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An Analysis of Citizen Science and its Effect on Marine Plastic Pollution

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An Analysis of Citizen Science and its Effect on Marine Plastic Pollution

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Honors Capstone Project in Information Management and Technology

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Abstract

My Honors thesis is an analysis of pollution data to gain more insight about the growing problem of marine plastic pollution. I retrieved online datasets collected by the Clean Swell trash collection mobile application and then analyzed this data using the Python programming language. After my Python analysis, I used Tableau to create data visualizations. This paper analyzes the effect that citizen science has on plastic pollution. Syracuse University's recycling and trash figures, provided by Syracuse Haulers, are also analyzed. The purpose of including Syracuse University's data is to bring a local point of view to this project and possibly motivate readers to work towards a solution to marine plastic pollution.

Executive Summary

The purpose of this study is to analyze the impact of the Clean Swell mobile application on marine plastic pollution. The data used for analysis was collected by the Clean Swell trash collection mobile application. Ocean Conservancy created the Clean Swell application, which was designed with the purpose to "keep beaches, waterways, and the ocean trash free" ("Clean Swell"). Users collect and record trash collection data using the app and this data "will instantaneously upload to Ocean Conservancy's global ocean trash database" ("Clean Swell"). Clean Swell logs data about the cleanup date, location, quantity of people participating, categories of trash found (e.g. cigarette butts, plastic bottle caps, etc.), and total amounts of trash collected in each cleanup.

Using the Python programming language, I analyzed Clean Swell datasets for the United States and New York State with the goal of creating a more relatable impact for the Syracuse University community. After my Python analysis, I used Tableau to create data visualizations. In addition to the Clean Swell data, this project analyzes Syracuse University's recycling and trash data, which was provided by Syracuse Haulers. The purpose of including this data is to bring a local point of view to the project and motivate community members to become involved in working towards a solution to marine plastic pollution.

This study found that the Clean Swell app has a significant environmental impact even with a limited quantity of users. From the United States alone, over 8.8 million pounds of trash have been collected, documented, and removed from the environment. That is over 15 million pieces of trash. If apps like Clean Swell become more mainstream, citizen science could skyrocket and even more pollution could be saved from entering the oceans. This study also

found that most of Clean Swell's users are from areas with higher populations and higher median incomes.

I also discuss data challenges I faced throughout this project. Two of the most common challenges of data science today are "inaccessible data" and "dirty data" (UJ). I quickly learned that there is limited publicly available data on plastic pollution, and the data that is available frequently contains inaccuracies. We are living in a data-driven world, but the quality of data is problematic and rarely consistent. Information needs to be better managed for it to be meaningful and useful. Citizen science is one way to increase environmental data collection, and mobile applications such as Clean Swell are effective ways to do this. Apps can help minimize data errors with automatic location and time/date recording as well as limiting the options for classifying types of trash. Then, the app's data can be combined into one organized, public database. Making databases public and accessible encourages education and research.

Clean Swell is a good example of data collection. App users are only able to record data as integers, which makes datasets consistent. Clean Swell provides users with clear categories for classifying trash, rather than allowing users to type their own description of the item found. This helps to reduce complexities and clarify data. One thing to consider is that data for these apps is manually entered by users. Therefore, errors in quantities or classifications are possible. While this is something to consider, manual data is typically the only environmental data available for analysis. As more data is collected, larger datasets will hopefully reduce the effect that some inaccuracies have on the overall data analysis. Using mobile applications for data collection can help to reduce "inaccessible data" and "dirty data" that currently pose significant challenges to data science (UJ).

Table of Contents

Preface

During the Fall 2017 semester, I took a course in the Python programming language with Professors Michael Fudge and Deb Nosky. I quickly realized how much I enjoy coding and knew I wanted to apply this to my passion for working towards a solution to plastic pollution.

Marine plastic pollution is a growing crisis, yet the general public is unaware of the magnitude of this issue. For example, plastic is predicted to outweigh fish in the ocean by 2050 (Kaplan). One of the five ocean gyres in the world, the North Pacific Gyre, has accumulated so much plastic in recent years that it is now referred to as the Great Pacific Garbage Patch. This floating garbage patch is a "plastic soup" that is now double the size of Texas ("FAQs"). When I share these facts with others, they typically are surprised by how much pollution there is and that they were unaware of such a massive problem.

In my opinion, a key factor in working towards a solution to marine plastic pollution is public involvement. If people become invested in ending this destruction, then legislation and changes in industry that consumers demand will hopefully follow. One way to increase public interaction with this environmental crisis is the use of citizen science applications that allow users to utilize their mobile devices to record trash found in the environment.

I will analyze data[1] collected by the Clean Swell trash collection mobile application with the purpose of illustrating the effect that this app has on reducing marine plastic pollution. Furthermore, I aim to bring awareness to this topic and ultimately help citizen science become more common and therefore successful.

Clean Swell's database includes data about more than just plastic found in the environment. It includes reporting options for a variety of different types of trash, such as glass, cans, and paper bags. Although my focus initially was solely on plastic pollution, I have found that it is informative to analyze all types of trash found in the environment. The growing amounts of all types of pollution are representative of our increased dependence on single-use items and the throw-away culture of society. Single-use plastics, such as plastic to-go containers, plastic straws, plastic coffee cup lids, and plastic bags, are everywhere. Plastic is convenient and this combined with our love for single-use items is a terrible combination for the planet. Plastic is designed to last forever, yet we use this material to create items that are designed to be used once and thrown away. Clean Swell's pollution data will help me analyze this citizen science app and its effect on marine plastic pollution.

[1] http://www.coastalcleanupdata.org/

Acknowledgements

I would like to thank Professor Michael Fudge for his role as my Thesis Faculty Advisor. I am deeply grateful for Professor Fudge's guidance, support, and encouragement. This thesis would not have been possible without Professor Fudge and Professor Deborah Nosky, who both taught me the Python programming language. I would also like to thank Blythe Scherrer for her constant support and advice as my Thesis Coordinator and Honors Reader. Thank you to all of Honors for believing in my thesis. As well, I would like to thank Melissa Cadwell and Meg Lowe of Syracuse University's Energy Systems and Sustainability Management for their support and introductions to sustainability professionals in the Syracuse community.

Thank you to Ocean Conservancy for creating the Clean Swell application and publicly sharing this data via the TIDES (Trash Information and Data for Education and Solutions) System. Thank you to Syracuse Haulers for sharing Syracuse University's trash and recycling data. I would also like to express my gratitude to Win Cowger, Ph.D. student at University of California, Riverside. I was introduced to Win by the 5 Gyres Institute. Win shared plastic pollution data and helped me explore different research ideas.

I am appreciative of everyone who has been supportive of my thesis and has encouraged me to follow my passion of working towards a solution to marine plastic pollution.

Chapter 1

Introduction

The National Geographic Society defines citizen science as, "the practice of public participation and collaboration in scientific research to increase scientific knowledge. Through citizen science, people share and contribute to data monitoring and collection programs" ("Citizen Science" 2012). Citizen science is a great tool for gathering data about pollution. Now that smartphones equipped with Global Positioning System (GPS) abilities, exact time and date logging, and photo capabilities are so common, people have the ability to more conveniently record data.

Ocean Conservancy created the Clean Swell application, which was designed with the purpose to "keep beaches, waterways, and the ocean trash free" ("Clean Swell"). Users collect and record trash collection data using the app and this data "will instantaneously upload to Ocean Conservancy's global ocean trash database" ("Clean Swell"). Clean Swell logs data about the cleanup date, location, quantity of people participating, categories of trash found (e.g. cigarette butts, plastic bottle caps, etc.), and total amounts of trash collected in each cleanup. The Clean Swell data for the state of New York is dated from 2015 to 2019. The data for the United States is dated from 1993 to 2019.

I focus on Clean Swell's datasets for the United States and New York State, with the goal of creating a more relatable impact for the Syracuse University community. In combination with

Clean Swell's data, I utilize population and median income data. Population data for each New York county was obtained from the New York State Department of Labor ("Population Data and Projections"). The most recent population estimates were reported for July 2010, which is the data I utilized in my analysis. Population data for each state was found on the World Atlas website ("The 50 US States Ranked By Population"). Median income data for each New York county was obtained from IndexMundi ("New York Median Household Income, 2009-2013 by County"). This data was collected from the US Census Bureau. Median income for each state was acquired from The Henry J. Kaiser Family Foundation, which was reported in 2016 dollars ("Median Annual Household Income").

Applications like Clean Swell collect large quantities of data that scientists can use to learn more about the marine plastic pollution crisis. This data can help bring awareness to the issue and inspire people to go out into their communities to clean up and remove pollution that would otherwise enter waterways, which all lead to the ocean. In addition to removing trash from waterways, citizen science apps encourage people to engage with the environment. Fostering empathy for the environment is what will save our planet from the downhill slope we currently face with pollution. When people are engaged, they become more aware of how we each affect this environmental crisis and hopefully start to care more about finding solutions. As the United States Forest Service explains:

> Citizen Science can engage people...increasing firsthand understanding of conservation or environmental issues, and encouraging participants to become more responsive to the issues they care about. Participants may be more likely to appear at public meetings and to provide constructive comments on proposed actions once they have engaged in a citizen science effort. (US Forest Service)

Similarly, I predict that increased participation with apps like Clean Swell would result in more consumers demanding environmentally friendly products. As well, citizen science has a positive impact on more than just the volunteers. In fact:

> Citizen scientists can spread knowledge among their friends, family, and colleagues by sharing their citizen science activities and discussing the issues they care about through a wide range of social networks. The information they impart and the example they set can motivate others to get involved or to change their behavior. People are more likely to change their behavior in response to examples set by their friends and neighbors than in response to public information campaigns. (US Forest Service)

Citizen science has significant potential to create change and apps like Clean Swell can make positive change a reality.

The purpose of this study is to learn more about the environmental impact of citizen science in the form of the Clean Swell mobile application. This analysis will also determine which populations most often use the app. If Ocean Conservancy can increase participation with the app, then more trash may be collected. The purpose of these trash collection apps is to remove more pollution from the environment. I want to figure out how to make that more effective, and better designed trash collection apps might be one way to accomplish this.

Chapter 2

Data Challenges

Two of the most common challenges of data science today are “inaccessible data” and “dirty data” (UJ). Inaccessible data was a challenge during the data collection phase of this project. I began my thesis with the intent to analyze data about marine plastic pollution found in the North Pacific Gyre, which is the gyre that largely affects the coast of my home state California. I soon discovered that data about plastic pollution in the ocean gyres is often not publicly available. Then I turned my focus to plastic pollution in local rivers throughout the Northeast of the United States. After an initial analysis of this data, I learned that data is not collected consistently over time and is often incomplete. Without collection over time, it is impossible to see change. This becomes an obstacle in establishing trends and making predictions. Important attributes, such as the date trash was collected, are often missing. The quality of data collected is repeatedly inconsistent and flawed, which makes it difficult to analyze data and draw reasonable conclusions. The need for complete, detailed, and consistent data collection is very apparent.

Often, the data I found was obviously inaccurate. For example, there were dates recorded in the future. Use of a mobile device in recording data could automatically document accurate time, date, and location. This would help to minimize errors. Many of the datasets I received had inconsistent data measurements. In some cases, trash would be measured using vague text such

as, “large quantities,” instead of a specific number. While data may be manually entered and/or entered by citizens without training in proper data collection, there still need to be regulations for what data can be stored. Use of a mobile app could help enforce restrictions by making text options unavailable. Data needs to be collected properly to be a reliable resource. Otherwise, huge amounts of data go to waste. Limiting errors will help to minimize “dirty data” (UJ).

Clean Swell is a good example of data collection. App users are only able to record data as integers, which make datasets consistent. Clean Swell provides users with clear categories for classifying trash, rather than allowing users to type their own description of the item found. This helps to reduce complexities and clarify data.

Figure 2.1. This screenshot of the Clean Swell application shows options for classifying trash, which make records more clear and consistent.

It is important to consider that data for these apps is manually entered by users. Therefore, errors in quantities or classifications are possible. While this is something to consider,

manual data is typically the only environmental data available. As more data is collected, larger datasets will hopefully reduce the effect that some inaccuracies have on the overall data analysis.

As well, data collected from citizen science may misrepresent a population. The data is not balanced because it is dependent on the public's participation in data collection. For example, Chautauqua County in New York State has a significant amount of trash recorded using Clean Swell. This county has nearly the same amount of trash recorded as New York County. New York County is one of the most populated areas in the state, and Chautauqua County is a significantly less populated area. There seems to be so much trash in Chautauqua County only because there were more documented cleanups there. The data all depends on participation. It is challenging to increase participation with citizen science because people are generally unaware or uninterested in citizen science opportunities. Hopefully apps like Clean Swell that make it easier for people to participate in citizen science gain more attention. More participation will lead to larger datasets that better represent the population.

Ocean Conservancy has several supporting partners, such as the Coca-Cola Foundation and Norwegian Cruise Line Holdings Ltd ("Partners"). Perhaps these partners could advertise the Clean Swell app to increase participation. For example, Norwegian Cruise Lines could encourage their travelers to install and utilize the app while exploring cities that the cruise ships visit. This could have a ripple effect as more people are exposed to the app and may continue using it beyond their vacation.

Chapter 3

Clean Swell's Environmental Impact

The purpose of this study is to analyze the impact of the Clean Swell mobile application on marine plastic pollution. Analysis of Clean Swell's New York state data showed that, on average, each adult that participated in a cleanup collected 104 pieces of trash per cleanup. For the United States data, each adult collected 85 pieces of trash on average across the country.

When comparing the quantity of adults participating with the total quantity of items collected, there is a clear positive correlation. If more people utilize the app and participate in cleanups, then more trash will be collected from the environment.

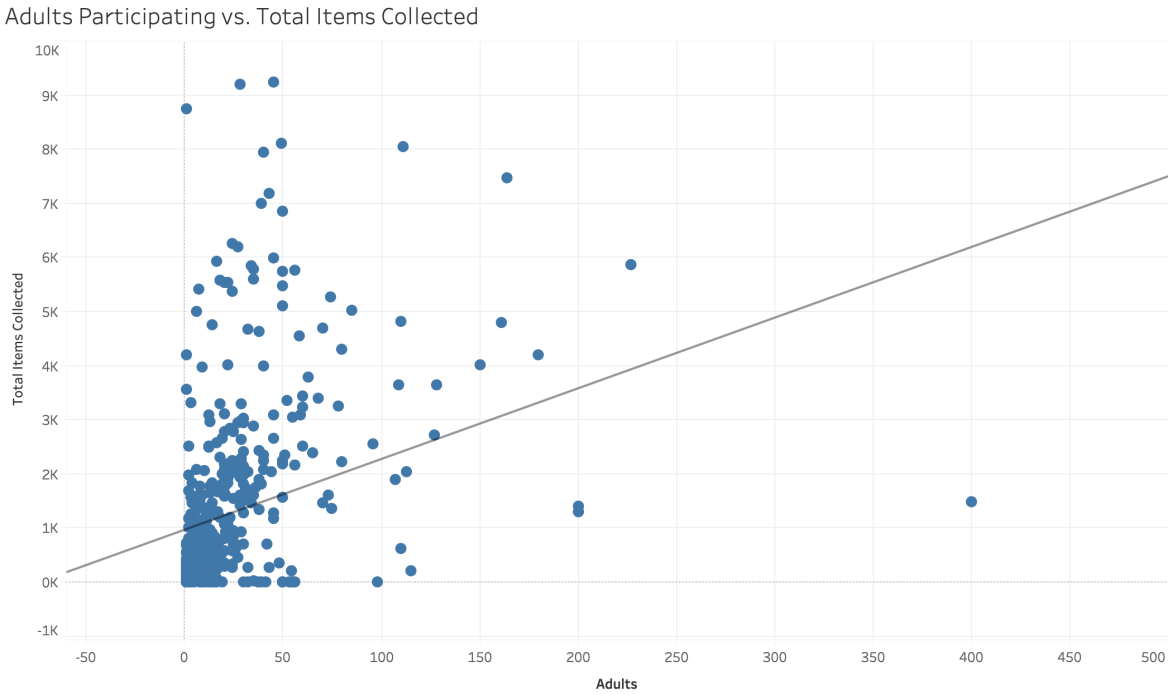

Figure 3.1. This graph shows a positive correlation between the quantity of adults participating in a cleanup and the total quantity of items collected.

