ASSESSING THE EFFECTS OF GEOSPATIAL FEATURES ON BIRD STRIKE OCCURRENCES AT SELECTED AIRPORTS IN THE US

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ABSTRACT

The main goal of this study was to utilize geospatial technologies including GeoMedia Suite and ENVI to determine the relationships between geospatial features and the occurrence of bird strikes at selected airports in the nation. Bird strike on aircraft, a type of foreign object and debris (FOD) is a major problem in the air transportation safety, and cost the aviation industries over $4B annually including loss of lives. As air travel increases so also will bird strike incidents, unless steps are taken to address this problem. In this regards, bird strike data were acquired from the FAA for the period 1998 to 2008, and analyzed in order to identify - hot spots. Multi spectral high resolution satellite images of selected airports including the BWI were then acquired and processed. Level I classification of land-use/land-cover feature types were carried out. The geospatial features examined were urban/built-up areas, vegetation, wet land/marsh, and water bodies. Post classification procedures were then carried out and the results compared with bird strike incidents at the selected airports. Analysis of the 70 airports revealed one major international airport had 14 incidents during this study period which raised some concern and as such it was used as a "hot spot". It was observed that most of the geospatial features were being utilized by the birds. For example, vegetated areas were used for nesting, feeding, and resting; water bodies provided the birds with both food and water; wetlands/marsh serves as nesting/resting grounds, providing some form of food for them. Preliminary results showed some relationships between high incident of bird strike and geospatial features. As such, concrete steps will have to be taken, in order to stem this trend.

KEYWORDS: remote sensing, bird strike, geospatial features.

INTRODUCTION

The forced landing of US Airways Flight 1549 on the Hudson River in New York, on January 15, 2009, brought to the forefront once again the threat posed to aviation safety by foreign objects and debris (FOD) and for that matter bird strike. While no lives were lost on the US Airways Flight 1549, over 113 people lost their lives when the Concorde (Air France Flight 4590) was brought down by FOD (a piece of iron rod) in Paris, France on July 25, 2000. FOD is a world-wide problem, and every year in the US alone, it cost the aviation industry over $4B billions not to mention the cost of injuries and lives (FOD, 2010; George, 2009). The danger posed by FOD will continue to grow as more air travel increases, unless urgent and effective steps are taken to address/combat this phenomenon.

Foreign object debris (FOD) is defined as objects that are found in the immediate vicinity of aircraft which can easily make contact with not just the body of the aircraft but the safe operation and performance of the aircraft and its crew. FOD can be both biotic (living) and abiotic (non-living). Examples of biotic FODs are birds, mammals, bats, and human beings; abiotic FODs include metals objects, plastic, paper, and bits and pieces of building materials such as concrete, asphalt, and wood.

This study focuses on bird strike, because it is one of the most pervasive kinds of FOD according to the U.S. Federal Aviation Administration (FAA) and it accounts for around 97% of the total wildlife FOD incidents reported in the US. Annually, bird strike alone causes the aviation industry over $500M in damages (Brown, 2001). This study tries to understand and determine the factors responsible for such increase in bird strike at airports in the US. In other words, this study examines the geospatial features such as water bodies, wetlands, and vegetation at selected airports to determine the cause-consequence relationship of bird strike and airports/airport vicinities.

Bird strike incidence data for the period 1990 – 2008 for 70 airports in the US, were acquired and analyzed for this study. The geospatial technologies used include both geographic information systems (GIS) and remote sensing. IKONOS multispectral highresolution satellite images for Baltimore Washington Thurgood Marshall International

Airport (BWI) and John F. Kennedy International Airport (JFK) were purchased for this study. Analysis showed that BWI had lower incidents of birds strike than JFK, which had the highest incidence during the same period. Therefore, it was decided to conduct Level I land-use/land-cover classifications for both BWI and JFK and compare the geospatial features class results. The software used include the ArcGIS and the environment for visualizing images (ENVI). These geospatial technologies though expensive are very cost-effective and offer extraordinary versatility, high accuracy, and optimum performance (IIT VIS, 2010). It is hoped that results from this study will lead to better understanding of bird strike and contribute significantly to efforts geared toward combating FOD thus enhancing flight safety in the Nation.

