Green Infrastructure Increases Vegetation Growth

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Introduction

Urbanization introduces new infrastructure which alters water flow, water quality, and natural ecosystems (Askarizadeh et al., 2015). Increased land coverage of impervious surfaces contributes to the decline in health of local water systems by increasing the volume of stormwater runoff (Dietz & Clausen, 2008). Pollutants are accumulated by runoff as the water travels across land surfaces which then enter nearby water systems (EPA, 2017). Over time pollutant amounts rise causing water quality to decline (Dietz & Clausen, 2008). One method to combating these negative effects is implementing green infrastructure (GI). Green infrastructure systems are man made landscapes engineered to mimic the function of natural ecosystems (McMahon & Benedict, 2001). GI is designed to capture storm water which in turn offers habitat, flood protection, cleaner water, and water storage (Askarizadeh et al., 2015). Water harvested by GI becomes a source of nonpotable water (Askarizadeh et al., 2015) which can be used for a variety of tasks, including irrigation. Increases in water available to grow vegetation are expected to result in greater vegetation volume compared to if this water was not available.

This project was designed to test the idea that areas with GI will demonstrate greater increases in tree size compared to areas that do not have GI. This analysis was done using lidar data for Bronx and High School washes located in Tucson, Arizona, from years 2005, 2008 and 2015. Canopy height models of the washes were created from this lidar data. The difference in these models represent how these heights changed over time.

Methods

1) Created canopy height models for 2005, 2008 and 2015 using lidar data
   - Created digital elevation model (DEM) and digital terrain model (DTM)
   - Subtracted DEMs from DTMs to create canopy height models (CHM)

Figure 1. Digital Elevation Model for Bronx Wash 2005

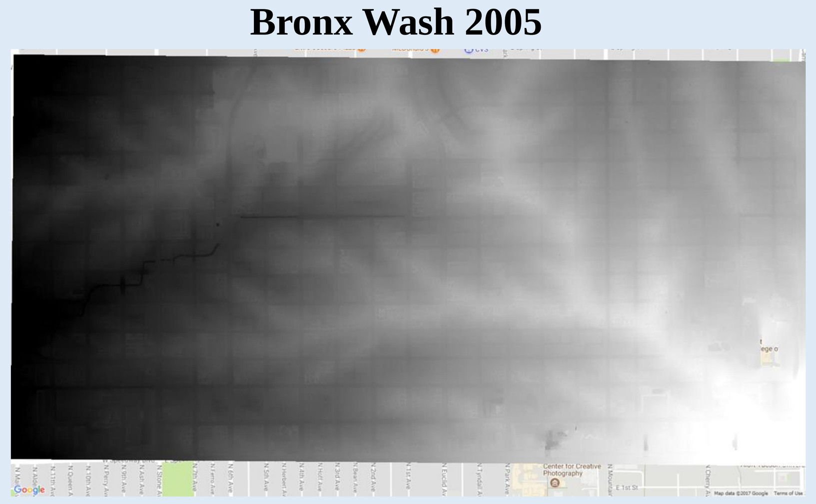


Figure 2. Digital Terrain Model for Bronx Wash 2005

Figure 3. Canopy Height Model for Bronx Wash 2005

2) Identified boundaries for areas with and without green infrastructure
   - Identified locations of GI for both washes using GPS coordinates
   - Created rectangular regions 50 feet thick and the length of the street block where GI is located.
   - Used same approach as GI boundaries except shifted locations 1 to 2 streets over from GI. Areas chosen based on environmental similarities to GI regions.

