview

In the previous section, we add four more stations to improve library service accessibility for more teenagers. Yet, we did not consider the item operation on the bus. In this section, we would trace the circulation of the regions that the bus reaches every weekday to generate a better item arrangement, thus improving our service's efficiency.

For the limited 2700 items space, considering the dream bus is mainly to distribute the books, the total planned space for books and video is around 2000 and 500. We also leave 200 items space for patrons' return or other flexible function. The item operation on the dream bus would like to fictionalize as a supplement for stationary libraries in the short term to mitigate the shrank circulation of teenagers in each region, and also to improve the attractiveness of the bus via more targeting local popularity in

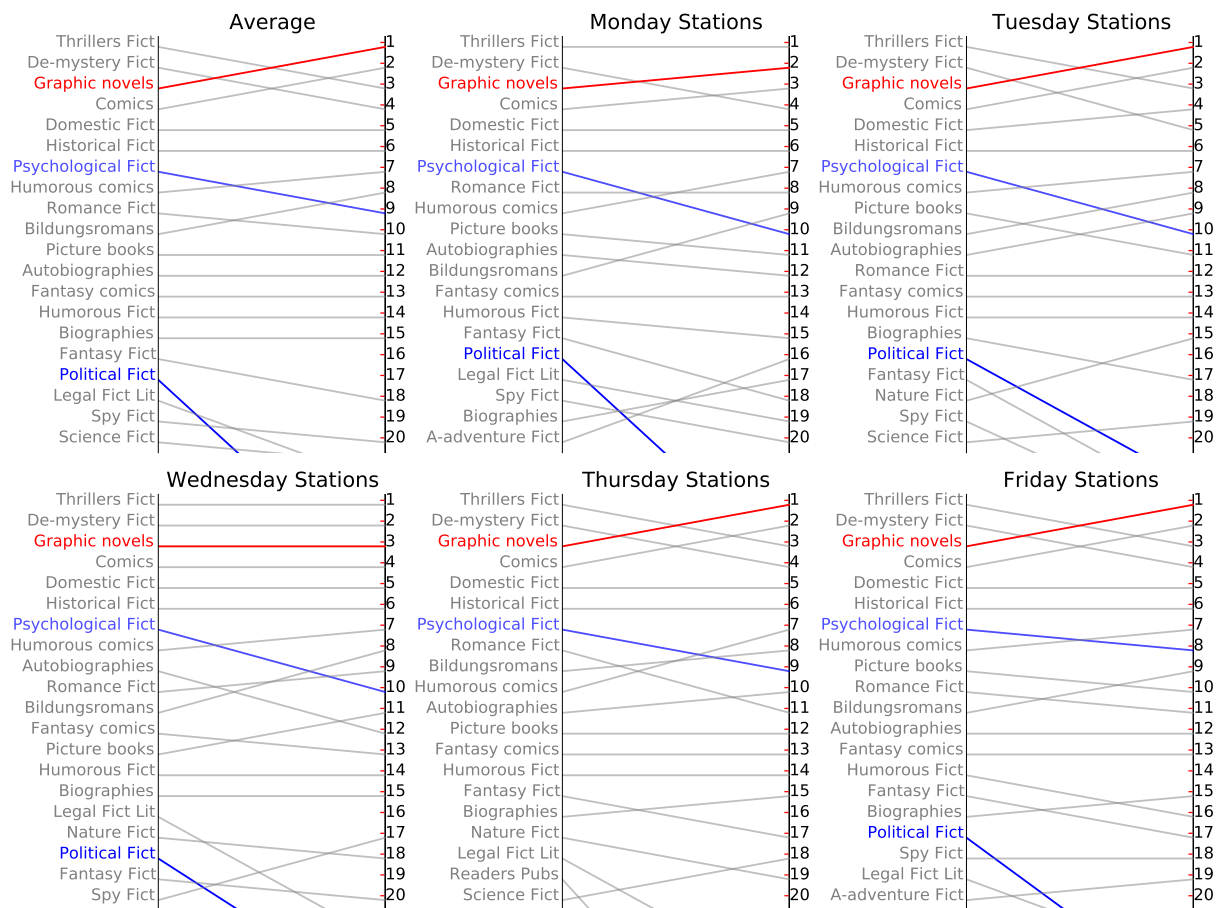


Figure 10: Most Circulated Book Genres Rank Fluctuation Between 2019 and 2020

the long term. At the same time, the dream bus carries the mission to overcome the language barrier for these bilingual children. Our recommendation principle would highly be aimed at these elements.