STUDY AREA

The BWI Airport is located in the State Maryland, and JFK Airport is in New York State. Both sites in this study have the same areal extent and covers approximately 35,010.5 acres. The sites were selected in such a way as to place the airports in the center, and surrounded them by approximately 3.5 miles buffer zone. This approach allows to captures some of the geospatial features impacting the airports. Some of the geospatial features observed in these sites include Water Bodies (streams, rivers, lakes and ponds), Urban/Built-Up areas (buildings, roads, runways/aprons/taxi-ways, and parking lots), Vegetation (forests, grass, and shrub/bushes), and Marsh (marsh and wetland). While JFK sits on an island (Long Island), BWI is on the mainland. Both are classified as International Airports which means that they both play very crucial roles in the Nation's economy (Figures 1 and 2).

METHODOLOGY

Bird strike data for the period 1990 to 2008 were acquired form FAA and analyzed to determine the magnitude of incidence at 70 airports in the Nation. In order to be able to process the data in a GIS, some geographic attributes were added to the database including airport codes, coordinates in both decimal degrees (DD) and degrees, minutes (DMS). Statistical analysis and GIS procedures in ArcGIS (a GIS software) were then employed to further process and analyze the data. Spatial distribution maps of bird strike were generated for all 70 airports in the US. This color-coded map makes it much easier to display and understand the location of "hot spots" which can then be used for further detailed study in the future.

Using results from the incidence analysis, it was then decided to examine the geospatial features distribution at an airport with the highest occurrences of bird strike incidence. It happened to be JFK, which had a total of 17 incidences during the study period (1990 – 2008). It was also interesting to see how another airport with lower incidence would compare with JFK. BWI was then selected since it happens to our State's international airport and had just 3 incidences. Thus, two IKONOS satellite images were acquired for JFK and BWI (Figures 1a and 1b).

IKONOS satellite image was selected because of its high spatial resolution (4 meters pixel multispectral bands and 1 meter pixel panchromatic band). Multispectral images are very important when doing general land-use/land-cover classification (Geoeye, 2010). Image processing was done using the Environment for Visualizing Images (ENVI) software. The georeferenced images were resized in order to obtain equal study area sizes for both BWI and JFK. The total area of each study site was around 35,010.5 acres, with each airport in the center of the study area. Unsupervised classification procedures were carried out using different band combinations. The bands used in the classification process were selected based on the spectral profile of the four selected geospatial features (water bodies, marsh/wetlands, vegetation, and urban/built-up areas).

Class statistics were computed for each band combination, and the average for each geospatial features used in the final result. The final classified images were then clumped and also used in the final analysis of the study.