Below is a representation of the quantities of trash collected across the United States to date. Unsurprisingly, the states with the most trash collected are states with the highest populations. The top four most populous states in order are California, Texas, Florida, and New York ("US States - Ranked by Population 2019").

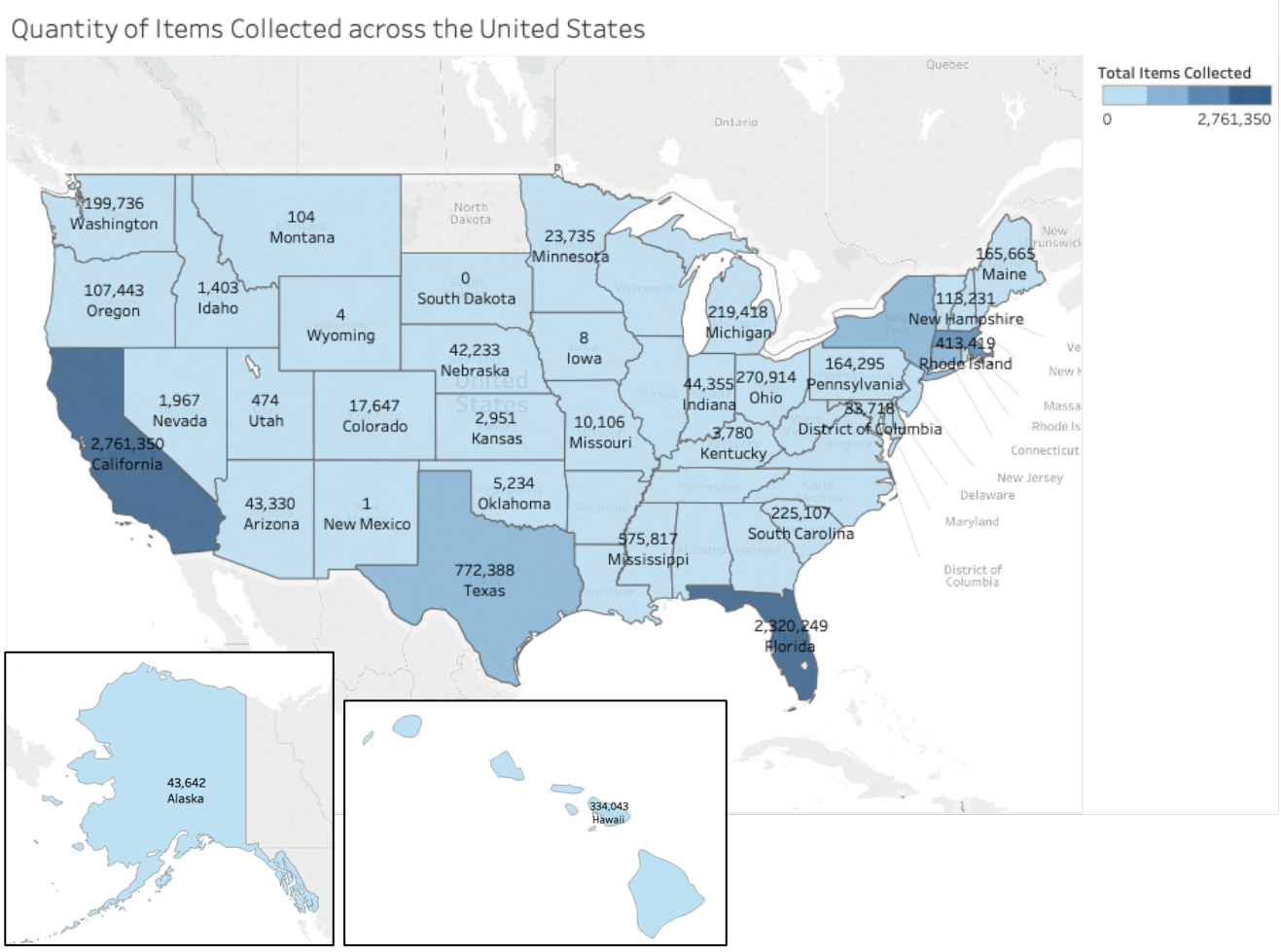

Figure 3.2. A map of the quantities of trash collected and documented with Clean Swell across the United States.

Figure 3.3 illustrates the quantities of items collected and recorded using Clean Swell across the United States. The top three most common items are foam pieces, cigarette butts, and plastic pieces. All three of these categories contain plastic. Styrofoam, or polystyrene, is Plastic #6 and typically cannot be recycled. Most United States facilities "do not accept it as part of their recycling program… [and] much of the Styrofoam we use is contaminated with food or drink

and is not even acceptable at a drop-off site or a mail-back recycling program" ("The Rundown on Plastic #6 (Styrofoam)"). Coupled with the inability to recycle it, foam does not break down. In addition to the chemicals that cigarette butts leak into the environment, cigarette butts actually contain plastic filters. In fact, "cigarette butts are the most common form of plastic litter found on beaches worldwide" ("Cigarette Butts"). Clean Swell users across the United States have removed almost six million pieces of Styrofoam, over five million cigarette butts, and over four million plastic pieces from the environment. Clearly, citizen science can have a powerful impact.

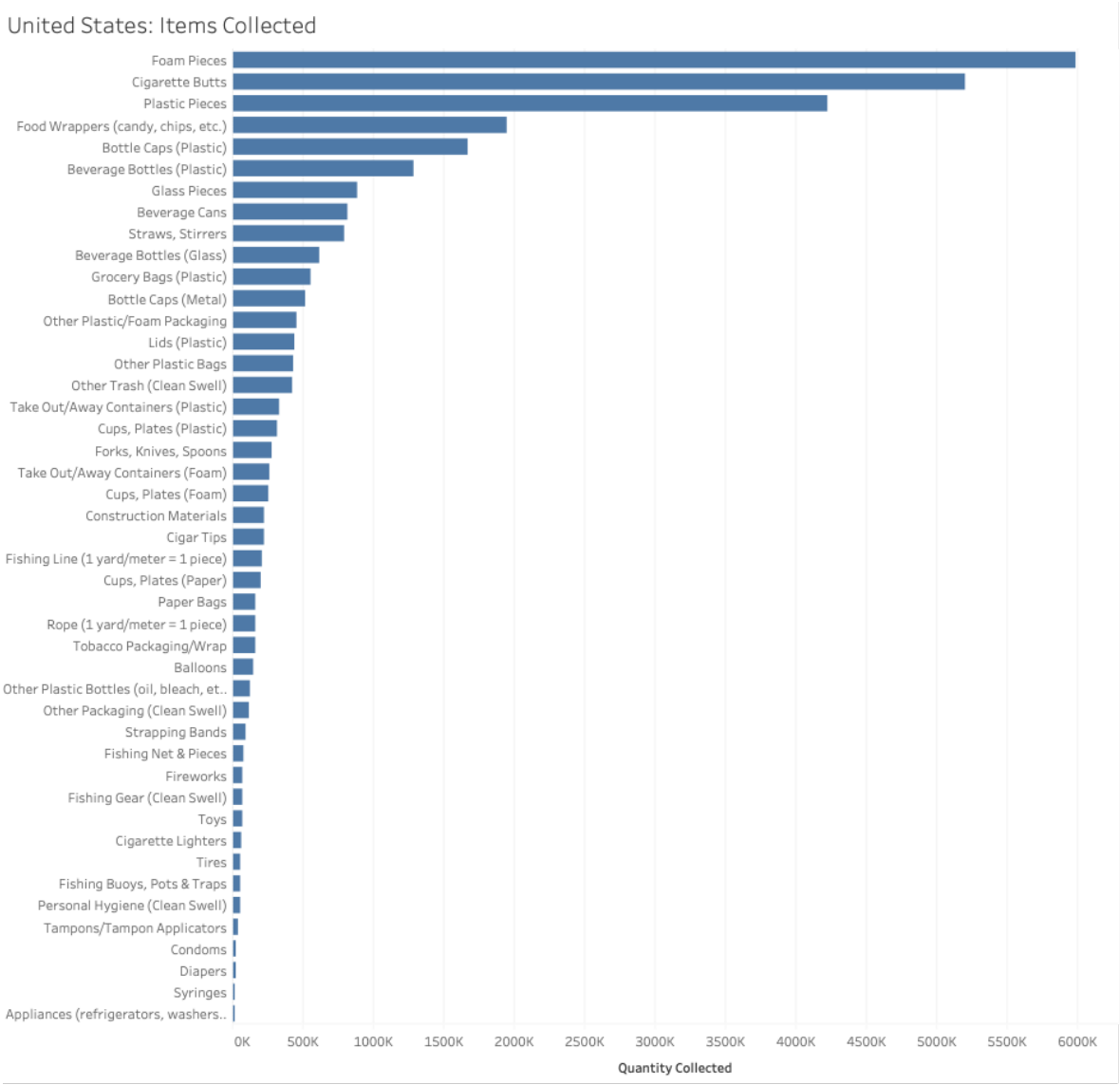

Figure 3.3. Items collected in the United States.

Clean Swell's environmental impact is impressive. From the United States alone, over 8.8 million pounds of trash have been collected, documented, and removed from the environment. That is over 15 million pieces of trash. If apps like Clean Swell become more mainstream, citizen science could skyrocket and even more pollution could be saved from entering the oceans.

Chapter 4

Clean Swell Over Time

The Clean Swell datasets were then analyzed to learn about the app's environmental impact over time. In both New York and the United States, it seems that less trash is collected annually than in previous years. It is possible that this is due to less participation with the app.

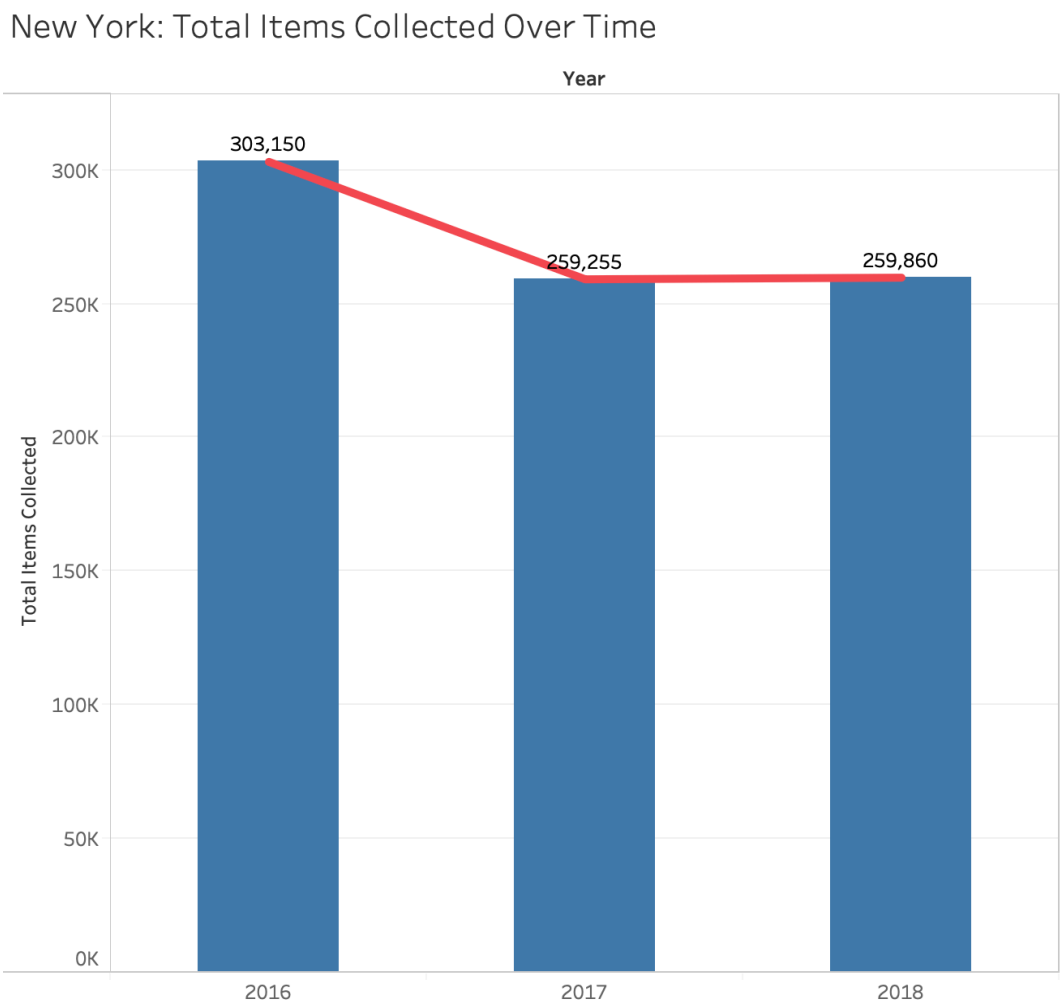

Figure 4.1. The quantity of trash collected annually in New York State has decreased.

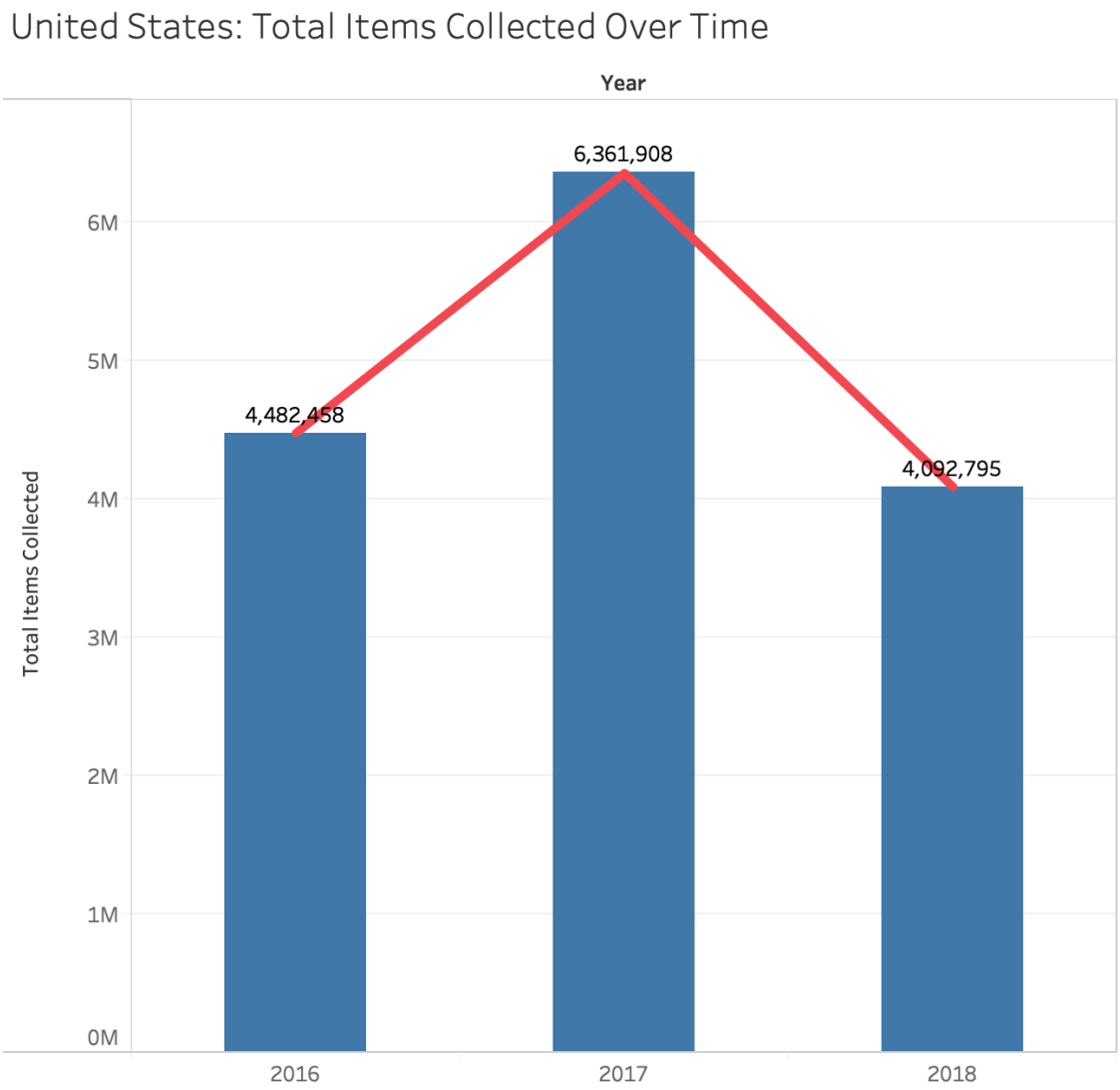

Figure 4.2. The quantity of trash collected annually in the United States has decreased.