Figure 4. Boundaries for Areas With and Without GI for Bronx Wash

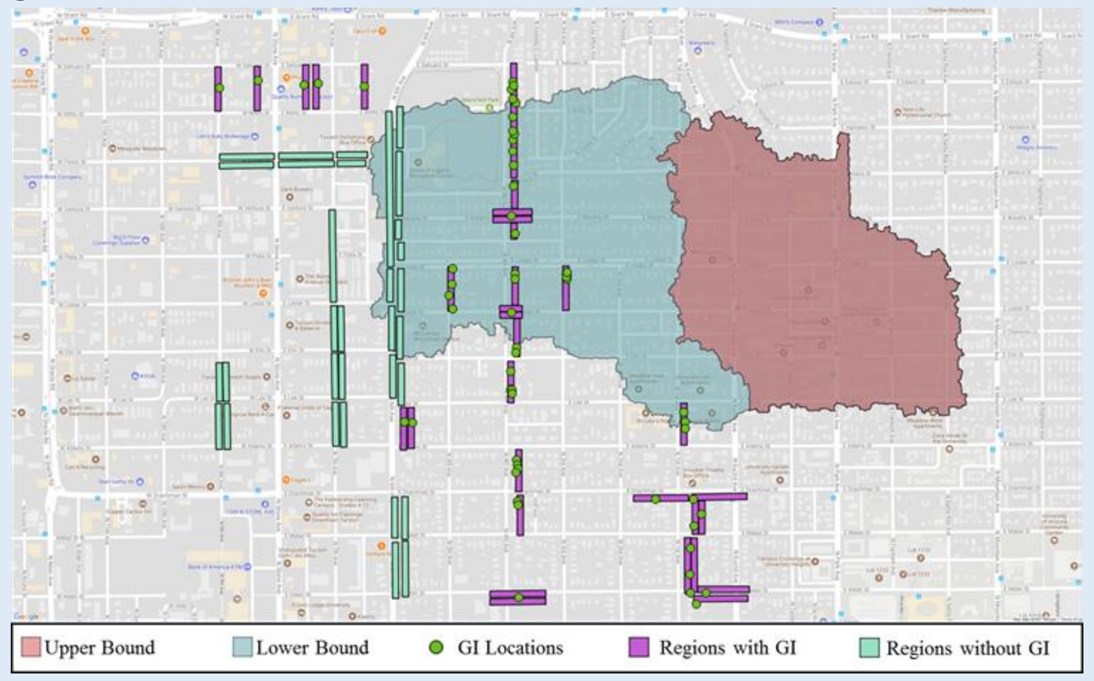
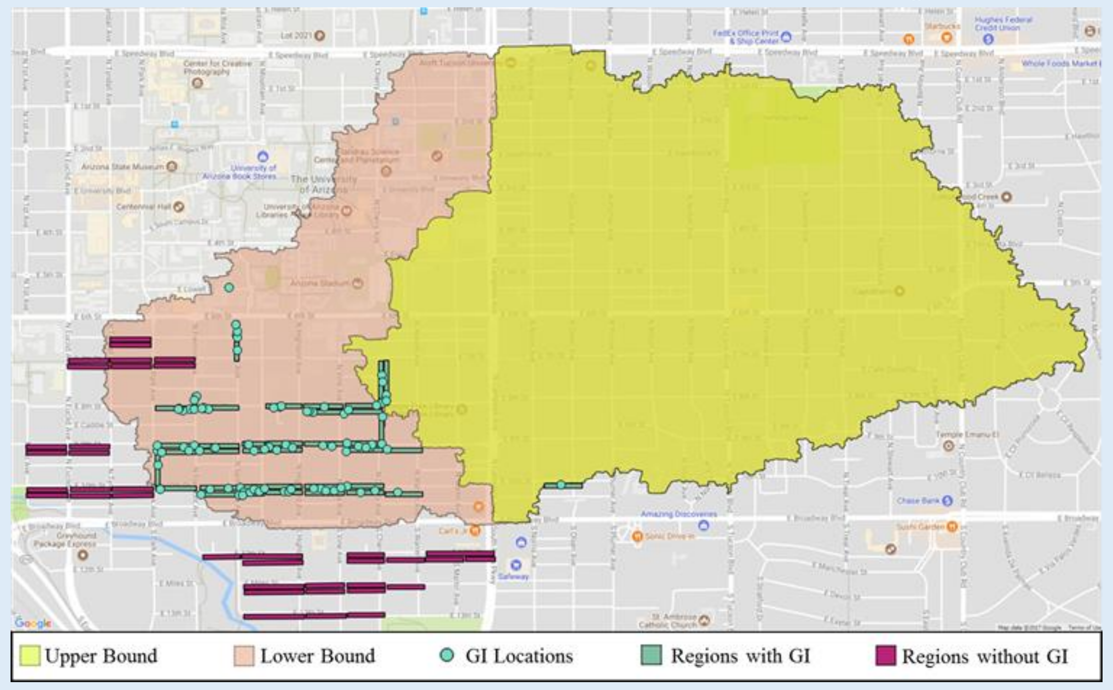


Figure 5. Boundaries for Areas With and Without GI for High School Wash



3) Determined change in canopy height for each time interval by subtracting the canopy height model of the earlier year from later year