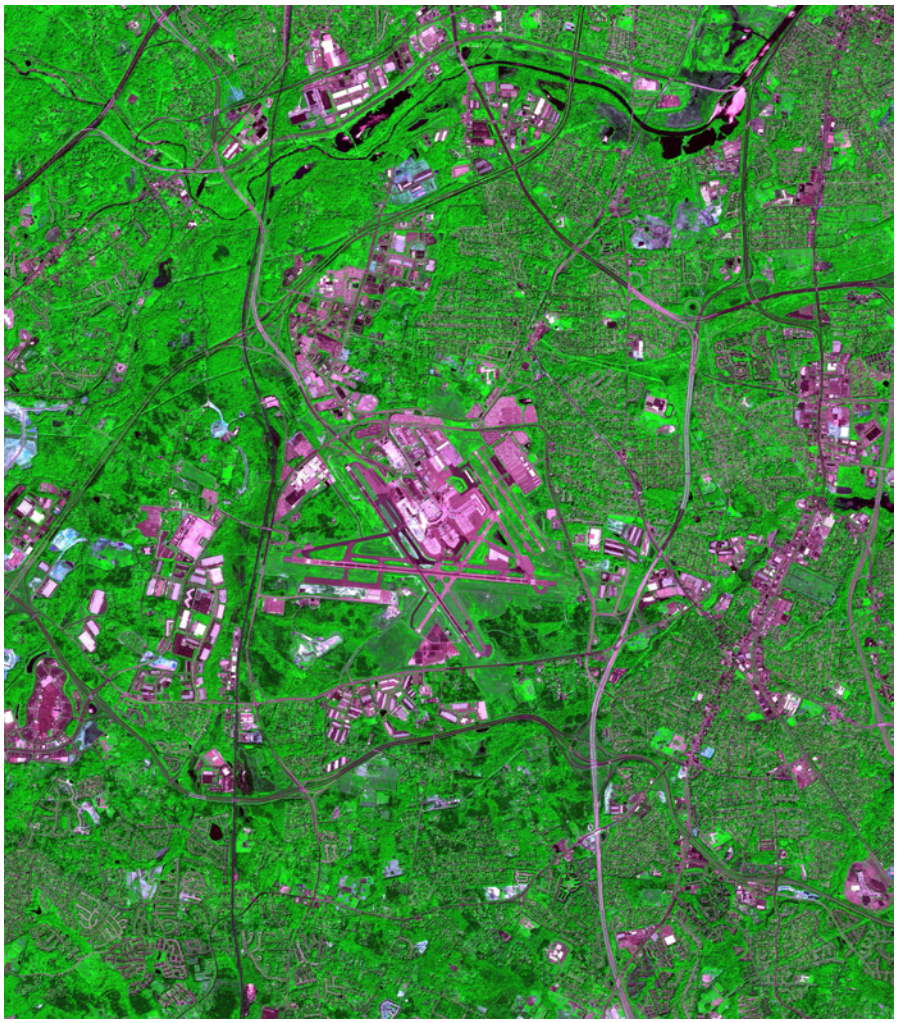

Figure 1a. Study area: A IKONOS Satellite Image of BWI Airport (Real Color Composite).

