Land Usage Change of the Halls Mill and Rabbit Creek Sub-Watersheds over the Last 30 years.

Anthony T. McGrady, Department of Earth Science, University of South Alabama, Mobile, AL 36688.

The city of Mobile, Alabama has grown substantially since its original founding in the year of 1702. Even though the majority of the city's growth has taken place within the Eslava Creek sub-watershed, this paper will focus on the growth and development of the Halls Mill and Rabbit Creek sub-watersheds. The growth of this area over the last 30-years will be displayed using remote sensing techniques to show which areas of these two sub-watersheds have grown or remained stagnant. Due to development within these areas, water quality has changed due to the introduction of pollutants from nonpoint sources. This project will provide a sense of where development within these sub-watersheds has taken place. Finally, the growth rates of these sub-watersheds, specifically of developed areas, will be compared between both locations by comparing them to other watersheds that have seen development over recent years.

Keyword: watershed development, remote sensing.

Introduction:

Over the last 30 years, the city of Mobile, Alabama has expanded immensely through the

construction of new businesses, residential areas, and major manufacturing companies.

According to the United States Census Bureau, the City of Mobile had a population of 195,111

in 2010, however, in 1980 Mobile's population was 200,452 (United States Census Bureau).

When considering Mobile's geography, the city lies within the Gulf Atlantic Coastal Plain of the

United States and ranges in elevation from 3 meters to 64 meters. The Dog River Watershed is

the location within Mobile that this research will be focused upon. This watershed covers

approximately 95 square miles within the Mobile area (Dog River Clearwater Revival). To be

more specific, the Halls Mill and Rabbit Creek sub-watersheds of the Dog River Watershed are

the primary locations that will be concentrated upon. The location of these sub-watersheds

within the Dog River Watershed can be seen in Figure 1. Even though the majority of

urbanization within the Dog River Watershed took place within the Eslava Creek sub-watershed,

it will not be focused upon due to it already being developed prior to the 30-year period that this project covers. This project will examine how the land usage of these sub-watersheds has changed over the past 30 years. The evidence of this growth and population expansion has been seen throughout these areas by the residents that have lived in this region during this time period.

This project will show how much the land usage has changed from areas that mostly contained permeable surfaces, such as marshes and grasslands, to areas that have been urbanized and developed for housing and business purposes (Henderson et. al 2006). Considering that nonpoint sources are a contributing factor of watersheds from development within them, it is important to show where the most developed areas are within these sub-watersheds (Randhir et. al. 2001).   Also, this project will show residents of these specified communities how much the land usage in these regions has changed and it can be used as archival data if further research would be warranted.
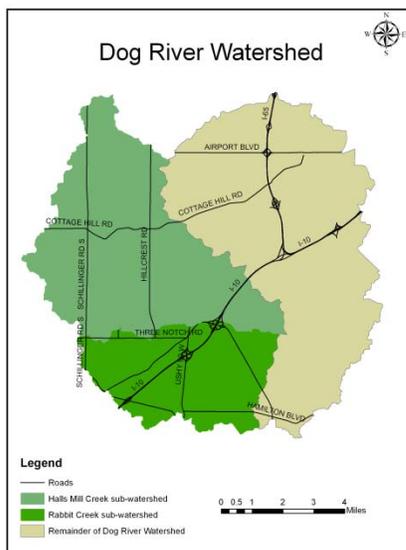

Figure 1

Research Question:

How much has land usage changed throughout the regions of the Rabbit Creek and Halls Mill Creek sub-watersheds within the Dog River Watershed over the previous 30 years? Also, are the land usage changes within these sub-watersheds similar or different from each other over this time period?

Methods:

The methods that were chosen in determining the land usage change for the Halls Mill and Rabbit Creek sub-watersheds were primarily based on the use of a remote sensing software program called ERDAS Imagine. The first step in evaluating the land use change was to download LANDSAT 5 Thematic Mapper satellite imagery from the United States Geological Survey GLOVIS website (Loveland et al. 2012). Next, images were chosen from the database that would give the best representation of Mobile, Alabama from an aerial perspective over the 30-year period. The dates selected for the images were April 15, 1984, June 17, 1995, November 16, 2004, and June 13, 2011.   No images were able to be obtained after 2011 due to GLOVIS website restrictions. The images that were chosen based on the major qualification of having no major cloud cover during the time in which the satellite photo was taken. Even though the four images that were collected were not able to represent the same time of year in each photo, the images that were selected fit the primary qualifications for an image that would be able to be used within this project.   Following this step, the zipped folder that the images came in had to be extracted twice in order to use the images within ERDAS Imagine. Once within the program, the various layers from both of the images had to be stacked together in order to get the completed image. Even though there were seven imagery bands for each specific date, only the first four imagery bands were used to complete the image for determining the classification for each type of land use within the region. The bands that were combined together were the blue, green, red, and near-infrared. Once the layer stacking process was completed, the image was displayed in a Red-Green-Blue, or RGB pattern, of 4-3-2. This band combination is known as the false color infrared combination. This band is used to display imagery that shows healthy vegetation with a deep red color, barren land or unhealthy vegetation with a blue-green color,

and urban developed areas with a white or light blue tint. This process was repeated for all four images used within this project.

