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Article

Flight paths over greenspace in major United States airports

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SUMMARY

Greenspaces refers to urban and wetlands that contain vegetation, essentially spaces that are green. Because greenspaces are beneficial to reducing pollution, we investigated whether if there is a trend where planes tend to fly over greenspace near airports. We used flight data to generate the flight paths and satellite images and then processed them to find if there was an observable pattern between the location of greenspaces and flight paths. Our hypothesis was that each airport would show a different percentage of planes that fly over greenspace; we expected airports in the suburbs to have higher values, whereas airports near the cities to have lower values. To test the hypothesis, we used image processing functions such as Binarize and SetAlphaChannel from Wolfram Mathematica and statistical analysis in Mathematica. We observed that generally near airports, around 10–15% of total flight paths go over greenspaces. From our observations, we believe that increasing greenspaces near airports would reduce noise pollution and having more trees will absorb the carbon dioxide from planes, resulting in less pollution near airports.

INTRODUCTION

Planes remain one of the most polluting means of transportation by polluting the air and causing noise pollution (1). With a total of around 100,000 flights per day globally, the effects of pollution from aviation contributes significantly to climate change (2). The fossil fuel burned from airplanes not only releases carbon dioxide (CO_2) emissions, but also has other non-CO_2 effects due to nitrogen oxides, which depletes the ozone layer, exposing the earth to more solar radiation (3).

CO_2 is harmful to the environment because as there is more CO_2, it increases the natural greenhouse effect, causing global temperatures to rise (4). Especially, if the airport is near a city, noise pollution becomes a glaring issue. Noise pollution has a correlation to increased risk of developing cardiovascular diseases (5). However, by flying over greenspaces, planes could potentially reduce their detrimental effects. Greenspaces provide vegetation, which absorbs CO_2, helping to offset greenhouse gas emissions (6). Greenspace offers a lot of benefits by improving air and water quality, regulating temperature (7). Wolfram Mathematica is a software system with built-in libraries for several areas of technical computing that allow machine learning, statistics, symbolic computation (8).

We investigated if planes fly over greenspaces near major airports to reduce pollution. We obtained our data from the Wolfram data repository. By using data analysis and image processing techniques to process satellite imagery, we made statistical conclusions for the percentages of greenspace that a plane flies over for each airport, gathered data from seven major United States (US) airports, and provided reasonable evidence to advocate for more greenspaces near airports. We hypothesized that every airport would have a different percentage of planes that fly through greenspace, and that the more suburban the airport is, the greater percentage of greenspace it would have. From our experiment, we found that 10-15% of planes go through greenspace. This study is important because it shows how there has to be improvement to reduce the effects of air pollution.

RESULTS

We used satellite images from seven US airports (Syracuse Hancock International Airport, LaGuardia Airport, Casper International Airport, John F Kennedy International Airport, Chicago O'Hare International Airport, Minneapolis-St. Paul International Airport, and Seattle-Tacoma International Airport) consisting of only flight paths and found the total length of all the flight paths added up from the satellite images from 15,000 ft. We used multiple image processing functions such as Binarize, which changes the green space into black and the non-green space into white. Then, we created a module where we combined all the functions into one module so that we could input the name of the airport and the data to produce all flight paths during that certain day.

From running the full function and testing different airports, we found that the flights for most major airports on average go over 9.41% of greenspaces near the airports. From the data from the seven major US airports in the form of a table, we see that out of the seven US airports we examined, Casper International Airport, a small airport in Wyoming, had the most amount of greenspace where flights go over with 16.1% and Minneapolis St. Paul Airport had the least greenspace with 5.16% (**Table 1**). Then, we erased the parts of the flight paths that go over greenspace. From this, we determined that 9.41% of flight paths went over greenspace near airports (**Table 1**).