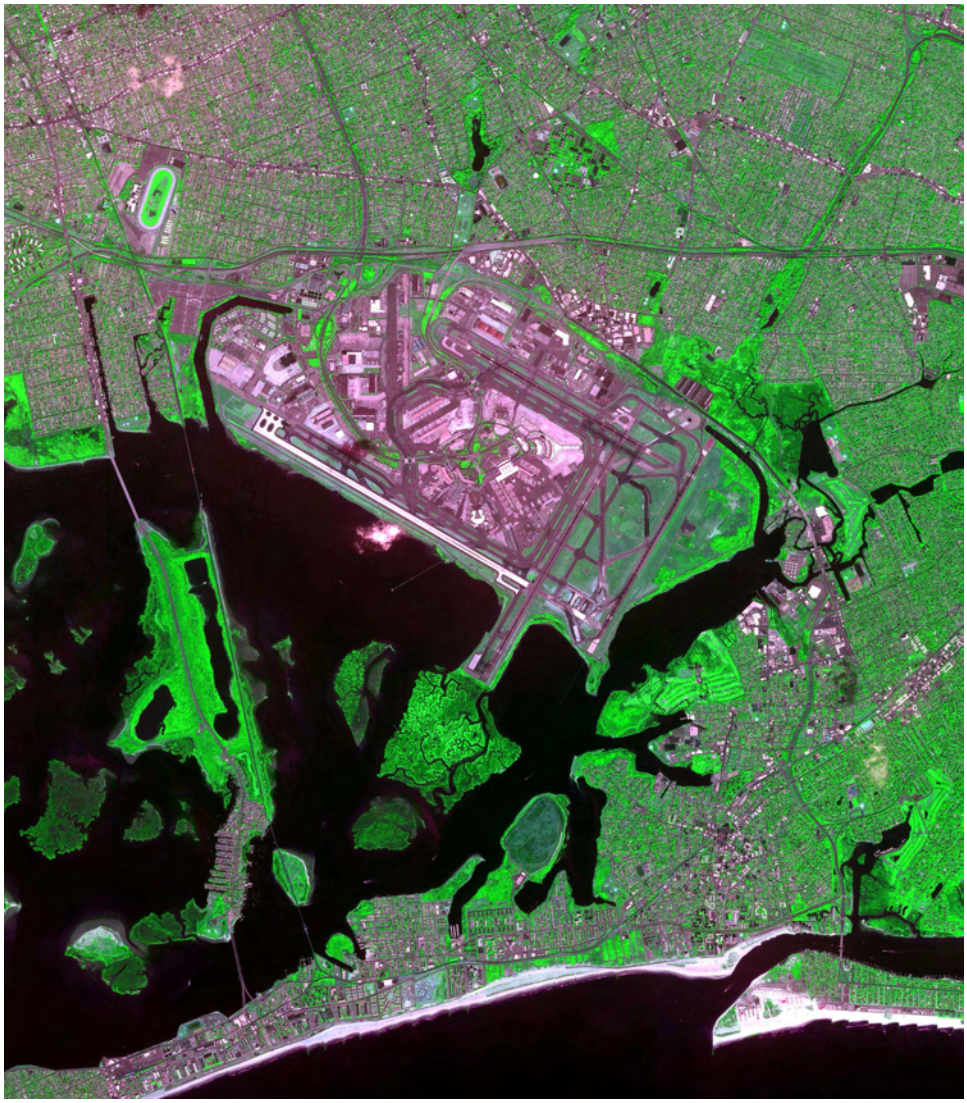

Figure 1b. Study area: A IKONOS Satellite Image of JFK Airport (Real Color Composite).

RESULTS AND CONCLUSION

During the study period (1990 – 2008), a total of 105 bird strike incidence were reported and most were caused by goose, gull, and horned grebe species of birds. Of this 105 bird strikes, three (3) airports experienced over 35%, 1 airport (JFK) had 14 (13.3%), the second had 12 (11.4%), and the third had 11 (10.8%) strikes compared to 29 other airports that experienced just 1 (0.9%) strike (Figure 2). In other words, 8 of the 70 (11.4%) airports were reporting over half (52%) of the bird strikes incidence in the US. This statistic is very troubling and requires urgent action. The GIS map clearly shows that bird strikes were higher at airports along coastal states, while the mid section of the country had relatively fewer incidences (Figure 3).