Our reasoning for the item operation would be based on teenagers' circulation data decomposed by stationary libraries in each region. Firstly, we would decompose stations each weekday into stationary libraries referring Figure 5. To dive into the preference, we would calculate each category's turnover rate, which is usually used in business to indicate one item's selling efficiency in stores. To be more specific, we would investigate the book and video's genres fluctuation to meet teenagers' favors. During our analysis, we would consider the timing of the updated items on the bus to form a closed circulation cycle as well. Through our recommendation, we believe the bus would play a more active and vital role in our teenage readers and hopefully cultivate their sense of identity with books and education.

5.2 Book Category Turnover Rate Fluctuation

Figure 9 shows how the book categorizes' circulation fluctuates in each library with an indicator, turnover rate. Turnover rate is defined as the monthly average circulation divided by the total number of that category owned by the library. The turnover rate indicates each category's expected circulated proportion, which is an excellent indicator considering we have limited space. For simplicity, we only include Top 10 categories. And we list all of these categories ordered by descending shrank percentage, which identifies the influence by COVID-19 in the short term. The items that saw the biggest drops are the items previously used by people now worried about going to stationary libraries due to COVID-19, and that we should therefore put these items on the Dream Bus

From Monday to Friday, we could notice that there is consistency in the top 5 categories. However, for Monday and Friday, they include paperback fictions particularly, while for other days, they include picture books. From here, we could expect a shuffle after Monday and Tuesday, which is consistent with the trend of total circulation showed in Figure 5.