The next step required in determining land usage change for the sub-watersheds was to classify the pixels within the imagery and segment the imagery into "mutually contrasting landform units" (Mulder et al. 2011). The supervised classification method was primarily used when distinguishing land usage of the collected imagery. "The classification process begins with selecting representative samples of each class present in the image. Previous knowledge along with aerial imagery was used to determine and select these training samples" (Superczynski et al 2011). Sites were chosen that were easily distinguishable using the false color infrared band combination. The sites were separated by land usage type into the following classes: water, urban/built-up, forested/vegetated, and wetland. Water areas are defined as "areas within the land mass of the United States that are persistently water covered, provided that, if linear, they are at least 1/8 mile wide and, if extended, cover at least 40 acres".   Urban/built-up areas are defined as "areas of intensive use with much of the land covered by structures". Forested/vegetated areas are defined as areas consisting of trees that are "capable of producing timber or other wood products" with coverage over 10% of a concentrated area. Finally, the wetland area is described as "areas where the water table is at, near, or above the land surface for a significant part of most years" (Anderson et. al.1976, 10-18).

Approximately 50 sites used from each of the four images to get the best representation of land usage change over the 30-year period. After the sites were chosen, the sites were classified together using the maximum likelihood method. This method is a "method for determining a known class distribution as the maximum for a given statistic", in this case a pixel, "is classified into the corresponding class" (Liu et al. 2011). After this method was completed,

the locations were recoded in order to join similar classes together. Once the classes were joined together, the classes were assigned colors in order to display attributed maps. Next, the total area of the study area was calculated and the percentage of each type of land usage had to be calculated. This percentage was found by creating a new column within the attribute table of the recoded maps. This column was labeled as "percent" and a formula was input into as the area of coverage of each class divided by the total area of the study area. This percentage, in turn, displayed the final area of coverage for each type of land usage. Next, the classes were classified into overall developed and non-developed areas whereas urban/built up areas represented the developed areas and the forested, water, and wetland areas represented the non-developed areas.

The final method used in determining where the sub-watersheds had changed over the thirty-year period was the layer stacking method. This method involved taking the layer 4 band, also known as the infrared band, from the April 1984 and June 2011 image and compare which areas received higher or lower reflectivity during the time period. Areas that experienced higher reflectivity would occur in areas that saw an increase in agricultural features, such as grass or crops, and was displayed in a green tint on the map. Areas that experienced a decrease in reflectivity would include areas that saw in increase in urban/built-up features, such as homes, barren land, or concreted areas, and was displayed in a red tint on the map.

Results:

When considering Halls Mill sub-watershed, it was approximately 20,909 acres in size. Starting with the April 15, 1984 recoded image, the classification areas were found to be as follows: water-1.44%, vegetated-29.59%, developed-37.01%, forested-19.40% and wetland-12.56%. For this image, developed areas represented 37.01% and non-developed areas represented 62.99%. Next, the June 17, 1995 recoded image displayed the following values:

water-1.25%, vegetated-13.80%, developed-52.04%, forested-30.73%, and wetland-2.18%.

Overall for this image, developed areas represented 52.04% and non-developed areas represented

47.96%. The November 10, 2004 recoded image produced the following values: water-1.22%,

vegetated-8.46%, developed-52.47%, forested-31.59%, and wetland-6.26%. For this image

developed areas represented 52.47% and non-developed areas represented 47.53%. The final

image for Halls Mill sub-watershed was taken on June 13, 2011. This image produced the

following values: water-1.29%, vegetated-9.00%, developed-59.80%, forested-27.18%, and

wetland-2.73%. Overall developed areas represented 59.80% and non-developed areas

represented 40.2%.

These results can be seen

in Figure 2.

When considering

the Rabbit Creek sub-

watershed, it was 10,773

acres in size. The image

taken on April 15, 1984

produced the following
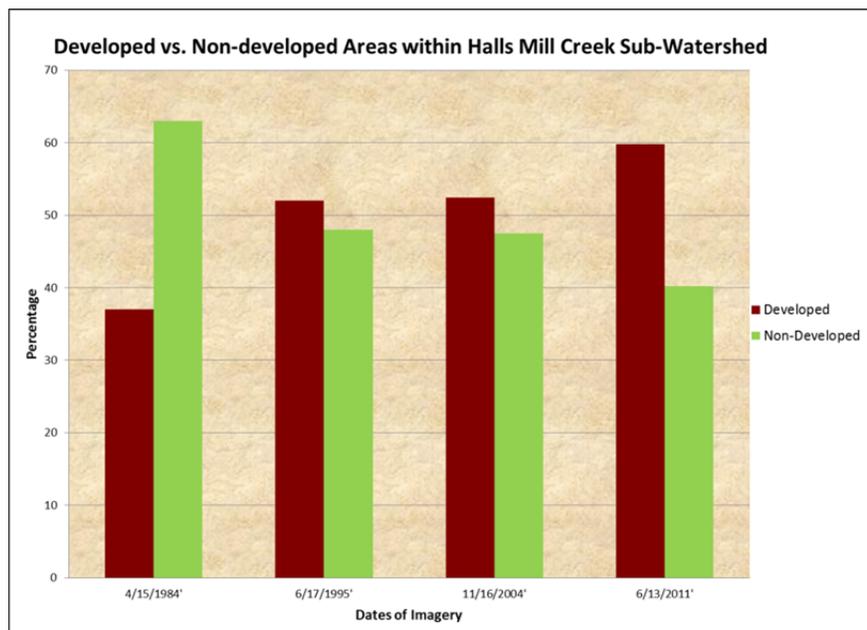
values: water-2.19%, vegetated-12.76%, developed-51.80%, forested-15.36%, and wetland-