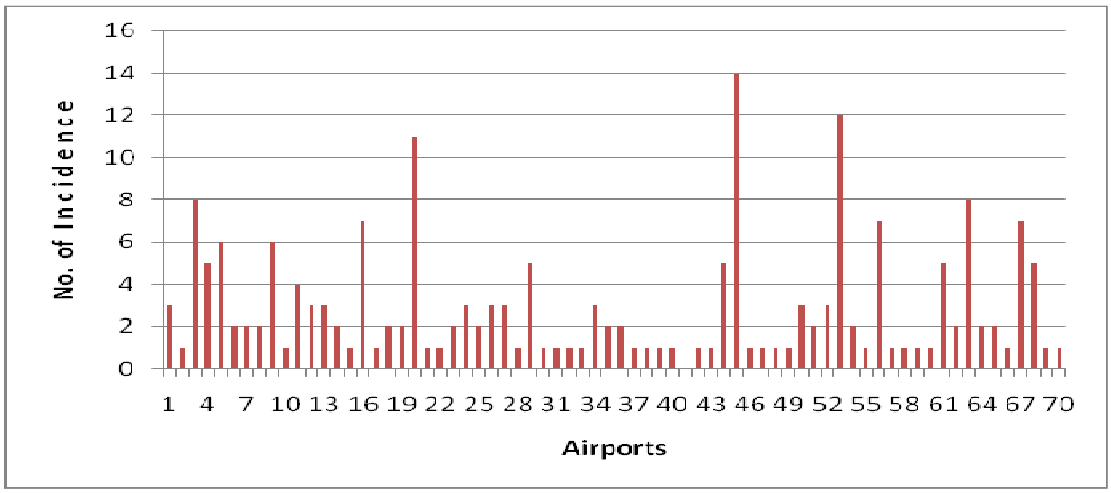

Figure 2. Bird Strikes Incidence at US Airports during the Period 1990 to 2008.

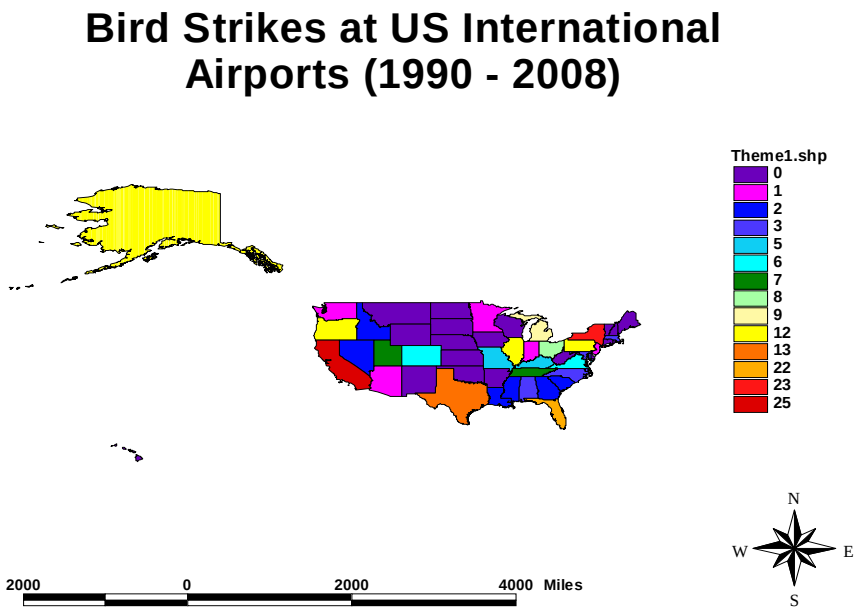

Figure 3. GIS Map of Bird Strikes Incidence Distribution at US Airports from 1990 to 2008 (Incidents were color coded, with red being high and blue being low).