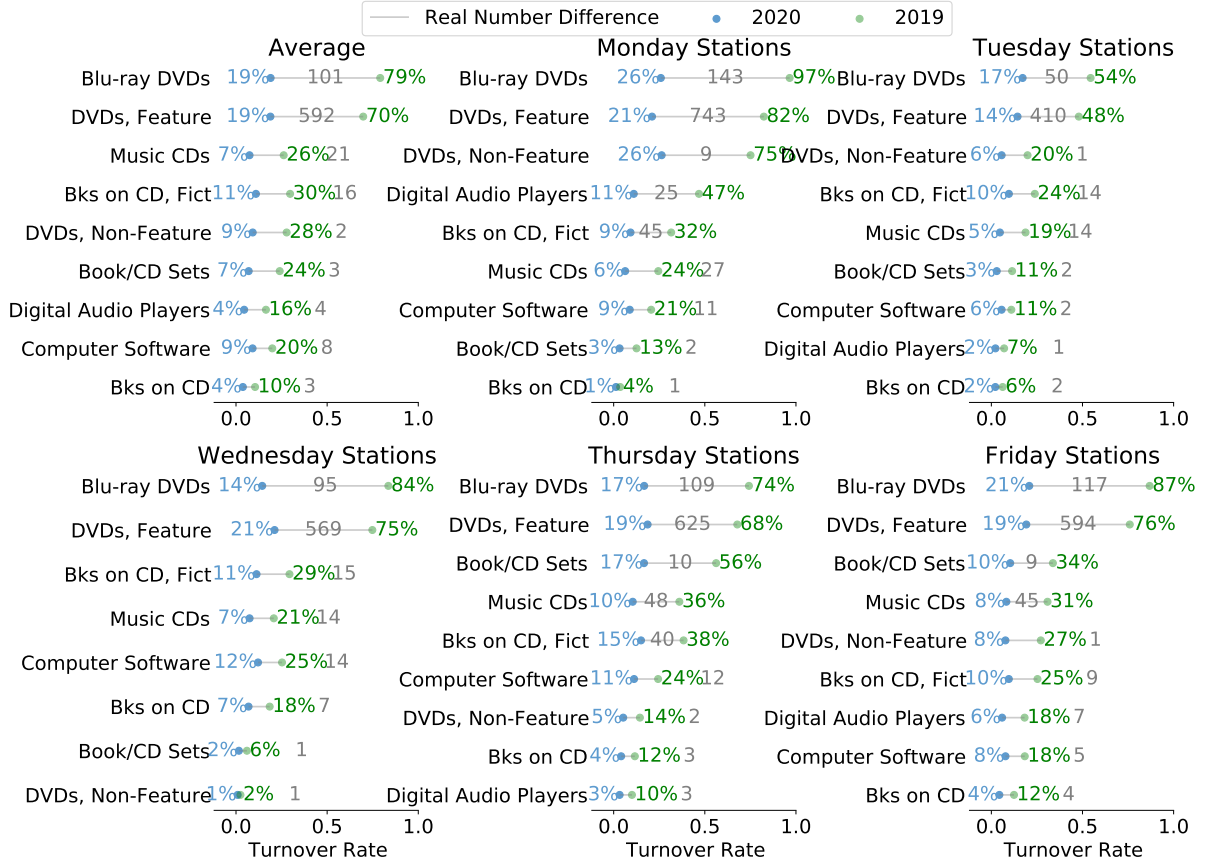


Figure 11: The Turnover Rate Fluctuation Between 2019 and 2020

To mitigate the reduction circulation, we refer to the average chart to tell the shrinks' real number. We propose 250 Board Books, 100 graphic novels, 300 graphic novels with non-fiction, and 300 early readers for a baseline situation. Regarding the paperback fiction, we notice that it takes only a small real number, so we propose 50, while the fiction books are very large, so we offer about 200. And we also propose a combination of young fiction and fiction about 350, depending on the bus operation per se, to decide the exact portion. Another purpose of the dream bus is to overcome the language barrier for bilingual children; therefore, we would also put 50 world language books on the bus. Based on the baseline situation, we have set 1500 books on the bus. The remaining space is to adjust by every month and for other categories.

5.3 Book Genres' Rank Fluctuation

We demonstrate the genre fluctuation in Figure 10 where the left-hand side is the genre's rank in 2019 while the right-hand side is the genre's rank in 2020. We mark the greatest increase or decrease in rank in solid red or blue, while that in the real number in a lighter color. The graphic novels category is the one has the greatest increase in rank and the real number at the same time.

According to the fluctuation, we could generate a list of specific books which have these labels. Hence, the targeting books would increase more attractive of items.

There is no significant movement in the top 15 expect there is a considerable decrease in political fiction. Legal fiction literature also suffer a considerable loss in rank, but the real number would be a little bit small. We would focus on the decrease part in the short term for daily operation because the reader's preference did not shift much during COVID-19. However, in the long run, people would probably find their interests shift, focusing on the increased part.

Thus, to mitigate the circulation gap, we recommend the dream bus add more psychological fictions from Monday to Wednesday as well as other things in blue every weekday. To increase the long-run attractiveness, we should add more items like Bildungsroman in the dream bus on Monday and Wednesday,