Figure 6. Change in Canopy Height from 2005 to 2015 for Bronx Wash

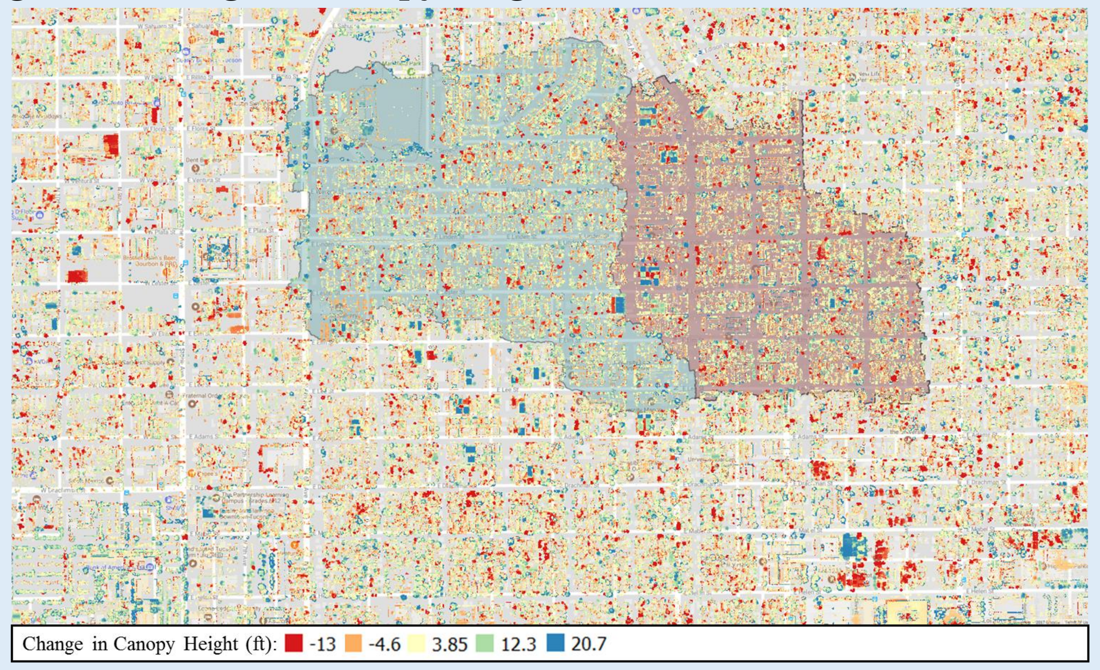
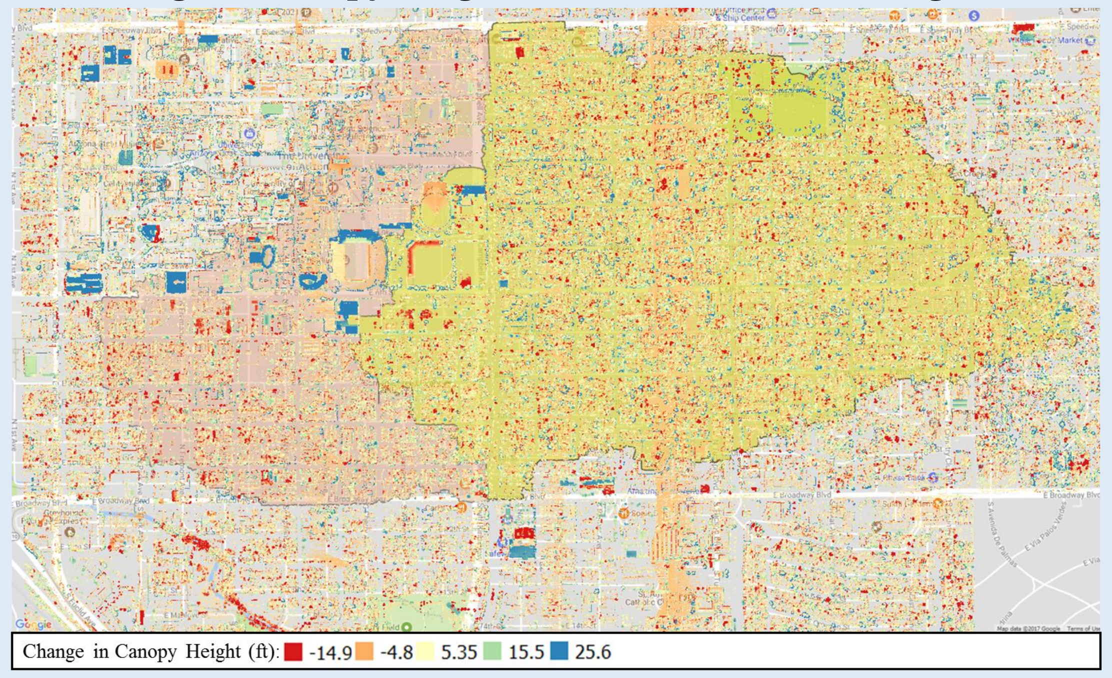