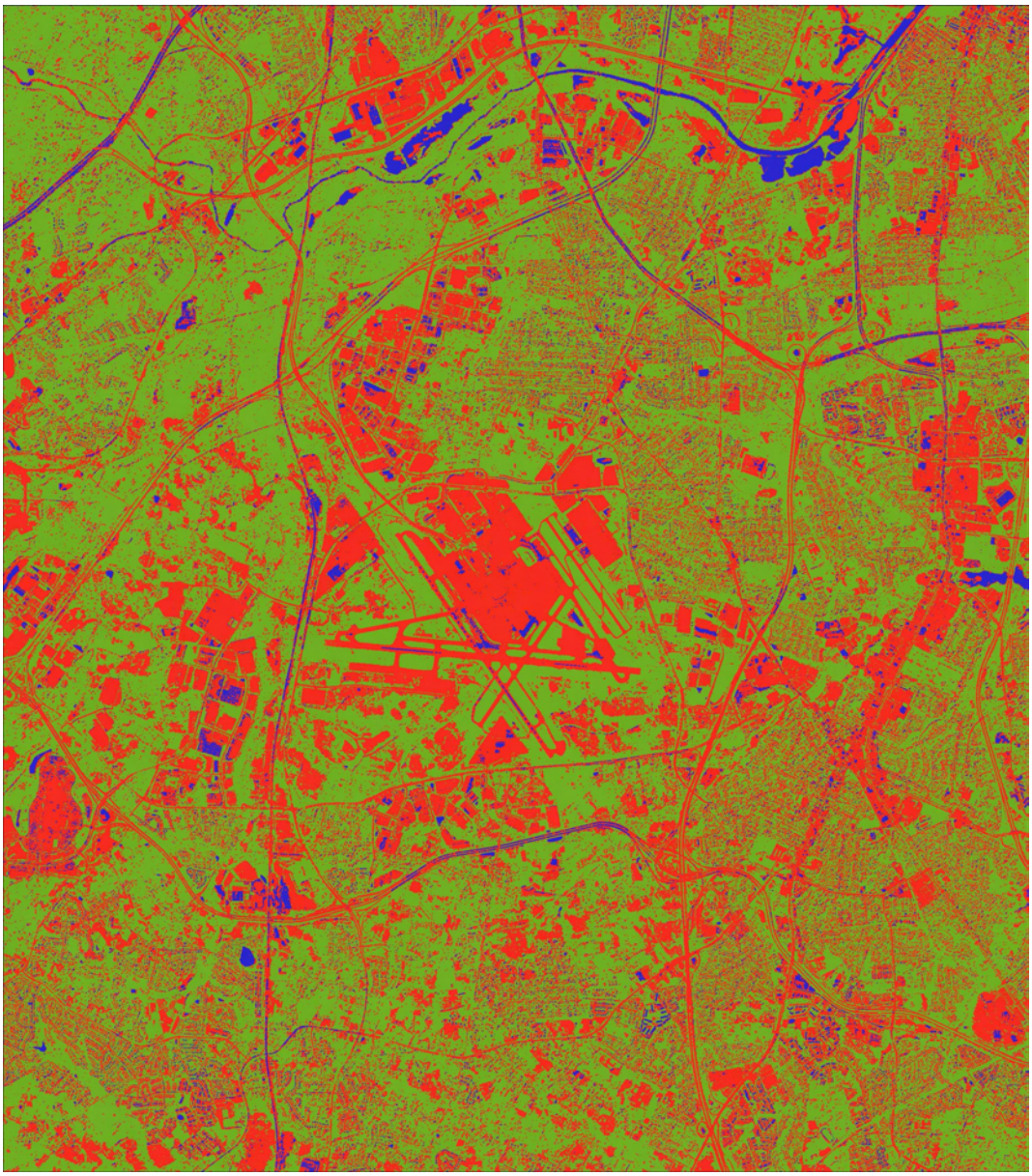

Figure 4a. BWI IKONOS Classified Image. Red – Urban/built-Up, Green – Vegetation, and Blue - Water Bodies; the image was clumped using ENVI's classification procedures.

The geospatial features (land-use/land-cover class) sizes estimated using remote sensing at the two study sites (BWI and JFK) using IKONOS images can be seen in Table 1. The BWI site had more urban/built-up areas (38%) than the JFK site (26%). The same is true for vegetation; JFK had less vegetation (32%) compared to BWI with around 49%.