The quantity of Clean Swell users across New York has not fluctuated too drastically over the years. However, across the United States there has been a large decrease (over 50% decrease) in the quantity of people using Clean Swell.

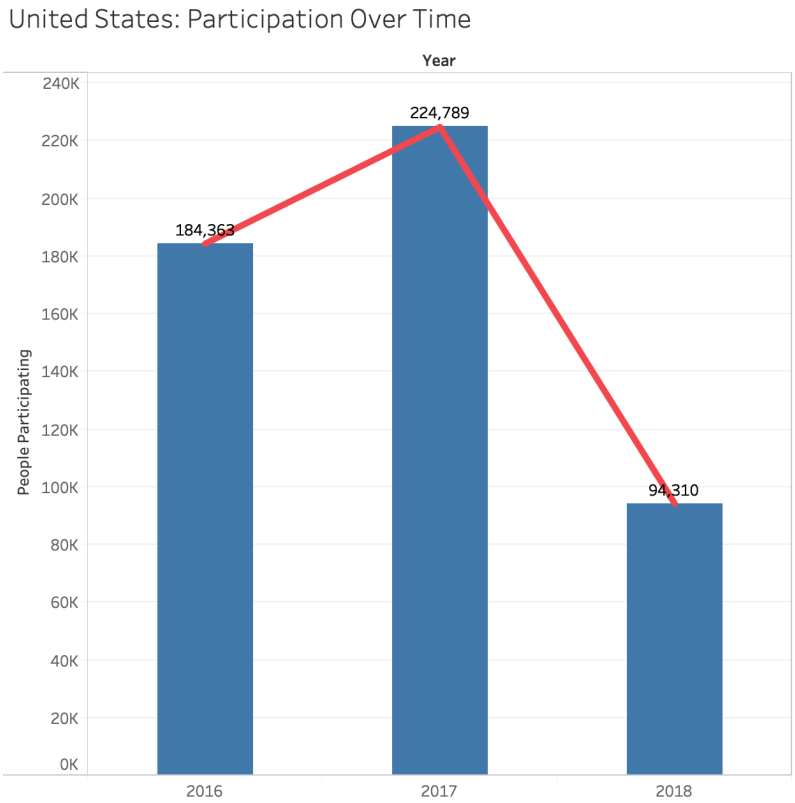

Figure 4.3. Participation with Clean Swell has decreased significantly across the United States.

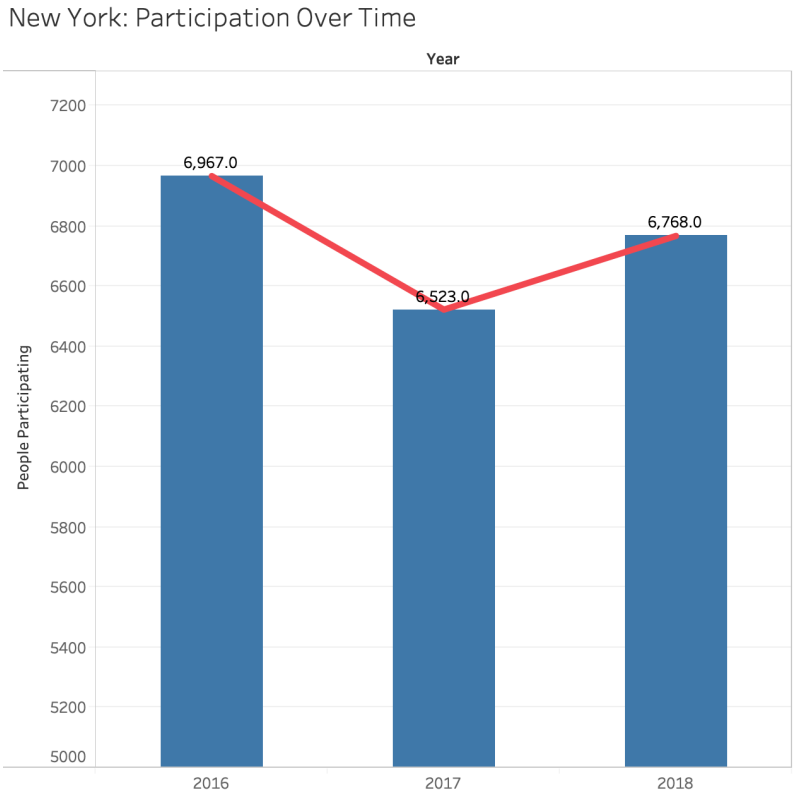

Figure 4.4. Participation with Clean Swell has been relatively consistent across New York State.

Chapter 5

The Effect of Income

The Clean Swell datasets were then analyzed to learn how user income affects participation with the app.

Quantity of Participants per Cleanup

For the New York data, I calculated the percentage of people involved in each cleanup by dividing the quantity of people who participated by the respective county's population. Then I calculated an average percentage of participation for each New York county. I merged the participation averages and the county populations into a new Pandas DataFrame. After exporting this DataFrame to a new csv file, I used Tableau to plot each county's participation average with its county's median household income.

Figure 5.1 shows the top five New York counties with the highest participation ratios per cleanup relative to their populations.

	County	Average Involved %
18	Hamilton County	0.241496
19	Delaware County	0.040419
17	Lewis County	0.036939
14	Orleans County	0.035003
7	Chautauqua County	0.031367

Figure 5.1.

Similarly for the United States data, I calculated a participation percentage (people / state population) for each cleanup. Then, I calculated average participation rates for each state. I merged the average participation rates and state populations into a new Pandas DataFrame. I again exported this DataFrame as a csv file and used Tableau to illustrate the data.

Figure 5.2 shows the six states with the highest participation ratios per cleanup relative to their populations.

	State	Average Involved %
13	California	0.000059
3	Florida	0.000041
5	Massachusetts	0.000278
24	Connecticut	0.000456
11	Texas	0.000161
10	New York	0.000125

Figure 5.2.

The data for New York showed a negative correlation between median household income and average participation rates per cleanup. New York counties with higher median incomes had less people participate per cleanup than counties with lower median incomes. This was also true when analyzing data for the United States.

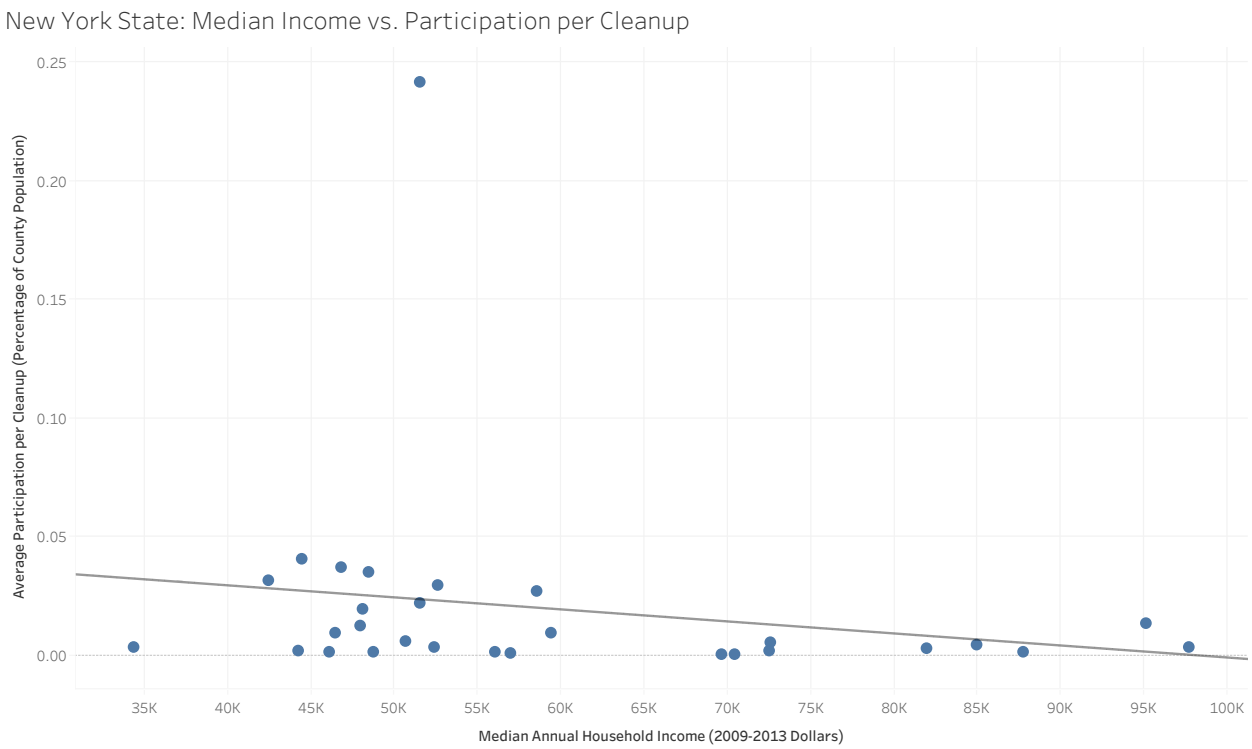

Figure 5.3. This graph shows the negative correlation between income and average participation per cleanup in New York State.

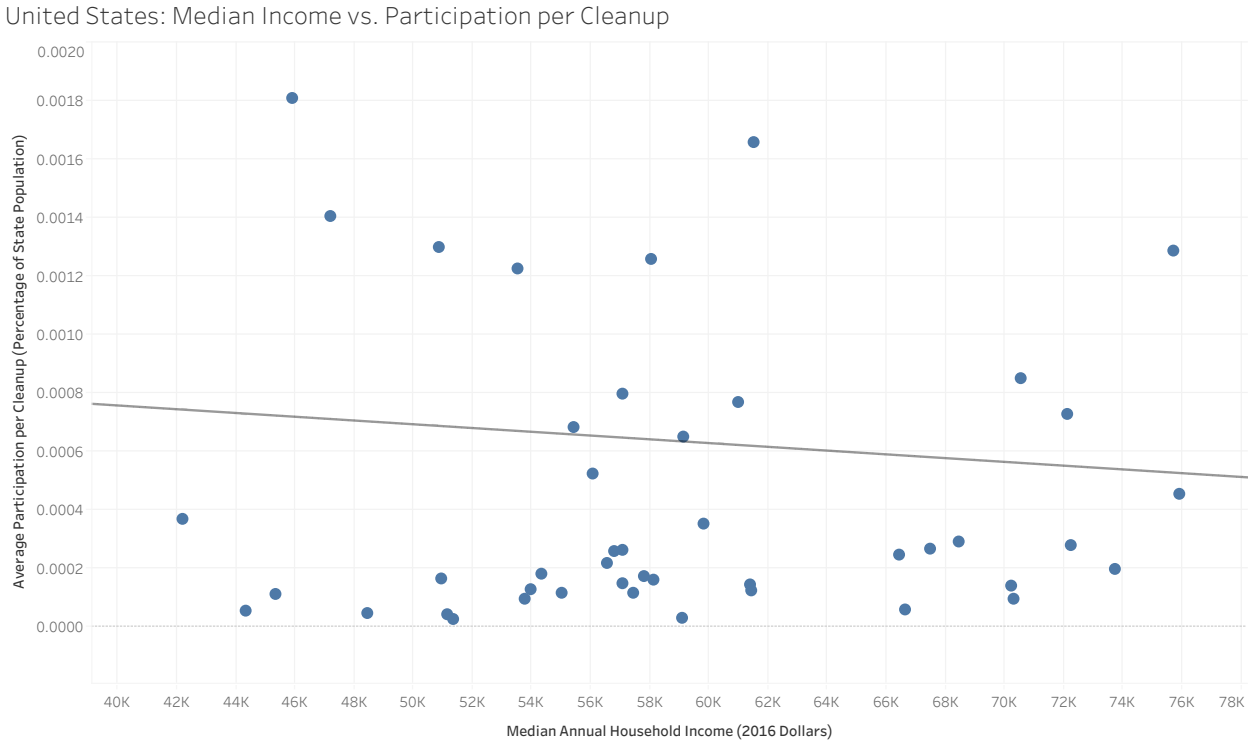

Figure 5.4. This graph shows the negative correlation between income and average participation per cleanup in the United States.

Quantity of Participants in Total

Then I analyzed the total amount of people per New York county that have ever participated in a Clean Swell documented cleanup. This quantity of total people could include duplicates, as it is possible that the same person participated in more than one cleanup. However, this total does represent the app's overall traffic better than participation per cleanup.

The data for New York showed a positive correlation between median household income and total participation. New York counties with higher median incomes had more people utilize the app overall than counties with lower median incomes. This also was true when analyzing data for the United States.

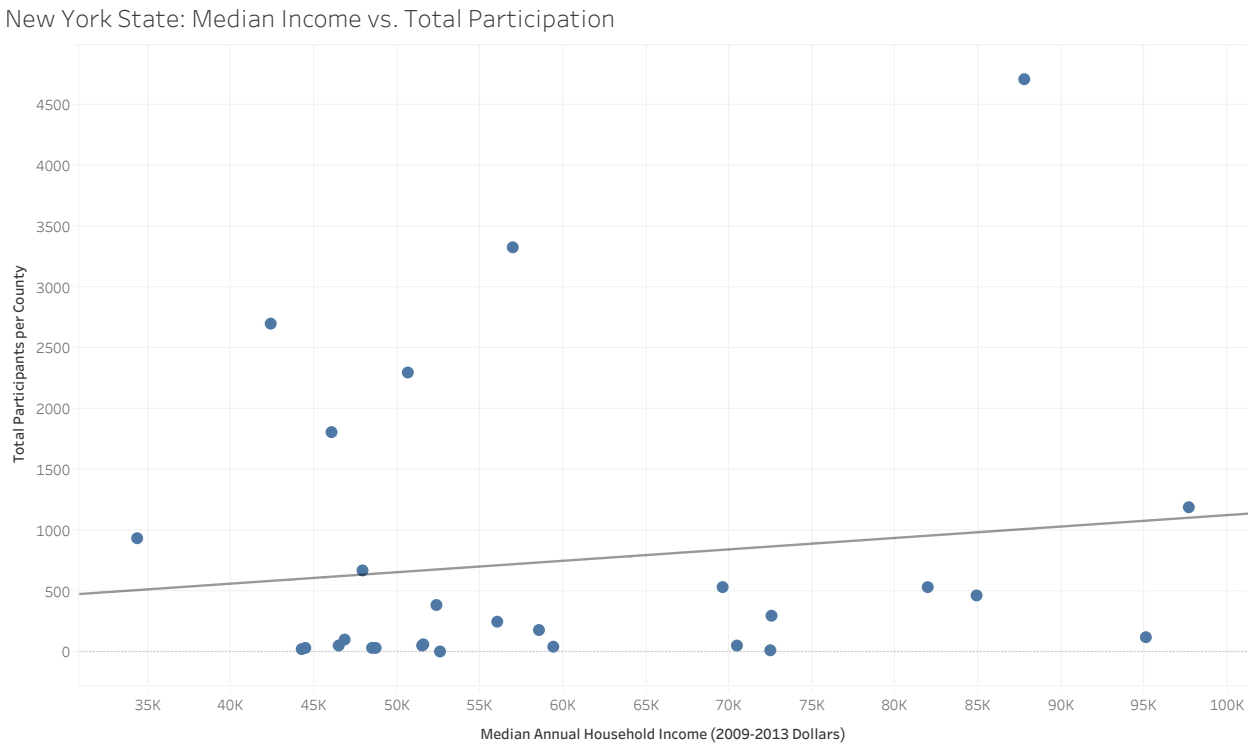

Figure 5.5. This graph shows the positive correlation between income and total participation in New York.