17.89%. Developed areas

Figure 2

within this image

represented 51.80% while non-developed areas represented 48.2% of total area. Next, the image

taken on June 17, 1995 produced the following values: water-1.02%, vegetated-10.45%,

developed-49.55%, forested-37.37% and wetland-1.61%. Overall, developed areas represented

49.55% of total area while non-developed areas represented 50.45% of total area. Next, the

image taken on November 10, 2004 produced the following values: water-1.18%, vegetated-

6.27%, developed-50.32%, forested-38.78%, and wetland-3.45%. Developed areas within this

image represented 50.32% of total area while non-developed areas represented 49.68%. Finally,

the image taken on June 13, 2011 produced the following values: water-1.01%, vegetated-8.67%,

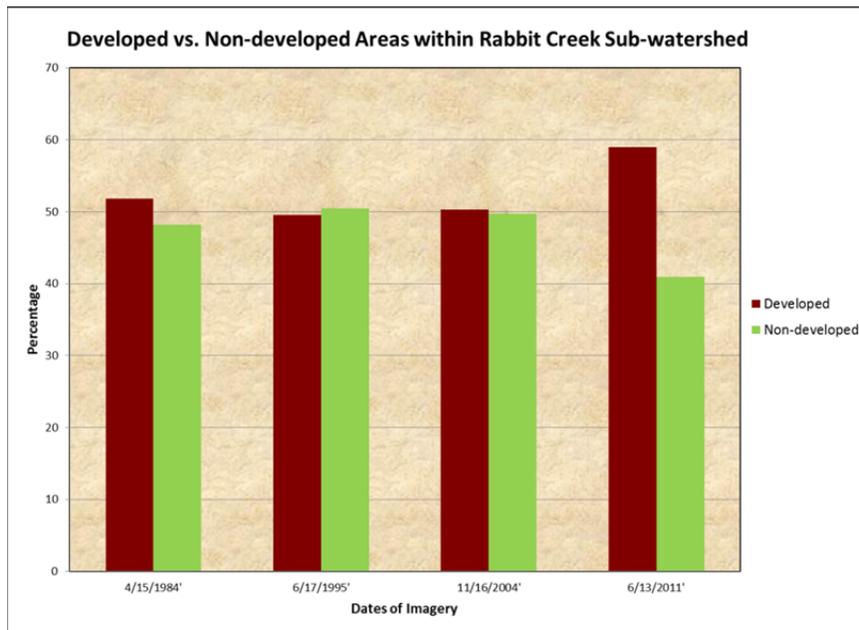developed-59.02%, forested-28.12% and wetland-3.18%.

Figure 3

Developed areas within this

region of the Rabbit Creek sub-watershed represented 59.02% of total area covered while non-

developed areas represented 40.98% of total area. These results can be seen in Figure 3.

Discussion:

From the results of the classification of the images, there was clearly a substantial gain of

nearly 13% in developed areas within the Halls Mill sub-watershed between the years of 1984

and 1995. This gain in developed areas contributed to the deterioration of water quality within

this area. Since this time period, the non-developed areas have seen a decrease. This decrease in

non-developed areas has led to erosion issues throughout the Halls Mill Creek sub-watershed.

The wetland areas within this region also took a considerable loss between the same time period; however, this may have been due to rains within the sub-watershed that may have given areas that are usually forested or vegetated the signature of a wetland region.

The Rabbit Creek sub-watershed has also seen its gain of developed areas over the 30-year period. Between the years of 2004 and 2011, the developed areas within this region had an increase of 9%. Before this time period, this region had nearly halved areas between developed and non-developed. This gain in developed area over the recent years may lead Rabbit Creek to follow in the same direction as Halls Mill Creek in the deterioration of water quality.

Conclusion:

In closing, the purpose of this project was to show how the Halls Mill and Rabbit Creek sub-watersheds have had their land usage altered over the last 30-year period. Even though the majority of the Dog River Watershed has seen its land usage change during this time, these two sub-watersheds have seen the most visible change using LANDSAT imagery. Due to the changes in developed areas within both of these sub-watersheds, the water qualities of these are visibly different from one another. Due to the earlier development throughout the Halls Mill sub-watershed, the water quality has deteriorated faster than that of the Rabbit Creek sub-watershed, which until the past decade has seen major development. This growth would only infer that Rabbit Creek's water quality should be similar to Halls Mill Creek within upcoming years; however, this can only be proven with further water quality sampling and monitoring within upcoming years.

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