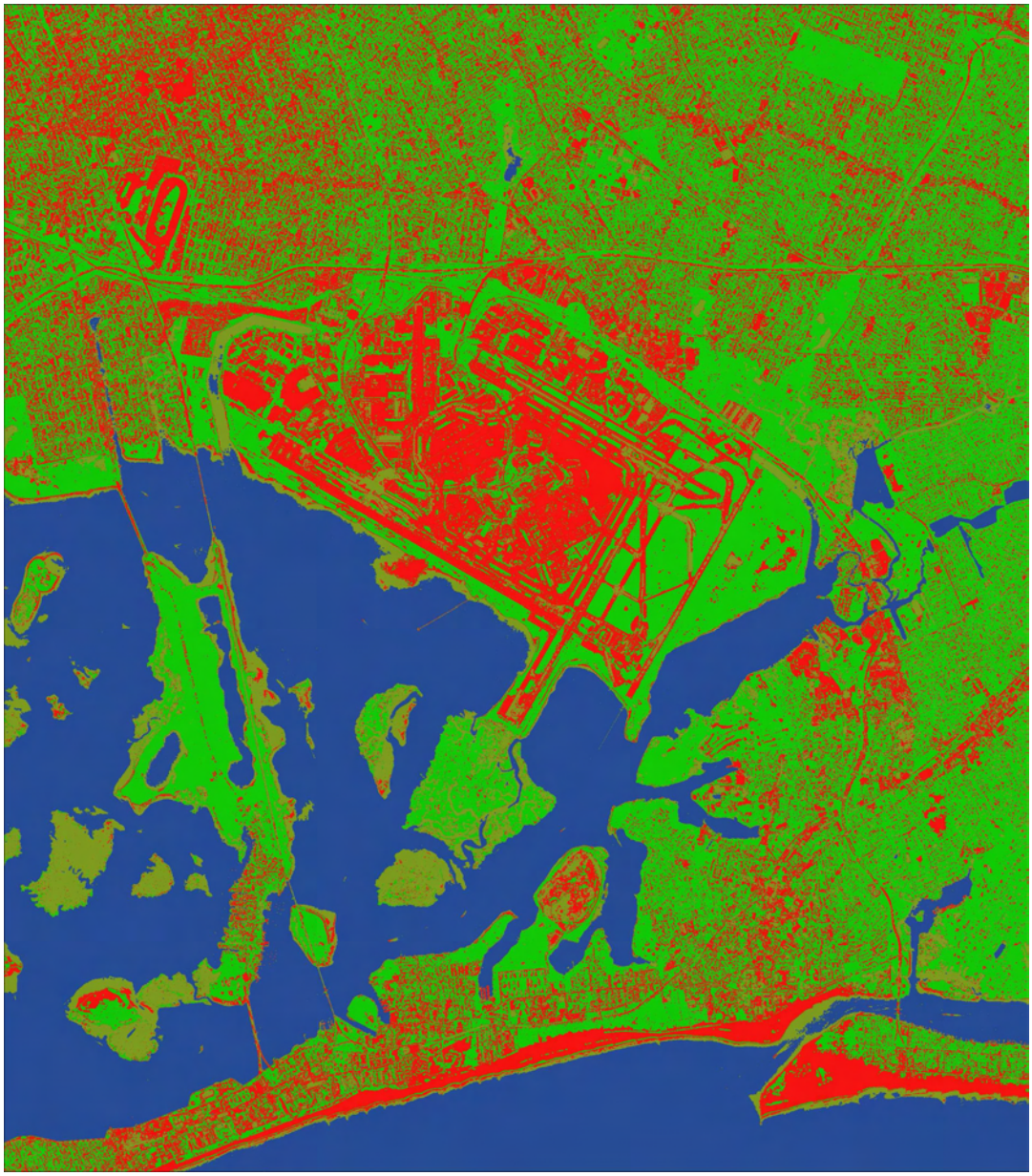

Figure 4b. JFK IKONOS Classified Image (Clumped; Red – Urban/built-Up, Green – Vegetation, Blue - Water Bodies, and Olive Green- Marsh/Wetlands).

Analysis of the IKONOS image classification (Level I Classification) of the study areas, show that JFK Airport site had considerable more water bodies and marsh/wetlands than BWI Airport site (Figures 4a and 4b). Studies have shown that birds are more attracted to such geospatial features for various reasons including using them for food and water sources, nesting areas, and rest stops (for migratory birds), and for habitation. Some of these water bodies around the vicinity of JFK are listed as marine protective sites, which facilitates increase in the population of these birds, which in turn leads to more occurrences of bird strikes at this airport.