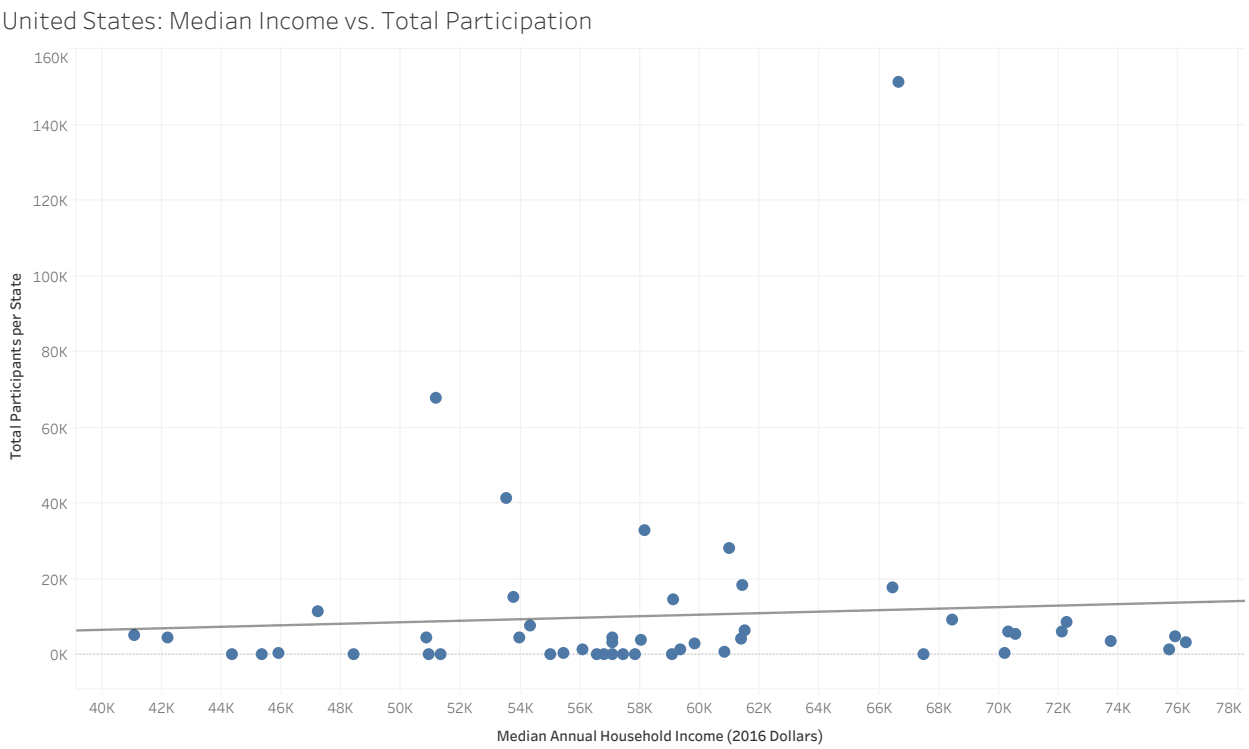

Figure 5.6. This graph shows the positive correlation between income and total participation in the United States.

Quantity of Items Collected

I also analyzed the total quantity of items that have been collected. The data for New York and the United States both showed positive correlations between median household income and total items collected. Locations with higher median incomes are removing larger quantities of trash from the environment than areas with lower median incomes.

Again, the New York data is showing similar correlations to the United States data, which is a good sign that one state may be representative of the greater whole.

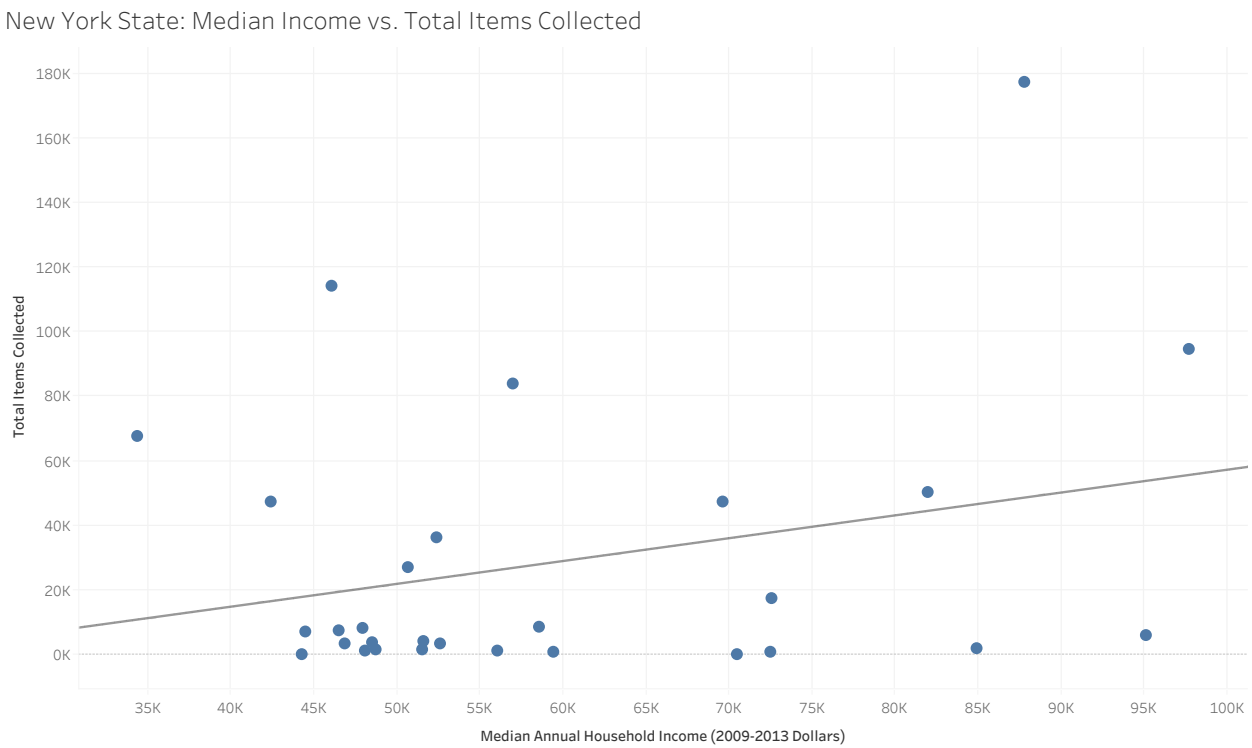

Figure 5.7. This graph shows the positive correlation between income and the total quantity of items collected in New York.

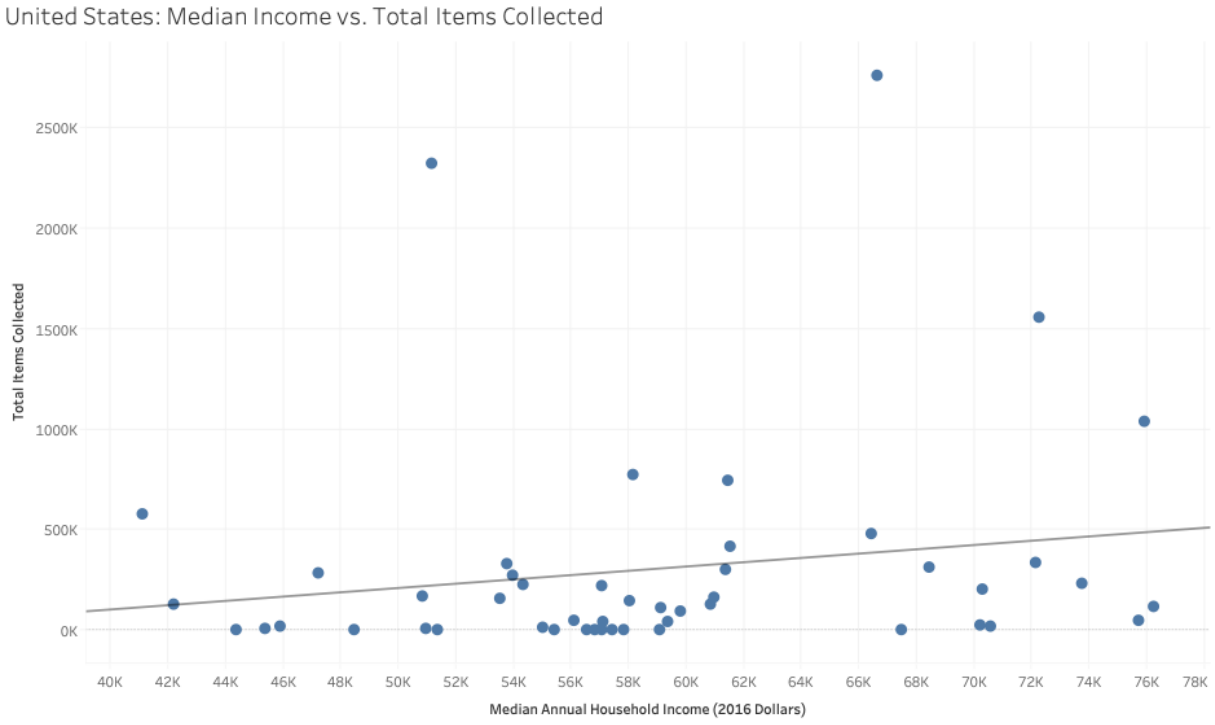

Figure 5.8. This graph shows the positive correlation between income and the total quantity of items collected in the United States.

Quantity of Clean Swell Documented Cleanups

When further analyzing the influence of income, it is seen that higher income areas document more cleanups with Clean Swell. Figures 5.11 and 5.12 illustrate this. Shown below are the New York counties and states ordered by the quantity of cleanups per location. The red highlighted bar represents the county or state with the median quantity of cleanups.

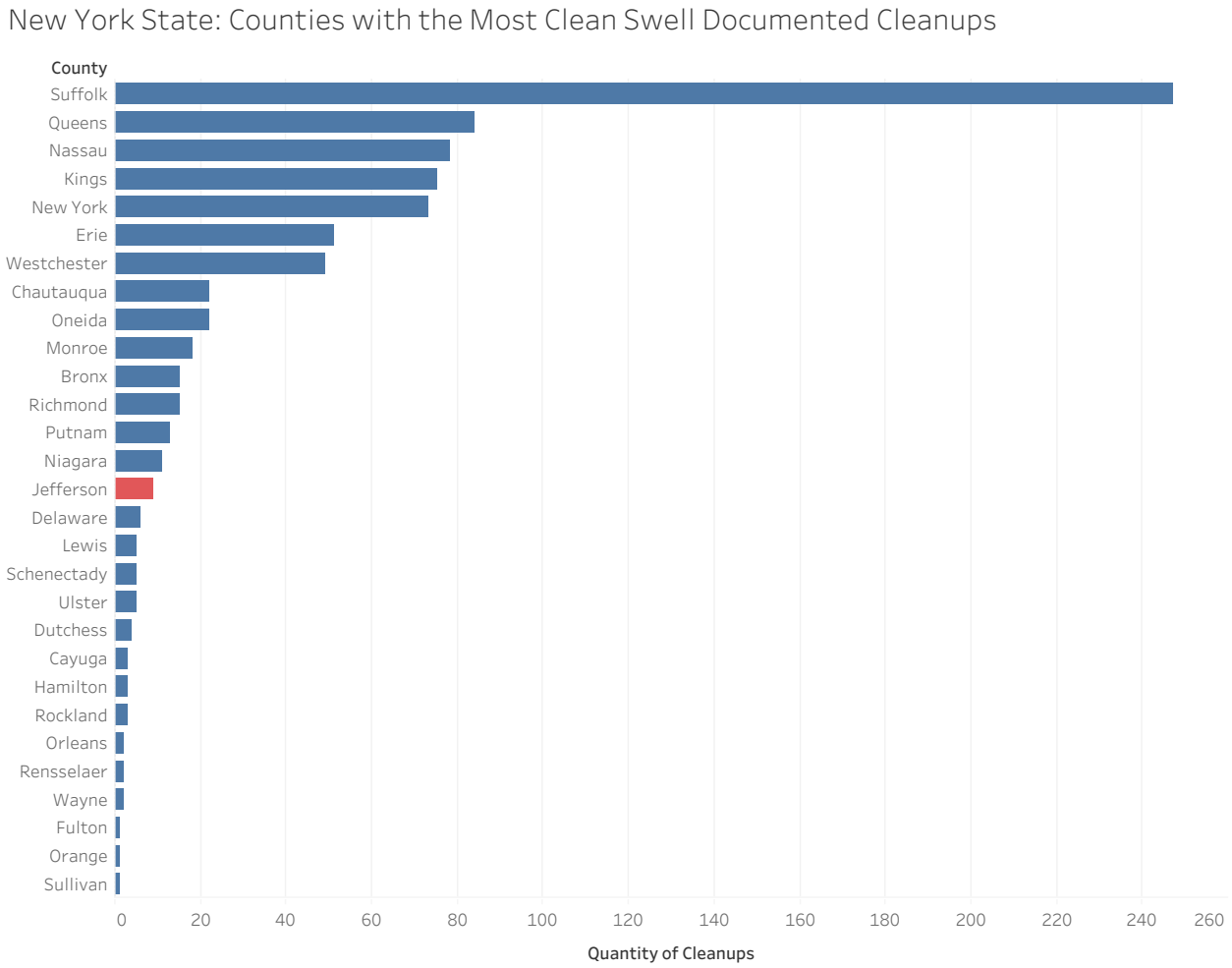

Figure 5.9. This graph emphasizes which New York counties have the most Clean Swell documented cleanups.