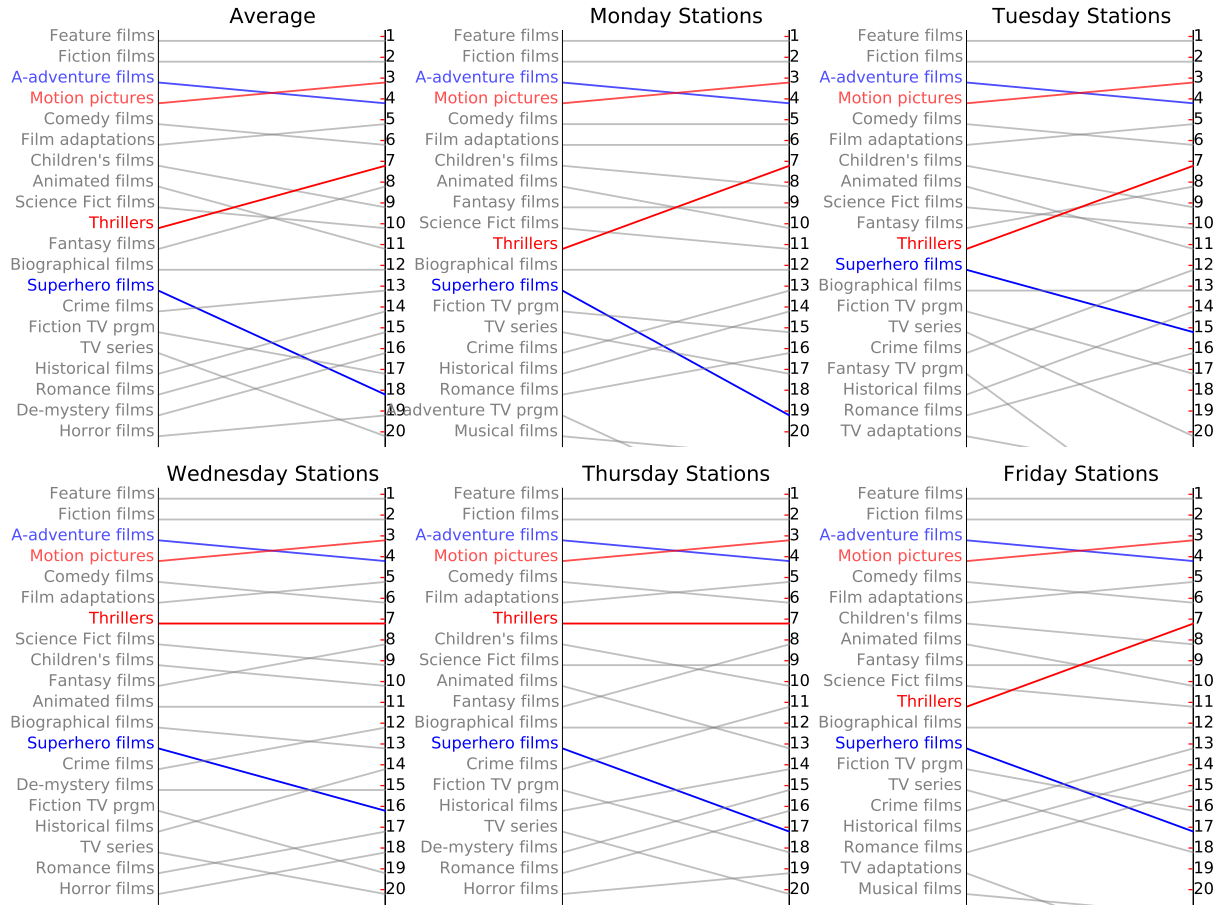


Figure 12: Most Circulated Video Genres Rank Fluctuation Between 2019 and 2020

as well as other things in red every weekday.

5.4 Video Category Turnover Rate Fluctuation

This graph shows how the video categorizes' circulation fluctuates in each library with the turnover rate. For simplicity, we only include categories' circulation beyond 20 in a month ordered by the shrank percentage.

To mitigate the reduction circulation, we refer to the average chart to tell the shrinks' real number. We propose 100 Blu-ray DVDs and 300 DVDs, Feature for a baseline situation. Based on the baseline situation, we have set 400 videos on the bus. We consider the dream bus is mainly to distribute the books so that the total planned space for videos is around 500. The remaining space is to adjust by every month and for other categories. Video categories' circulation provides limited information since the category is too general. It would be better if we could take a look at the video genres.