Table 1. Results of IKONOS Image Analysis of Study Areas (BWI and JFK Airports).

#	Geospatial Features						
1.	**Features**	**BWI Airport**		**JFK Airport**		**Difference**	
2.	**(*Level I*)**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**
3.	**Urban/Built-Up**	38.88	13612.082	25.92	9074.722	12.96	4537.361
4.	**Vegetation**	49.01	17158.646	31.85	11150.844	17.16	6007.802
5.	**Water Bodies**	12.11	4239.772	27.26	9543.862	15.15	5304.091
6.	**Marsh**	0		14.97	5241.072	14.97	5241.072

Analysis of the IKONOS image Level I classification of the study areas show that JFK Airport site has considerable more water bodies and marsh/wetlands than BWI Airport site. Studies and literatures have shown that birds are more attracted to water bodies and marsh/wetlands. Some of the reasons for birds to congregate on these geospatial features include using them as food/water sources, resting/wadding areas, and as sanctuaries (safe places to nest and bring-up their young). Some of these water bodies/marshes are listed as protected areas, which prohibits hunting. Therefore the number of these birds increase and so also the risks to aircraft in this areas.

This study demonstrated that geospatial technologies (remote sensing and GIS) can be used to assess the effects of geospatial features on bird strike occurrences at airports conveniently. The BWI/JFK and their surrounding areas, like most other airports around the nation, are experiencing formidable FOD (especial bird strike) challenges more than ever before. As air travel increases and bird population increases, this phenomenon will continue to grow. It is therefore important that studies like this be conducted to develop efficient techniques to combat FOD at airports. Further studies are needed to determine the cause-consequent relationships of geospatial features and bird strike at airports.

REFERENCES

Borrel, Brendan, 2009. What is a Bird Strike? How Can We Keep Planes Safe from them in the Future? http://www.scientificamerican.com/article.

Brown, Kevin M., 2001. "Managing Birds and Controlling Aircraft in the Kennedy Airport-Jamaica Bay Wildlife Refuge Complex: The Need for Hard Data and Soft Opinions" Environmental Management Vol. 28, No. 2, pp. 207-224.

Demers, Michael. Fundamentals of Geographic Information Systems Arizona: John Wiley & Son, PP 1-46.

ESRI, 2009. ArcGIS. www.esri.com

Estes, John, 1978. Introduction to Remote Sensing of the Environment. Iowa: Kendall/Hunt Publishing Company, 1978. pp. 15-40

Fleming, Arlene, 2011. Wildlife Strikes–Airline Incidents with birds and wildlife" http://airtravel.about.com/od/safetysecurity/qt/wildlifestrike.htm.

FOD (Foreign Object Debris), 2010. http://en.wikipedia.org/wiki/Foreign_object_damage.

George, Fred, 2009. Increasing Vulnerability to Bird Strikes. *Business & Commercial Aviation* 104(3):40-43.

IKONOS, 2010. www.geoeye.com/.

ITT VIS, Inc., 2010. ENVI. http://www.ittvis.com

Jensen, J. R., 1986. *Introduction to Digital Image Processing: A Remote Sensing Perspective*. Englewood Cliffs, New Jersey: Prentice-Hall, pp. 254-271.

Krabill, Alexander, R.H. and V.A. Milazzo, 1973. Urban and Regional Land Use Analysis: CARETS and Census Cities experiment Package. *Mo. Progress Report (E74-1 0252, NASA-CR-136566.*

Lillesand, T.M., R. Kiefer, and J.W. Chipman, 2008. *Remote Sensing and Image Interpretation, Sixth Ed.* John Wiley & Sons, pp. 482-585.

Lo, C.P. and T. Fung, 1986. Production of Land-use and Land-cover Maps of Central Guangdong Province of China, from Landsat MSS Imagery." *Int. J. of Remote Sensing, 7(1:1051-1074.*