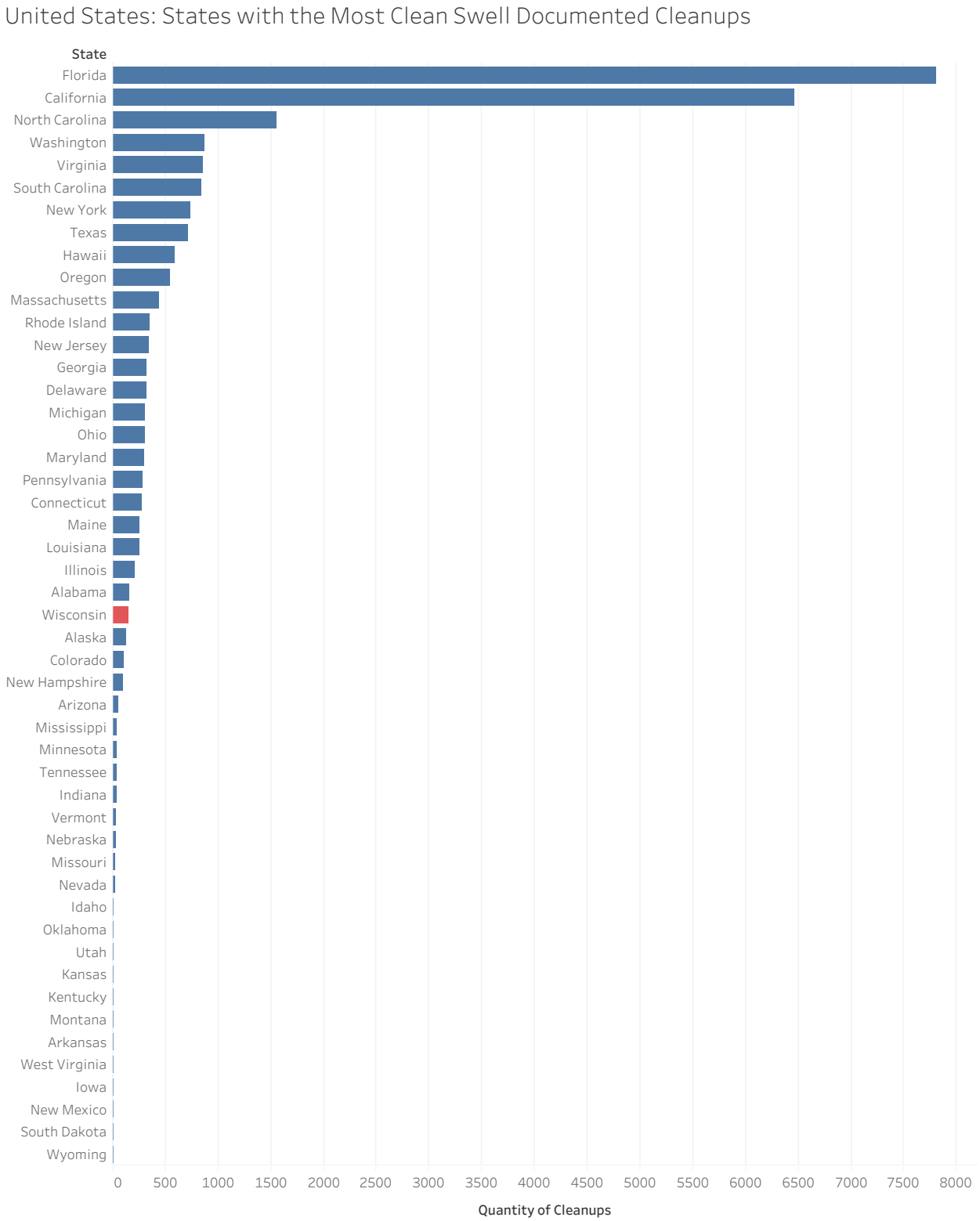

Figure 5.10. This graph emphasizes which states have the most Clean Swell documented cleanups.

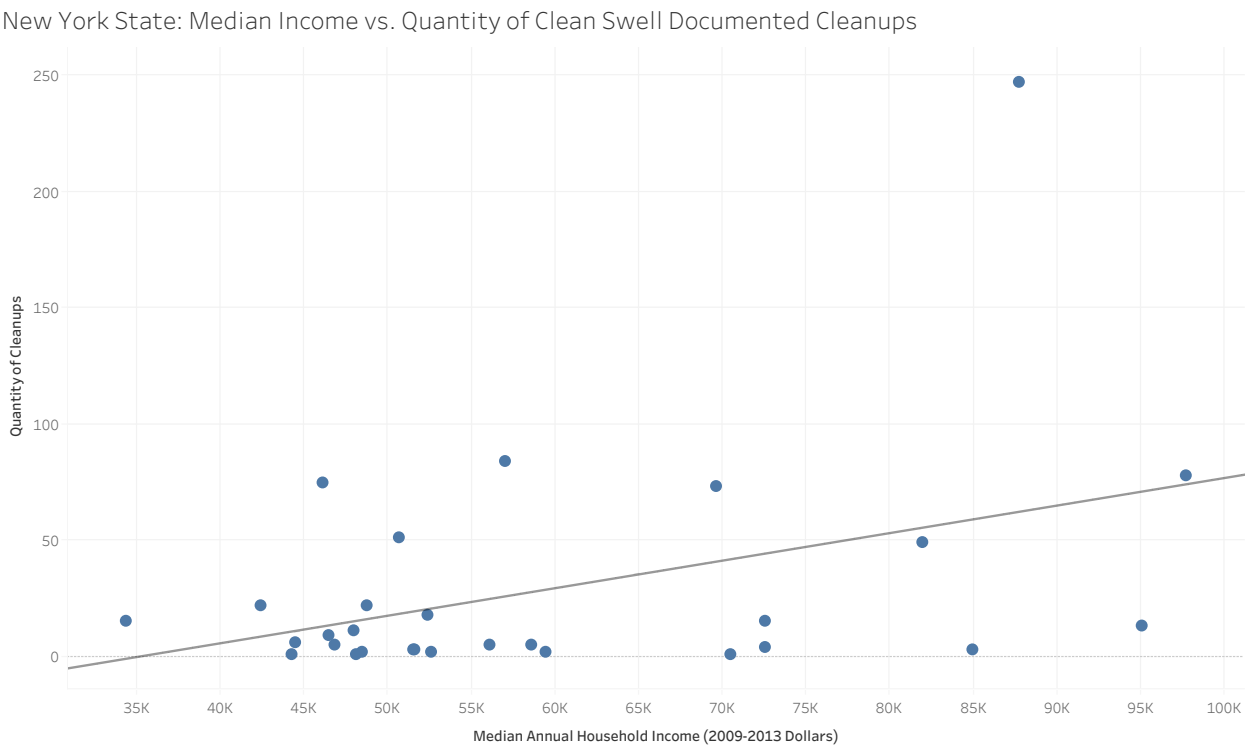

Figure 5.11. This graph shows the positive correlation between median income and the quantity of Clean Swell documented cleanups in New York State.

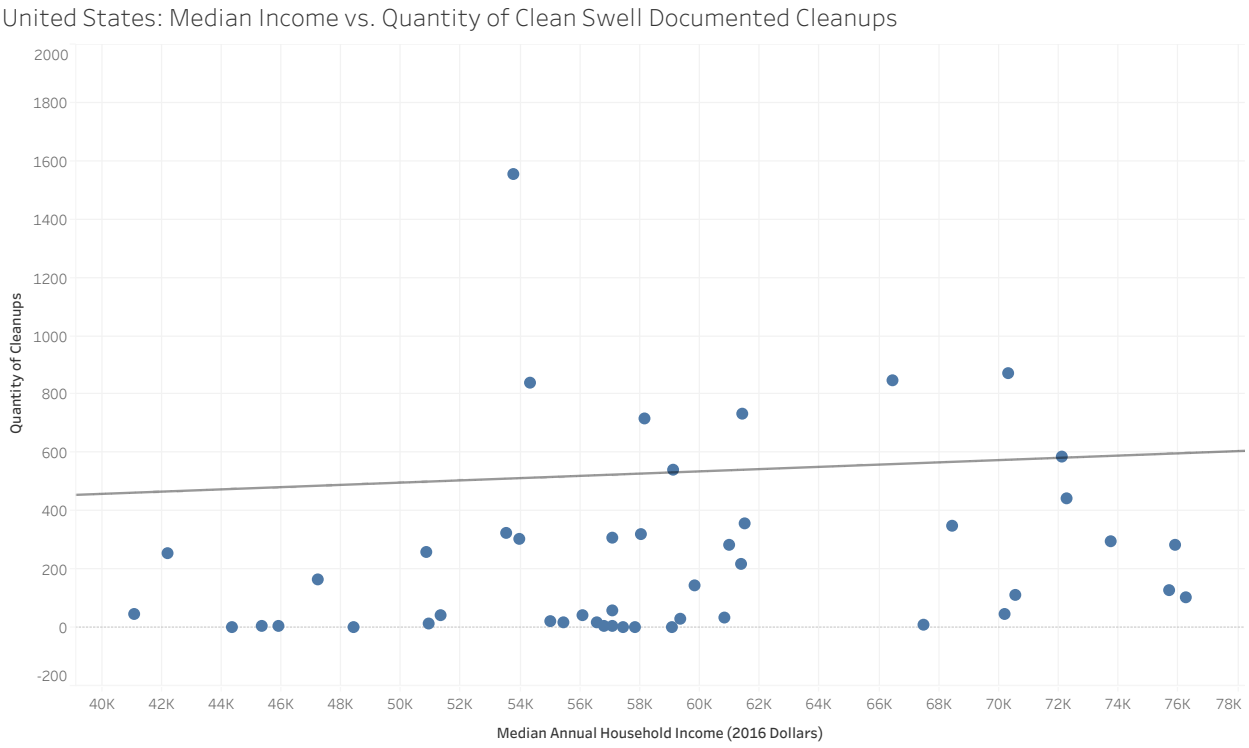

Figure 5.12. This graph shows the positive correlation between median income and the quantity of Clean Swell documented cleanups in the United States.

Summary

Therefore, it seems that higher income areas tend to have more people utilizing Clean Swell overall but less people attending per cleanup. Higher income areas are collecting a larger quantity of trash from the environment, which is likely due to these populations using the app more often.

It is evident that people from areas with lower median incomes are less likely to utilize the Clean Swell app than people from areas with higher median incomes. One possible solution is to increase advertising directed towards communities of lower income. This could primarily be targeted through community engagement opportunities at places such as community centers, religious centers, and parks. There seems to be a trend of higher attendance per cleanup in lower income areas, so perhaps Clean Swell could benefit from advertising through community programs. A cleanup documented with Clean Swell could become a community effort and may encourage more people to download and use the app.

These hypotheses are based on trends seen across the Clean Swell datasets. To validate these claims, a brief questionnaire could be added to the app's registration process. The current sign-up process requests the user's home country. It would be informative to also request the user's home state and city. As well, there should be three short, optional multiple choice questions. First, ask the new user how they identify. Possible choices could include retired, working professional, unemployed, student, or other. This will help to identify the age demographic of participants. The next question should ask how they discovered the Clean Swell app. It would be especially informative to learn how participants are hearing about Clean Swell for future advertising purposes. The final question should ask users to select what their annual income is from multiple options of income ranges. Although income responses may be inaccurate, their answers could be compared against the median income of their home county to

see if data is relatively consistent. Even if only a portion of new users choose to answer these optional questions when creating a profile, this would still provide a random sample. This random sample could be analyzed to see if the data is consistent with my claims that people of higher incomes are more often using Clean Swell.

Chapter 6

The Effect of Population

The Clean Swell datasets were then analyzed to learn how population affects participation with the app.

Quantity of Participants per Cleanup

The data for New York and the United States both showed a negative correlation between population and participation ratios per cleanup. More populated areas have less participation per cleanup relative to the local population.

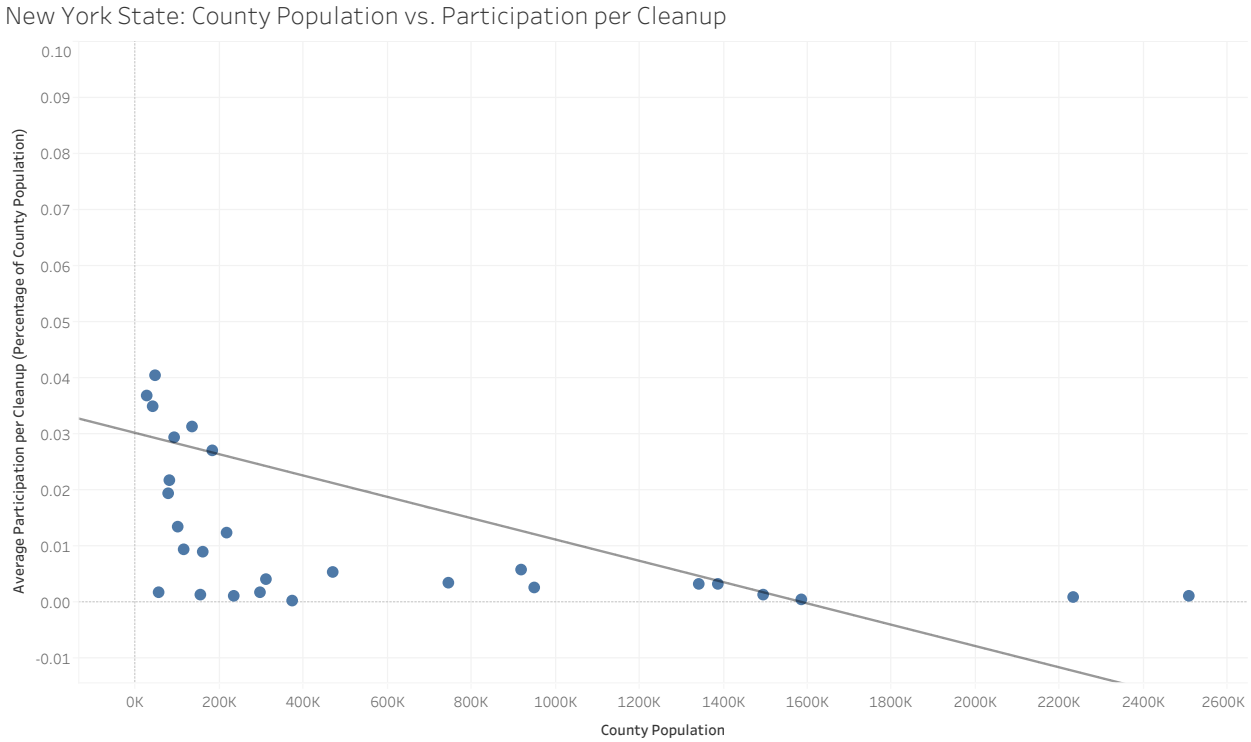

Figure 6.1. This graph shows the negative correlation between population and average cleanup participation in New York State.

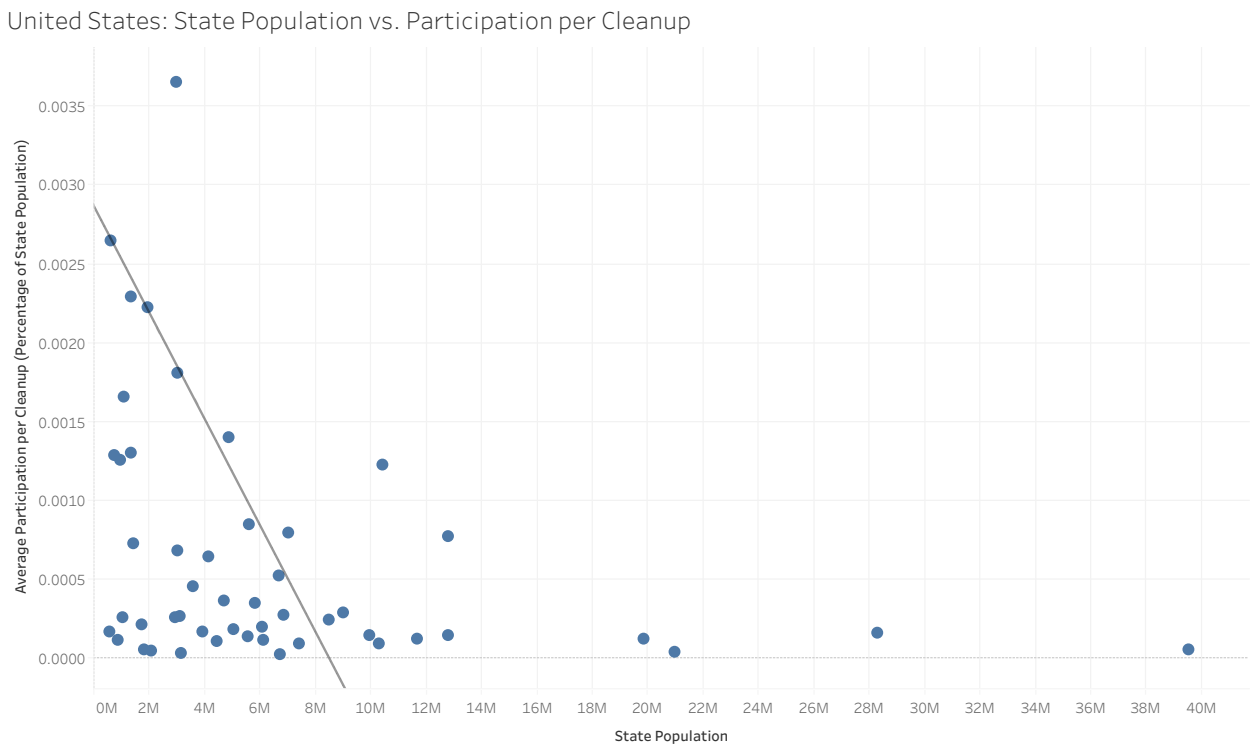

Figure 6.2. This graph shows the negative correlation between population and average cleanup participation in the United States.