DISCUSSION

The main conclusion from our study was that the number of flight paths that go over greenspace is low, which is quite concerning, considering how bad airplane pollution is. First, many of the airports that we looked at were in a large metropolitan center, where there is not much greenspace, as it is more convenient for passengers if airports are located

Airport	Percentage (%)
Syracuse Hancock International Airport	11.67
LaGuardia Airport	5.57
Casper International Airport	16.13
John F Kennedy International Airport	10.30
Chicago O'Hare International Airport	11.59
Minneapolis-St. Paul International Airport	5.16
Seattle-Tacoma International Airport	5.45
Mean	**9.41**

Table 1. Percentages of flights that go over greenspace for selected major US airports. Last row states the mean of the seven major airports.

near the city. Thus, there is not a lot of greenspaces for planes to go over that could account for the low percentage. Based on our study, we advocate for airports to be built in places where there are more abundant greenspaces or to build more greenspaces near existing airports.

One limitation of this research was that computing the satellite images was quite computationally expensive as it took a while for the code to produce results. Especially for very busy airports, such as Atlanta Hartsfield Jackson Airport, it took more than 30 minutes to process the data. Also, we set the altitude as 15,000 feet as our default value in this experiment because it took too long to compute if it was higher. Perhaps, the experiment would have been more accurate if we were able to process images from a higher altitude, as it would have given us a wider array of greenspaces that we could look at. We decided to look at altitude at 15,000 feet because a problem with going too high in altitude is that the resolution of the images is quite low. This makes it difficult to point out greenspaces and non-greenspaces because there are many specks of greenspaces, which are hard to identify. Another limitation is that we were not able to determine the percentage of greenspace that was near the flight paths but not part of the flight path. Our flight path was merely a line, and if the flight path did not exactly cross over the greenspace, we considered the flight path as not going over the greenspace. Had we made flight paths a thicker line, or as a gradient, we might have been able to consider this case too.

Some uncontrollable factors when determining whether planes go over greenspace are the wind factors. Airplane routes are largely affected by wind when determining which runway they plan to land on and how they approach the airport. For example, planes use different runways on different dates depending on the wind so that they can make the safest approach to the airport. This makes a discrepancy in our analysis because we did not account for the wind and only took a certain date to analyze the paths.

A potential future experiment would be to analyze the noise pollution of airplanes around airports by analyzing the contour noise plots. We can see if airplanes are maneuvering their paths to avoid going over dense areas with a lot of housing. Furthermore, we could compile data for all days in the year, which would lead to more accurate data collection.
The main conclusion from this research is that for the observed airports, airplanes do not tend to fly over greenspaces. In fact, flights for most of the observed major airports on average go over 9.41% of greenspaces near the airports. Because the surrounding area for each airport is different, by finding a method that works for all tested airports, we were able to make a good conclusion of the percent of airplanes that go over greenspaces. From our study, we strongly advocate to implement more greenspaces around airports, because as shown by other studies, greenspaces clearly provide a benefit by reducing pollution, and we believe that having more greenspaces near airports will significantly help the environment (7).

MATERIALS AND METHODS

Our first steps were to gather satellite images from Mathematica. Using the feature of satellite images and flight paths, we inputted the name of the airport, the flight date, and the altitude of the satellite images. We chose 15,000 feet as the altitude as that would allow us to look at the maneuvers that planes are making to go over greenspace. Then, we used image processing techniques to see which areas were "green." To get the satellite images, we used the natural language function in Wolfram. One problem was that the resolution of the images was low as we used satellite images from higher altitudes. Thus, we collaged nine satellite images with the corresponding coordinates so that we could produce an image with higher resolution. So, we created a black and white image using the Binarize function by identifying areas that contain green and coloring them black and identifying areas that don't contain green and coloring them white. After binarizing, we dilated the image because we only wanted to consider large areas of greenspaces. We didn't want to consider the green parts on someone's backyard because it would be impossible for planes to maneuver to go over someone's backyard or not. Thus, we chose the 30 largest patches of greenspaces for all airport satellite images and binarized the satellite image (**Figure 1**).