5.5 Video Genres' Rank Fluctuation

We demonstrate the genre fluctuation in Figure 12 where the left-hand side is the genre's rank in 2019 while the right-hand side is the genre's rank in 2020..We mark the greatest increase or decrease in rank in solid red or blue, while that in the real number in a lighter color.

Animated films, superhero films, and television series have a considerable decrease, while thrillers, fantasy, historical, romance, and de-mystery films greatly increase. Thus, to mitigate the circulation gap, we recommend the dream bus add more superhero films and television series, and other things in blue every weekday. To increase the long-run attractiveness, we should add more items like thrillers, fantasy, historical, romance, and de-mystery in the dream bus and other things in red every weekday.

5.6 Item's Time Length on the Dream Bus

Regarding how long a book should stay on the bus, we refer to the inverse turnover rate in the Figure 9 and Figure 11. The inverse of the turnover rate implies the expected time to circulate all the items. If an item stays on the bus beyond that time, we should replace it and fill it with new items. Also, for stationary libraries, a cycle for them would be a month, while for a bus, it would be a week. In the short term, we would use the average data from 2019 and 2020, where it would be more accurate considering both the COVID-19 effect and readers' preference. Thus, in the Figure 9, the board books and the graphic novels should replace every three weeks, a graphic novel with non-fiction and early readers would replace every one month, and others would replace more than one month. In the long term, we would use the data in 2019 and newly generated data.

6 Conclusion

Monday	Tree Lane Apt	The Crossings	ReNew Madison	Blackhawk Community
	12:00-12:45	13:00-14:00	14:15-15:15	15:30-16:30
Tuesday	Leopold Elementary	Bridge Lakepoint	Burr Oaks Community	
	11:00-12:00	12:15-1:15	13:30-14:30	
Wednesday	Mendota Elementary	Kennedy Heights	Oak Park Terrace	
	13:00-14:00	14:15-15:15	15:30-16:00	
Thursday	Sandburg Elementary	Vandenburg Heights	East Madison Center	Worthington Park
	11:30-12:00	12:45-13:15	14:00-14:30	14:45-15:45
Friday	Allied Drive	Owl Creek Park	Secret Places	
	13:00-13:45	14:15-15:00	15:15-16:00	

Figure 13: Proposed Item Arrangement

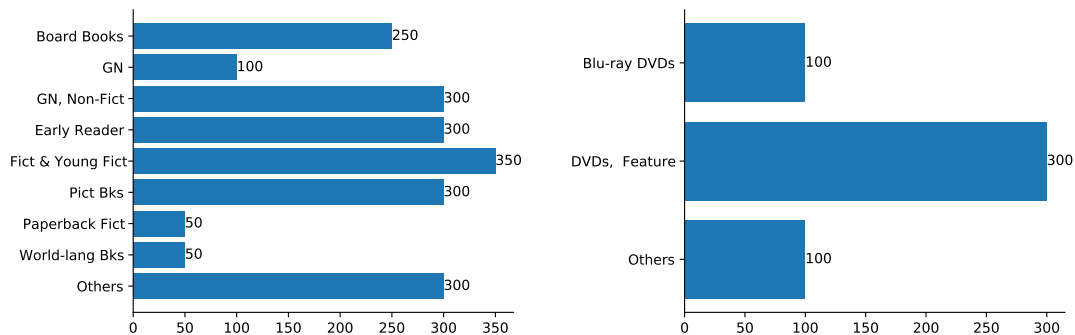


Figure 14: Proposed Item Arrangement

In conclusion, we recommend Madison Library System to improve the service of the Dream Bus from two aspects. For one thing, the Library System can add Blackhawk, Burr Oaks, Worthington Park and Secret Places these four stations into the current schedule and follow the recommended time slots to disperse some patron flow from stationary libraries, and the recommended schedule is Figure 13. For the other thing, it would be better to optimize the item arrangement based on the stationary operation, as showed in Figure 14.

We believe these changes would certainly make a difference to serve our teenagers, our community better, and further, our future generation.