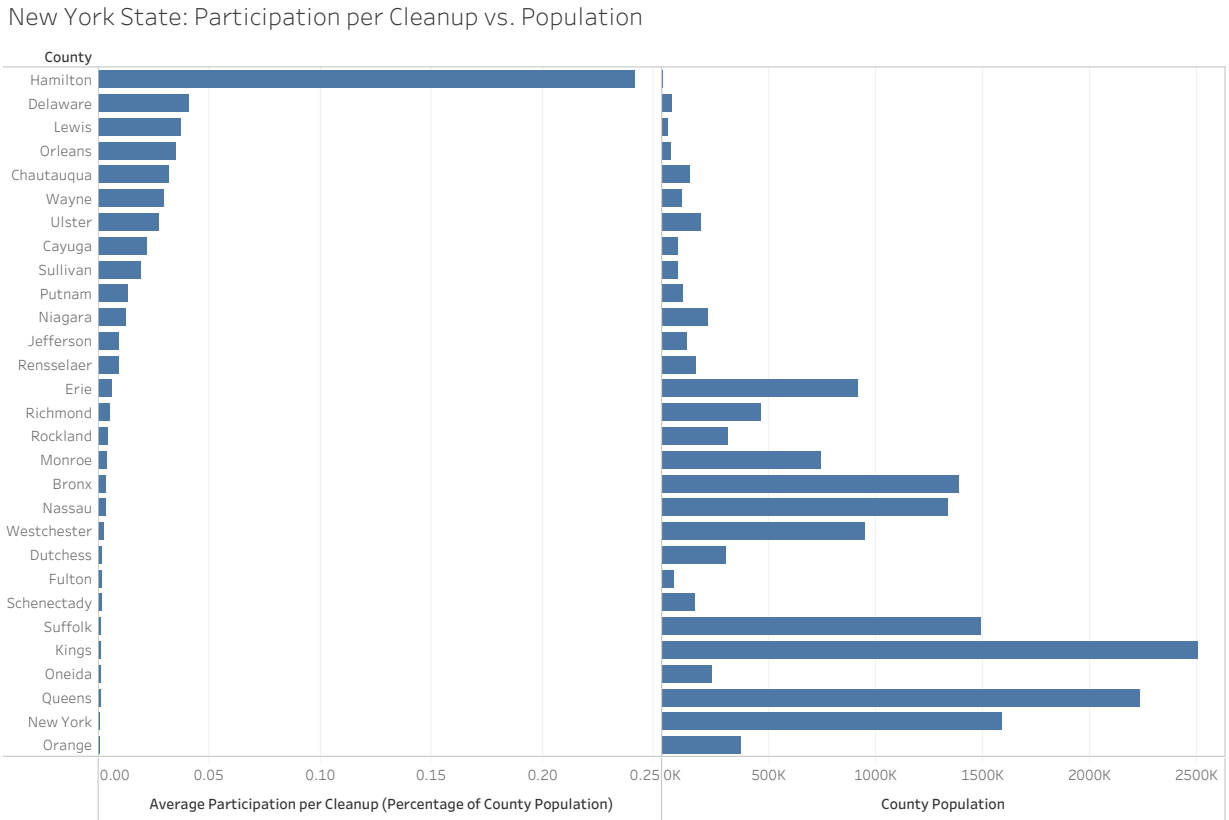

Figure 6.3. This graph shows the New York counties with the most participation per cleanup compared to their respective populations.

Quantity of Participants in Total

Then I analyzed the total quantities of people that have ever participated in a Clean Swell documented cleanup. This quantity of total people could include duplicates, as it is possible that the same person participated in more than one cleanup. However, this total does represent the app's overall traffic better than participation per cleanup.

The data for both New York and the United States showed a positive correlation between population and total participation. Areas with higher population levels had more people utilize the app overall.

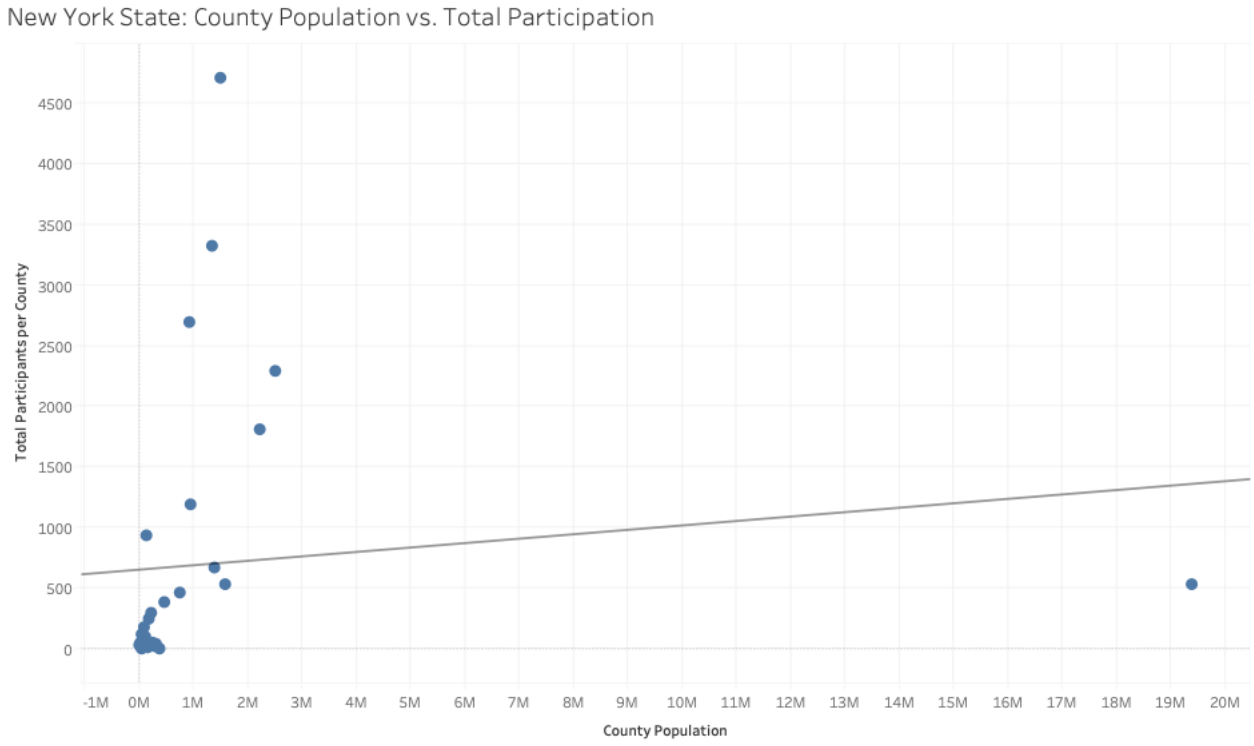

Figure 6.4. This graph shows the positive correlation between population and total participation in New York.

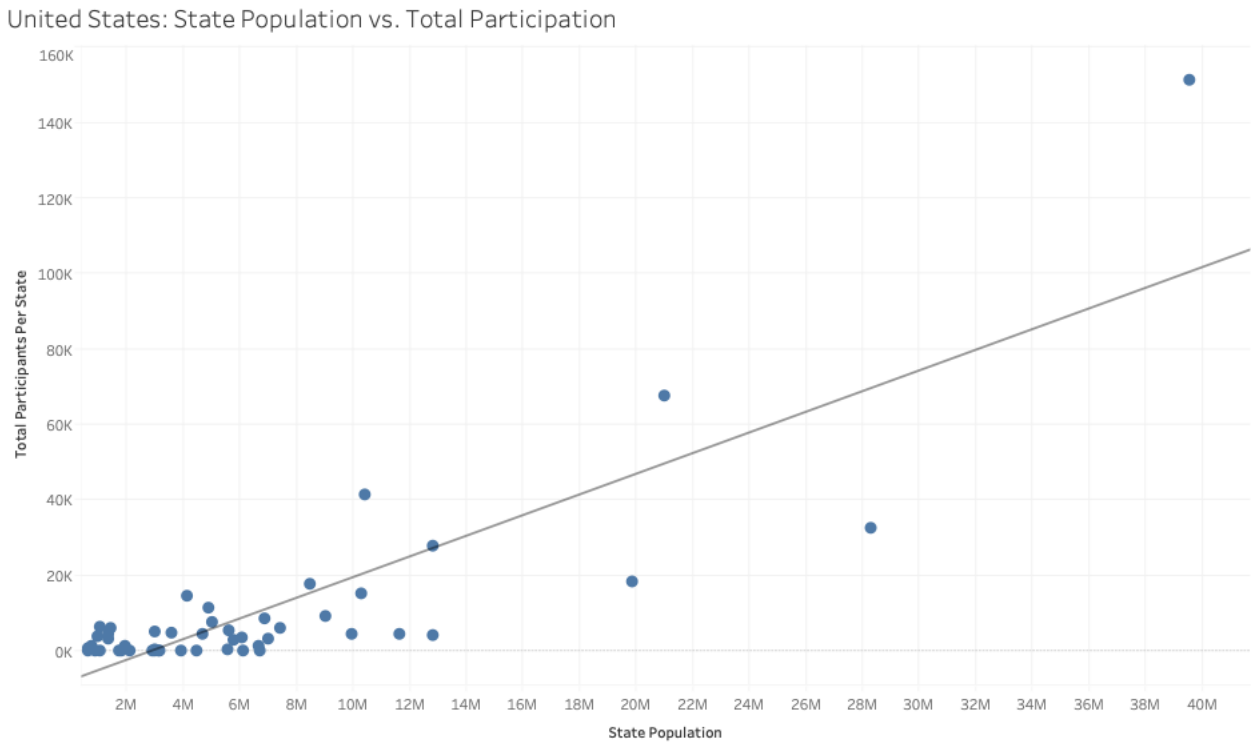

Figure 6.5. This graph shows the positive correlation between population and total participation in the United States.

Quantity of Items Collected

I also analyzed the total quantity of items that have been collected by Clean Swell users. The data for New York and the United States both showed positive correlations between population and the total quantity of items collected. Areas with higher populations are removing larger quantities of trash from the environment than less populated areas.

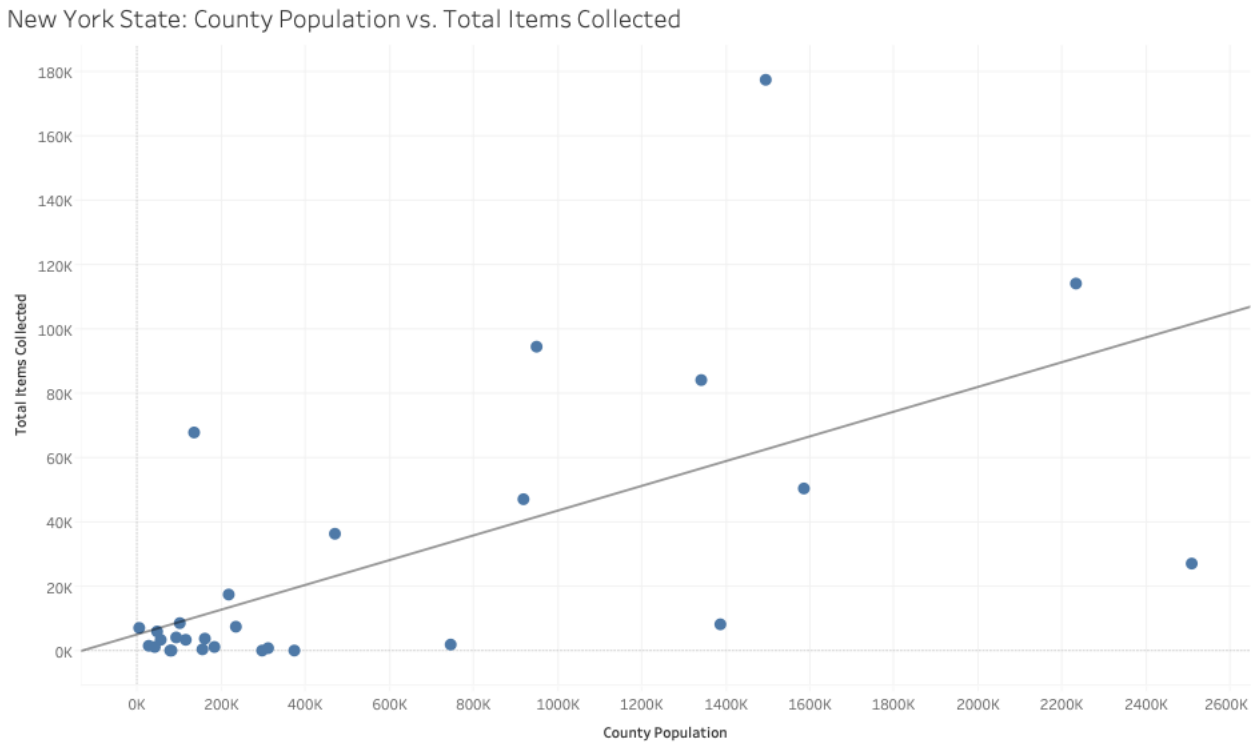

Figure 6.6. This graph shows the positive correlation between population and the total quantity of items collected in New York.