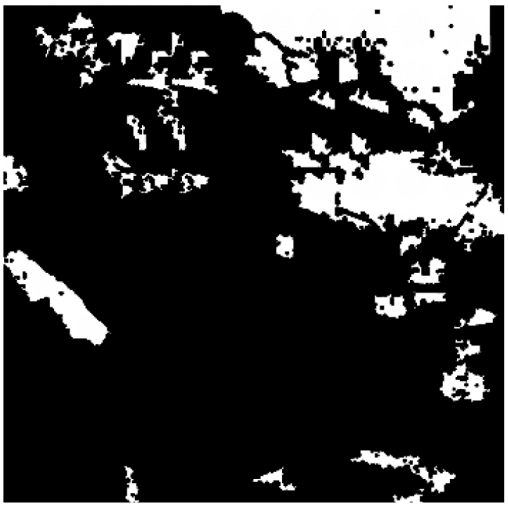

Figure 1. Representative binarized satellite image to contain only the 30 largest patches of greenspace. The image is taken from 15,000 feet of altitude. The image of Syracuse Hancock International Airport. The white area represents the green space and the black area represents non-green space. (Flight paths obtained from Wolfram Data Repository)

Next, we processed the flight paths using functions in Wolfram Mathematica and took the flight paths from 15,000 feet. We used the SetAlphaChannel function to erase the parts of the flight paths that go over greenspace. Then, we took the number of the flight paths that go over greenspace to total flight paths, to determine the percent of flight paths that go over greenspace. See the Appendix for the full function.

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APPENDIX

Full function

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percentages[airport_Entity,date_:DateObject[{2021,10,1}]]:=Module[{higherimageofflights1,geoposition1,collaged1,dominantcolors,colordistance1,binarized1,dilate,onlylargegreenspaces,img2,blackandwhiteflightsimage1,blackpercentagesofalphaimage1,blackpercentagesofallflights,percentagesofgreenflights1},\[IndentingNewLine]higherimageofflights1=flightdata[airport,date];\[IndentingNewLine]geoposition1=Partition[Table[{FindGeoLocation[airport][[1]][[1]]+0.086 i,FindGeoLocation[airport][[1]][[2]]+ 0.086 j},{i,1,-1,-1},{j,-1,1}]//Flatten,2];
collaged1=ImageCollage[Table[{GeoImage[GeoPosition[geoposition1[[i]]],GeoRangePadding->None,GeoRange->TemplateBox[{"15000", "\"ft\"", "feet", "\"Feet\""}, "Quantity"],GeoServer->"DigitalGlobe"]},{i,1,9}]//Flatten];\[IndentingNewLine]dominantcolors=DominantColors[collaged1][[1]];\[IndentingNewLine]colordistance1=ColorDistance[collaged1,dominantcolors];\[IndentingNewLine]binarized1=Binarize[colordistance1];\[IndentingNewLine]dilate=ColorNegate[Dilation[binarized,DiskMatrix[8]]];
onlylargegreenspaces=SelectComponents[dilate,"Count",-30];\[IndentingNewLine]\[IndentingNewLine]\[IndentingNewLine]img2=ColorNegate[Binarize[ColorNegate[SetAlphaChannel[onlylargegreenspaces,higherimageofflights1]]]];\[IndentingNewLine]blackandwhiteflightsimage1=ColorNegate[Binarize[higherimageofflights1]];\[IndentingNewLine]\[IndentingNewLine]blackpercentagesofalphaimage1=100.
ImageLevels[img2][[1,2]]/(ImageLevels[img2][[1,2]]+ImageLevels[img2][[2,2]]);\[IndentingNewLine]\[IndentingNewLine]blackpercentagesofallflights=100.
ImageLevels[blackandwhiteflightsimage1][[1,2]]/(ImageLevels[blackandwhiteflightsimage1][[1,2]]+ImageLevels[blackandwhiteflightsimage1][[2,2]]);\[IndentingNewLine]\[IndentingNewLine]percentagesofgreenflights1=100.0(Abs[blackpercentagesofalphaimage1-blackpercentagesofallflights])/blackpercentagesofallflights;\[IndentingNewLine]Print[percentagesofgreenflights1]\[IndentingNewLine]]
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