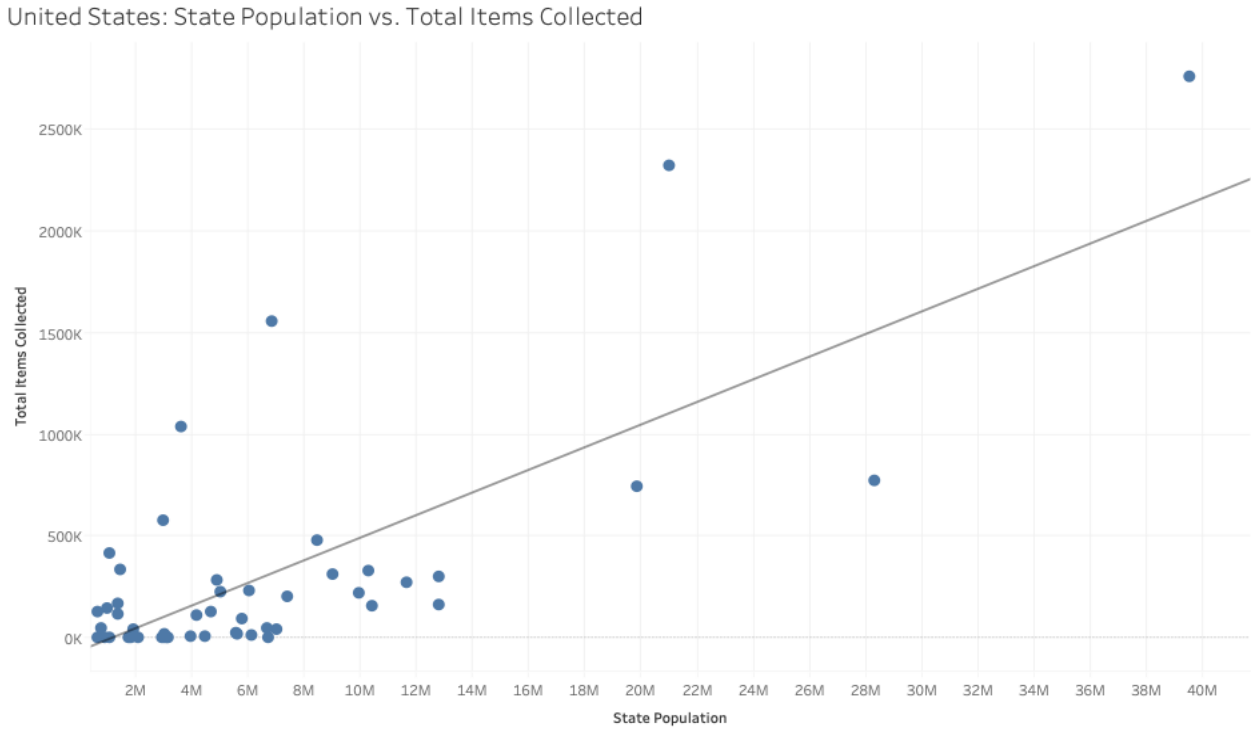

Figure 6.7. This graph shows the positive correlation between population and the total quantity of items collected in the United States.

Quantity of Clean Swell Documented Cleanups

Higher populated areas tend to have more cleanups that are documented with Clean Swell. There is a clear positive correlation between population levels and the quantity of Clean Swell documented cleanups.

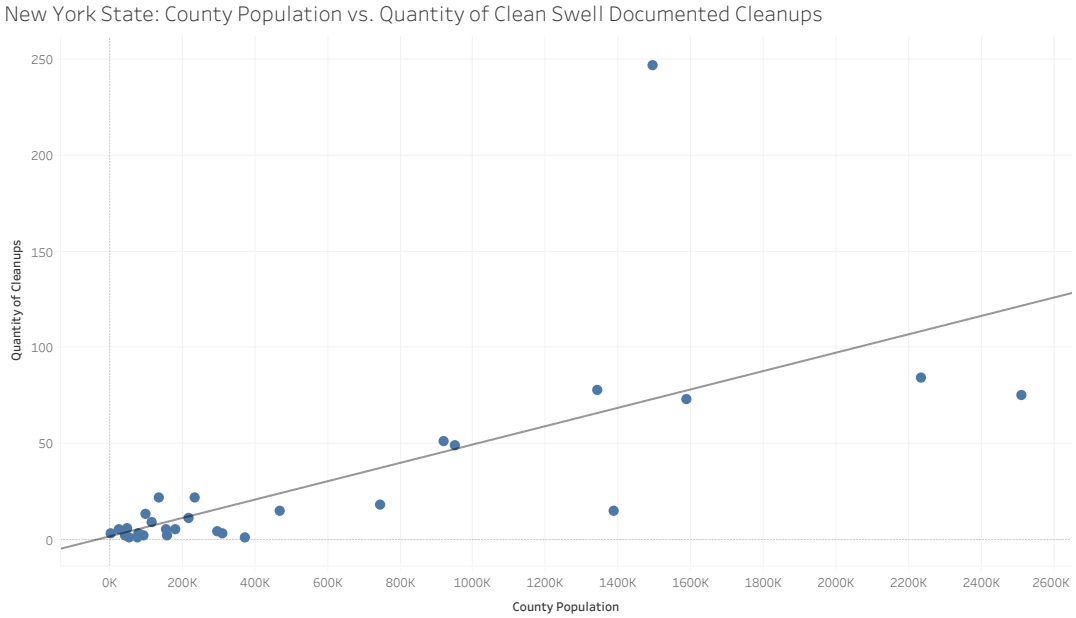

Figure 6.8. This graph shows the positive correlation between population and the quantity of Clean Swell documented cleanups in New York.

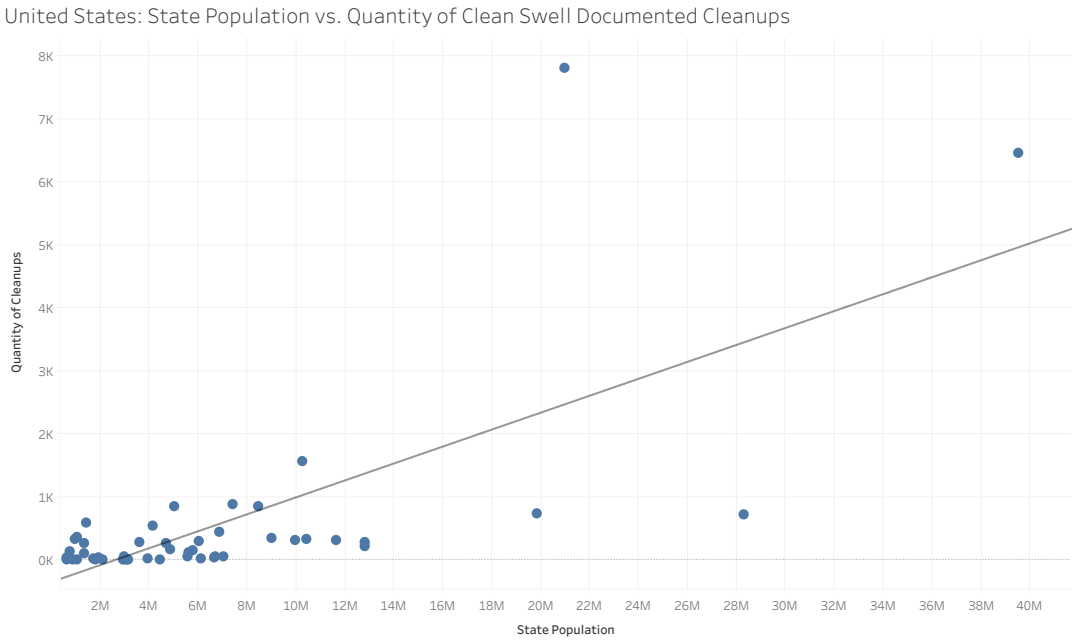

Figure 6.9. This graph shows the positive correlation between population and the quantity of Clean Swell documented cleanups in the United States.

Summary

Therefore, higher populated areas tend to have more people utilizing Clean Swell overall but less people attending per cleanup. More populous areas are also collecting a larger quantity of litter from the environment. This is likely due to higher populated areas using the app more often.

It seems that people living in less populated areas are downloading and using the Clean Swell app less often than people of densely populated regions. Targeted advertising in regions with low population levels could increase the quantity of Clean Swell users. No matter the population of a city, shared spaces such as community centers, religious centers, and parks are typically common. These places could be optimal choices to advertise the app. A cleanup documented with Clean Swell could become a community effort and may encourage more people to download and use the app.

These hypotheses are based on trends seen across the United States and New York State Clean Swell datasets. As previously mentioned, these claims could be validated by adding a brief questionnaire to the process of creating an account. The current registration process requests the user's home country. It would be informative to also request the user's home state and city. This location data could be used to find the median population of where the user resides. Even if only a portion of new users answer these optional questions when creating a profile, this would still provide a random sample. This random sample could be analyzed to see if the data is consistent with my claims that people of more densely populated areas are more often using Clean Swell.

Chapter 7

Syracuse University's Recycling and Trash Figures

Purpose

Often it can be easy to separate ourselves from an environmental problem such as plastic pollution, especially when our trash is conveniently hauled away. As the famous saying goes, "Out of sight, out of mind." The purpose of analyzing Syracuse University's recycling and trash figures is to better understand the SU community's environmental impact. Perhaps this will inspire community members to be more conscious of their waste and take action with citizen science.

Syracuse Haulers Data

Syracuse University's recycling and trash data is provided by Syracuse Haulers, which is the company that manages waste removal for the university. When analyzing this data, some common trends appear. For example, the quantity of trash that is sent to a landfill is almost always greater than waste that will be recycled. In some cases, the amount of trash is almost double that of recycled items per month. As well, there consistently is more trash produced in May than any other month, which is likely due to students moving out at the end of the academic year.

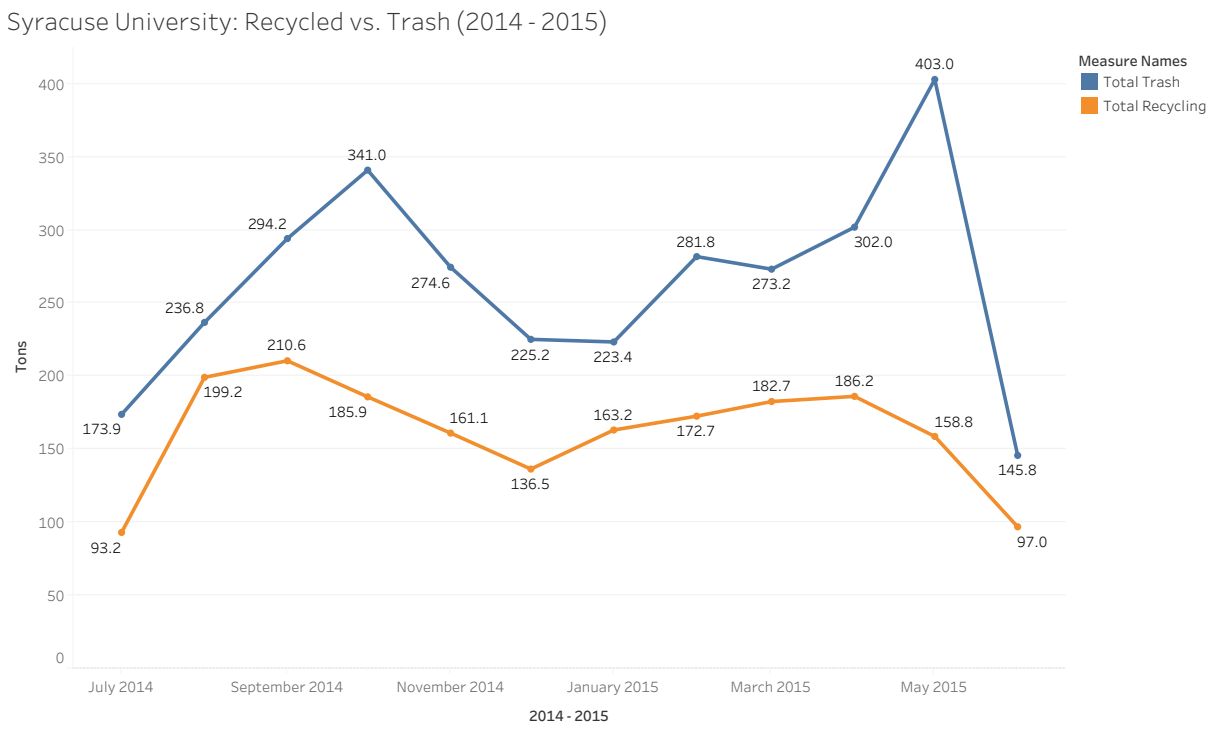

Figure 7.1. This graph illustrates Syracuse University's recycling and trash figures from July 2014 to June 2015.

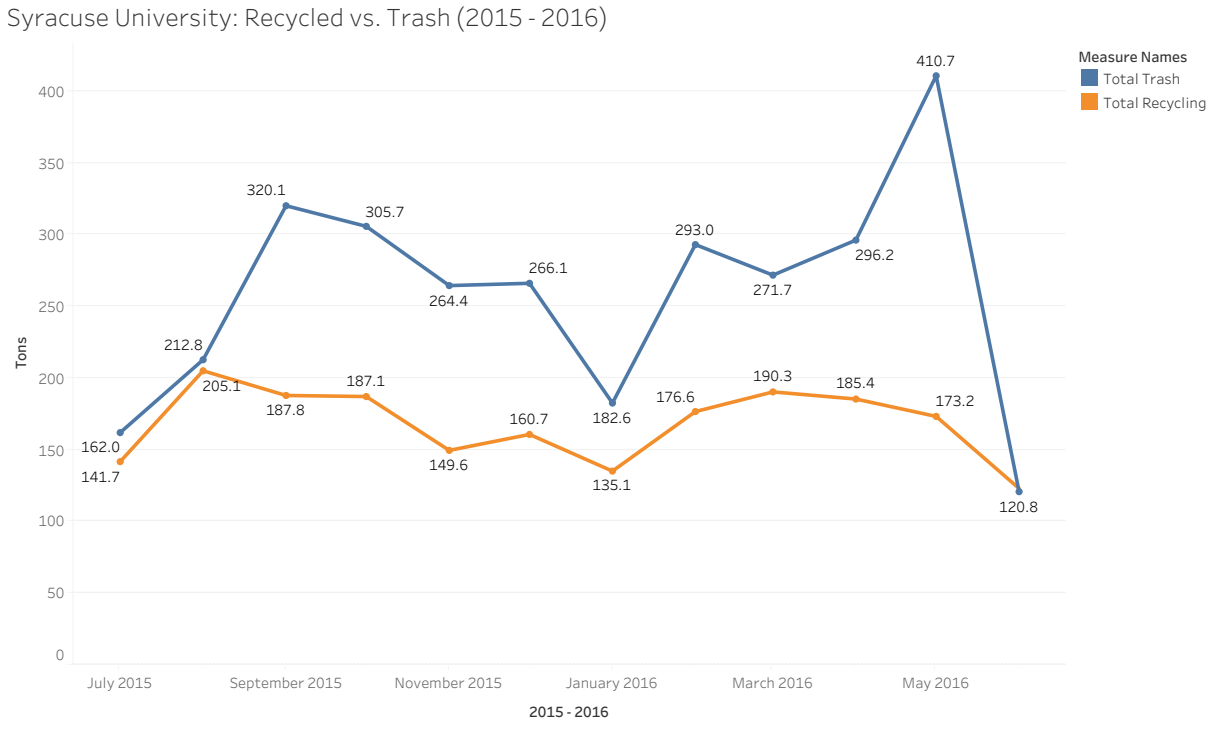

Figure 7.2. This graph illustrates Syracuse University's recycling and trash figures from July 2015 to June 2016.

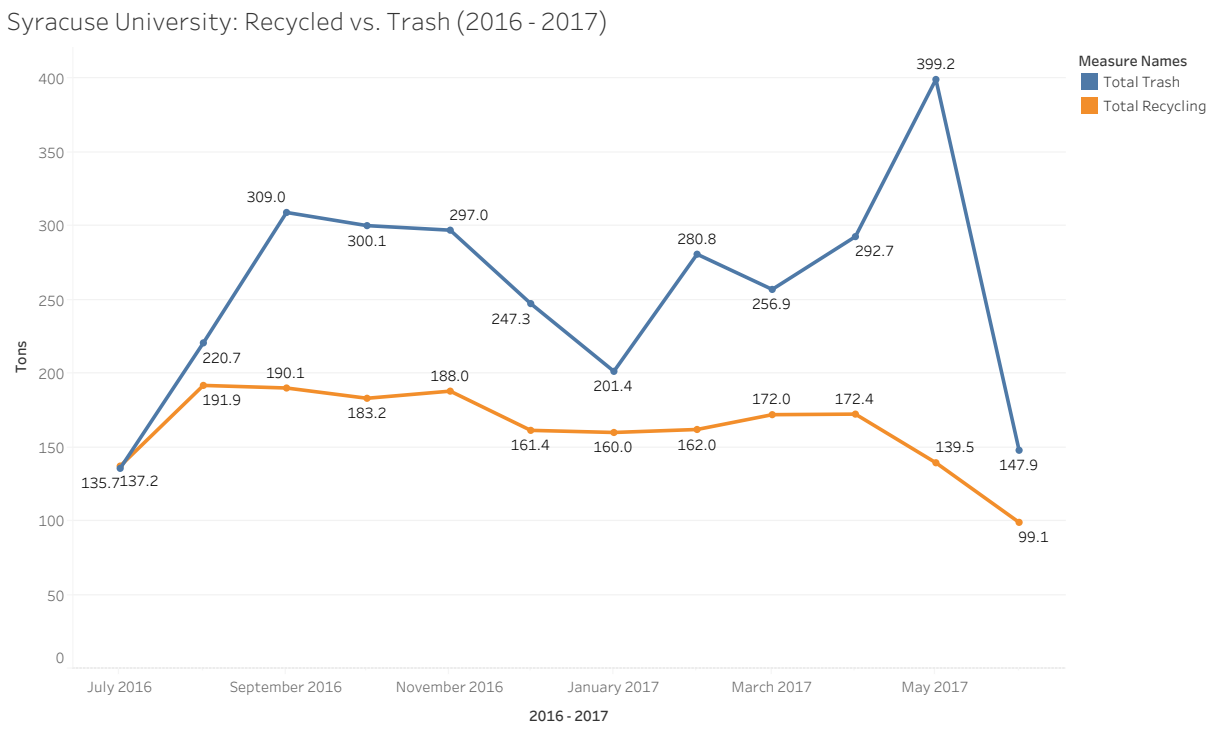

Figure 7.3. This graph illustrates Syracuse University's recycling and trash figures from July 2016 to June 2017.

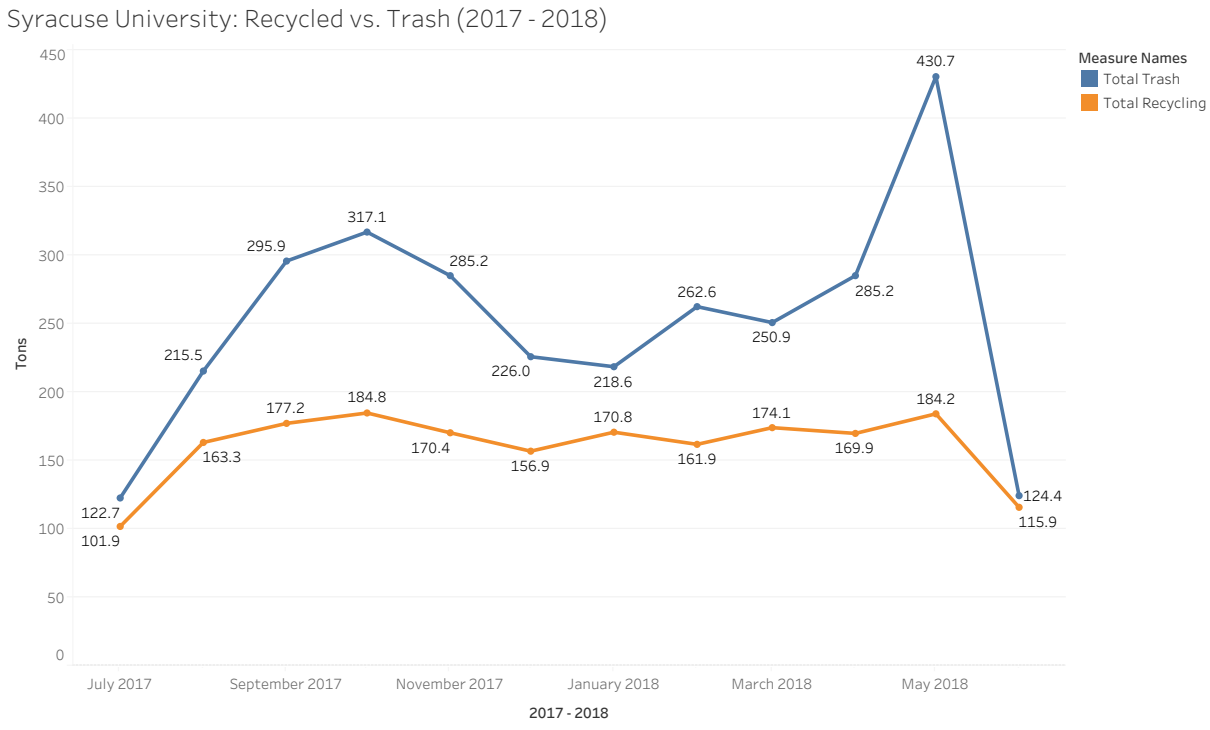

Figure 7.4. This graph illustrates Syracuse University's recycling and trash figures from July 2017 to June 2018.

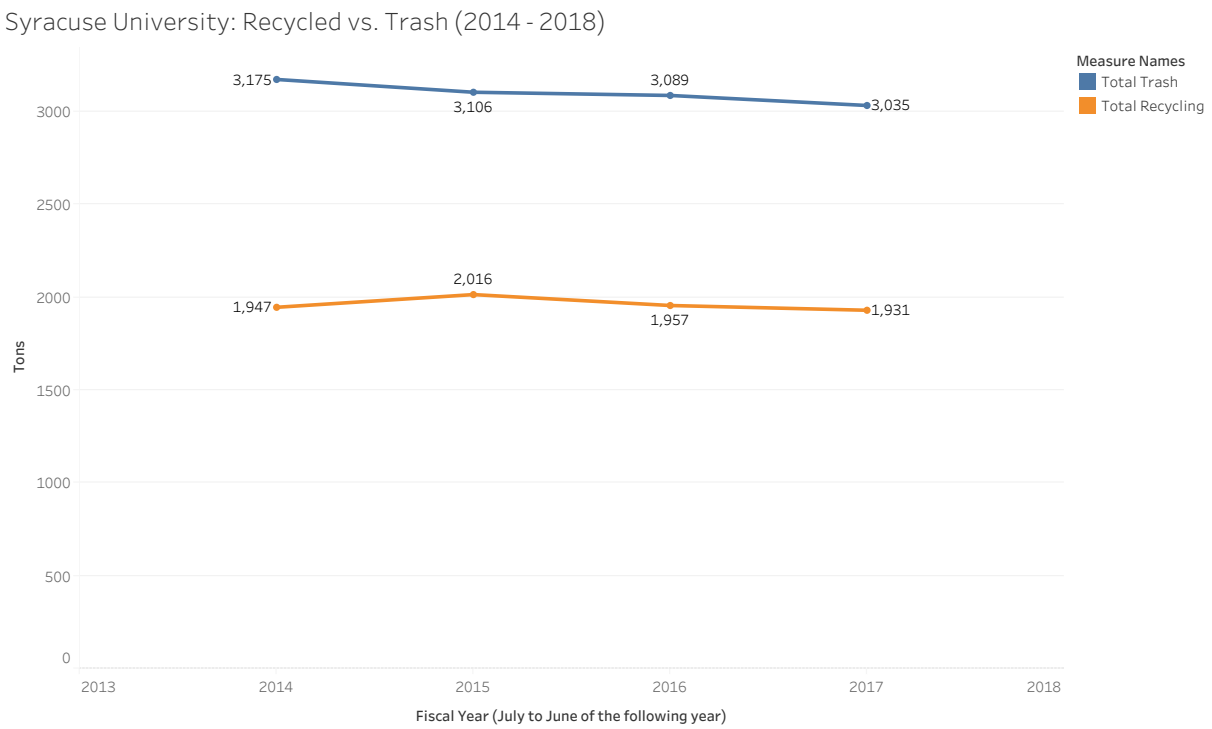

Figure 7.5. This graph shows the quantities of landfilled trash versus recycled trash per SU fiscal year (July to June).

Syracuse University has calculated the quantities of Syracuse University students, faculty, and staff. There are a total of 27,765 SU people ("Facts, Figures, and Rankings"). When comparing this quantity of people to the trash and recycling data for SU, I found that on average 223 pounds of trash is created per person on campus per fiscal year (July to June). On average, 141 pounds of recyclables are generated per person per fiscal year on SU's campus. I strongly believe that these are low estimates since a portion of the 27,765 people are not on campus (e.g. studying abroad, taking a leave of absence, etc.). I would infer that even more trash and recycled material is created per person on campus.

What does 223 pounds of trash look like? I analyzed the United States data from Clean Swell to get an average count of trash per pound. This gives a better perspective of the quantities of trash produced and hauled away from Syracuse University's campus. I found that on average,

26 items make up one pound of trash. This means that each person on campus is producing an estimated 5,798 pieces of trash and 3,666 recyclables per academic year.

Chapter 8

Conclusion

The purpose of this study is to analyze the impact of the Clean Swell mobile application on marine plastic pollution. This study found that the Clean Swell app has a significant impact even with a limited quantity of users. From the United States alone, over 8.8 million pounds of trash have been collected, documented, and removed from the environment. That is over 15 million pieces of trash. If apps like Clean Swell become more mainstream, citizen science could skyrocket and even more pollution could be saved from entering the oceans. This study also revealed that people from areas with higher populations and higher median incomes are using Clean Swell more often than other users.

This study also found that there is a serious need for more plastic pollution data. We are living in a data-driven world, but the quality of data is problematic and rarely consistent. There were other avenues I attempted to pursue in my analysis, but often the data was not available to make meaningful conclusions. For example, I looked at the Environmental Protection Agency's recycling data by state in hope of comparing states' efficiencies of recycling. Again, the pattern of missing data was prevalent. Most states do not provide the information, and the few that do have different ways of collecting data per state, which would have made comparisons challenging. Also, the most recent date of data varies per state. Some states have not reported this data since 2012, while another state has data from 2017. Even if I normalized the available

data by state population, so much data is missing. Few states have generated reports on this environmental data. There needs to be an uniform way of measuring and reporting recycling data for each state, and that could be enforced with legislation. Information needs to be better managed for it to be meaningful and useful.

Overall, environmental data is missing. Citizen science is one way to increase data collection, and mobile applications such as Clean Swell are effective ways to gather data. Apps can help minimize data errors with automatic location and time/date reporting as well as limiting the options that users have for classifying trash. Then, the app's data can be combined into one organized, public database.

In addition to collecting more data, citizen scientists provide other benefits. They "help to determine local litter sources, thereby contributing to keeping coastal regions clean" (Hidalgo-Ruz 439). In addition to cleaning up pollution, citizen scientists are the eyes on the ground. With more Clean Swell app users all over the country, there is an increased likelihood that someone will see something that has not been previously addressed or known of, such as a litter source. When people take the time that citizen science requires, they become invested in the issue and are more likely to take action.

In order to get people involved, this global environmental crisis needs to be communicated to the public. Plastic pollution needs to become a topic of discussion in mainstream media to increase awareness and motivate people to help. Households from lower-income areas and less populated areas are less inclined to utilize the Clean Swell app, so these populations should be important targets for advertising. Clean Swell could be advertised to these demographics through community centers, religious centers, parks, and other shared spaces in the community. A cleanup documented with Clean Swell could become a community effort that

would help to bring people together and provide a free, engaging activity for participants. A community approach to advertising may encourage more people to download and use the app.

Now is the time for people to get involved and take action. Some of the effects of marine plastic pollution can already be seen. In 2015:

> Marine researchers bought fish at public markets in California and Indonesia and examined their stomach contents. Around one in four fish in both locations had plastic particles in their guts. A previous study in 2014 found microplastics in the guts of oysters and mussels sold at supermarkets. (Oksman)

We are consuming plastic via the food chain. Plastic pollution has become a human health problem in addition to an environmental problem. Plastic is everywhere now. There is plastic litter on the streets, across littered beaches, and even at the bottom of the ocean (Gibbens).

What is the true magnitude of this plastic pollution crisis? There is not enough data to know exactly. However, we do know that society needs to become invested in this problem and take action. There needs to be more research and accessible data. New legislation should push states to collect and provide consistent data. Citizen science could make a huge difference. It is our responsibility to do something since we know our actions are causing and accelerating marine plastic pollution.

Works Cited

"Cigarette Butts." *5 Gyres Science to Solutions*, 5 Gyres Institute, www.5gyres.org/cigarette-butts/.

"Citizen Science." *National Geographic Society*, National Geographic Society, 9 Oct. 2012, www.nationalgeographic.org/encyclopedia/citizen-science/.

"Citizen Science." *US Forest Service*, www.fs.fed.us/working-with-us/citizen-science.

"Clean Swell." *Ocean Conservancy*, Ocean Conservancy, 2019, oceanconservancy.org/trash-free-seas/international-coastal-cleanup/cleanswell/.

"Facts, Figures, and Rankings." *Syracuse University*, Syracuse University, www.syracuse.edu/about/facts-figures-rankings/.

"FAQs." *Algalita Marine Research and Education*, Algalita Marine Research and Education, 2017, www.algalita.org/faqs/.

Gibbens, Sarah. "Plastic Bag Found at the Bottom of World's Deepest Ocean Trench." *National Geographic*, National Geographic Society, 16 May 2018, news.nationalgeographic.com/2018/05/plastic-bag-mariana-trench-pollution-science-spd/.

Hidalgo-Ruz, Valeria, and Martin Thiel. "Chapter 16: The Contribution of Citizen Scientists to the Monitoring of Marine Litter." *Marine Anthropogenic Litter*, by Melanie Bergmann et al., Springer International Publishing, 2015, pp. 429–447.

Kaplan, Sarah. "By 2050, There Will Be More Plastic than Fish in the World's Oceans, Study Says." *The Washington Post*, The Washington Post, 20 Jan. 2016, www.washingtonpost.com/news/morning-mix/wp/2016/01/20/by-2050-there-will-be-more-plastic-than-fish-in-the-worlds-oceans-study-says/?utm_term=.e93c43c98aed.

"Median Annual Household Income." *The Henry J. Kaiser Family Foundation*, The Henry J. Kaiser Family Foundation, 22 Sept. 2017, www.kff.org/other/state-indicator/median-annualincome/?currentTimeframe=0&sortModel=%7B%22colId%22%3A%22Location%22%2C%22sort%22%3A%22asc%22%7D.

"New York Median Household Income, 2009-2013 by County." *IndexMundi*, www.indexmundi.com/facts/united-states/quick-facts/new-york/median-household-income#table.

Oksman, Olga. "Fish for Dinner? Your Seafood Might Come with a Side of Plastic." *The Guardian*, Guardian News and Media, 31 Aug. 2016, www.theguardian.com/lifeandstyle/2016/aug/31/fish-plastic-pollution-ocean-environment-seafood.

"Partners." *Ocean Conservancy*, Ocean Conservancy, 2019, oceanconservancy.org/trash-free-seas/international-coastal-cleanup/partners/.

"Population Data and Projections." *New York State Department of Labor*, labor.ny.gov/stats/nys/statewide-population-data.shtm.

"The 50 US States Ranked By Population." *World Atlas*, Worldatlas.com, www.worldatlas.com/articles/us-states-by-population.html.

"The Rundown on Plastic #6 (Styrofoam)." *American Disposal Services*, American Disposal, www.americandisposal.com/blog/the-rundown-on-plastic-6-styrofoam.

UJ, Anjali. "What Are the Major Challenges Faced by Data Scientists?" *Analytics Insight*, Stravium Intelligence LLP, 1 May 2018, www.analyticsinsight.net/what-are-the-major-challenges-faced-by-data-scientists/.

"US States - Ranked by Population 2019." *World Population Review*, World Population Review, 2019, worldpopulationreview.com/states/.