Figure 7. Change in Canopy Height from 2005 to 2015 for High School Wash



4) Compared changes in canopy height for regions with and without GI
   - Used QGIS Zonal Statistics to determine mean change in canopy height within each bounded region
   - Conducted two sample t-test to determine if significant difference existed

Results

Table 1: Average Canopy Height within Bronx Wash by Year

	Average Canopy Height (ft) 2005	Average Canopy Height (ft) 2008	Average Canopy Height (ft) 2015
Regions with GI	4.857	4.939	5.803
Regions with No GI	3.601	3.745	4.406

Table 2: Average Canopy Height within High School Wash by Year

	Average Canopy Height (ft) 2005	Average Canopy Height (ft) 2008	Average Canopy Height (ft) 2015
Regions with GI	4.214	4.931	6.216
Regions with No GI	5.157	5.755	6.560

Table 3: Average Change in Canopy Height within Bronx Wash for 3, 7 and 10 Year Intervals

	Average change in Canopy Height (ft) 2005 to 2008	Average change in Canopy Height (ft) 2008 to 2015	Average change in Canopy Height (ft) 2005 to 2015
Regions with GI	0.097	0.889	1.001
Regions with No GI	0.122	0.628	0.841

Table 4: Average Change in Canopy Height within High School Wash for 3, 7 and 10 Year Intervals

	Average change in Canopy Height (ft) 2005 to 2008	Average change in Canopy Height (ft) 2008 to 2015	Average change in Canopy Height (ft) 2005 to 2015
Regions with GI	0.608	1.284	1.875
Regions with No GI	0.511	0.779	1.308

Figure 8. Average Change in Canopy Height for Regions With and Without Green Infrastructure within Bronx Wash from 2005-2015

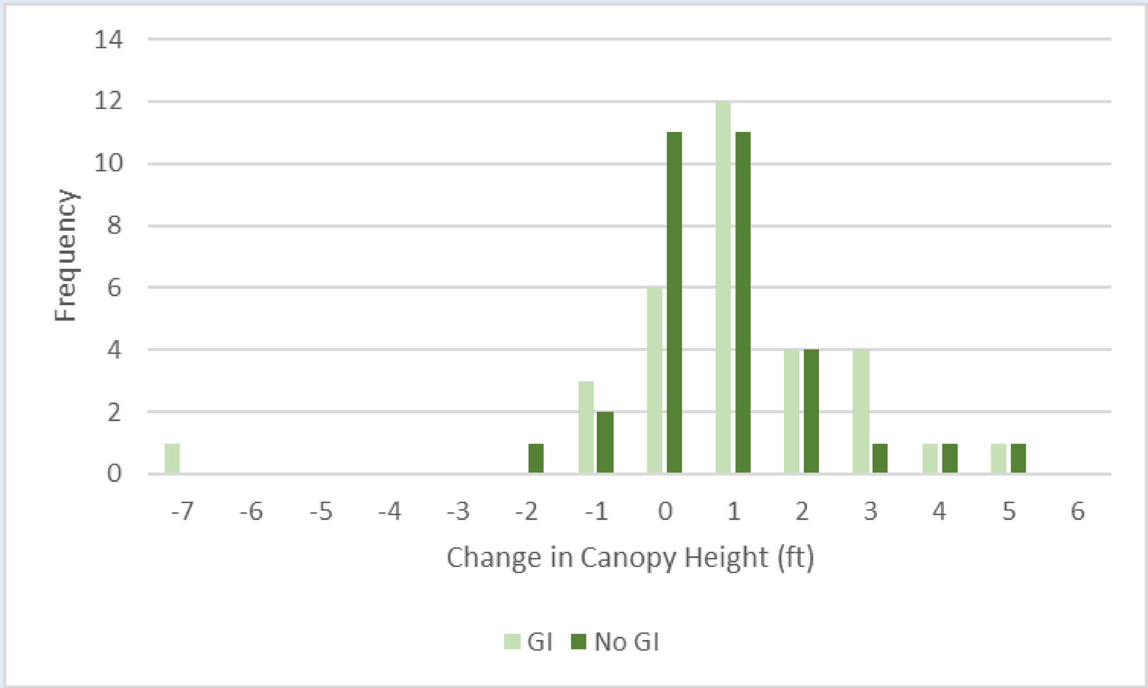
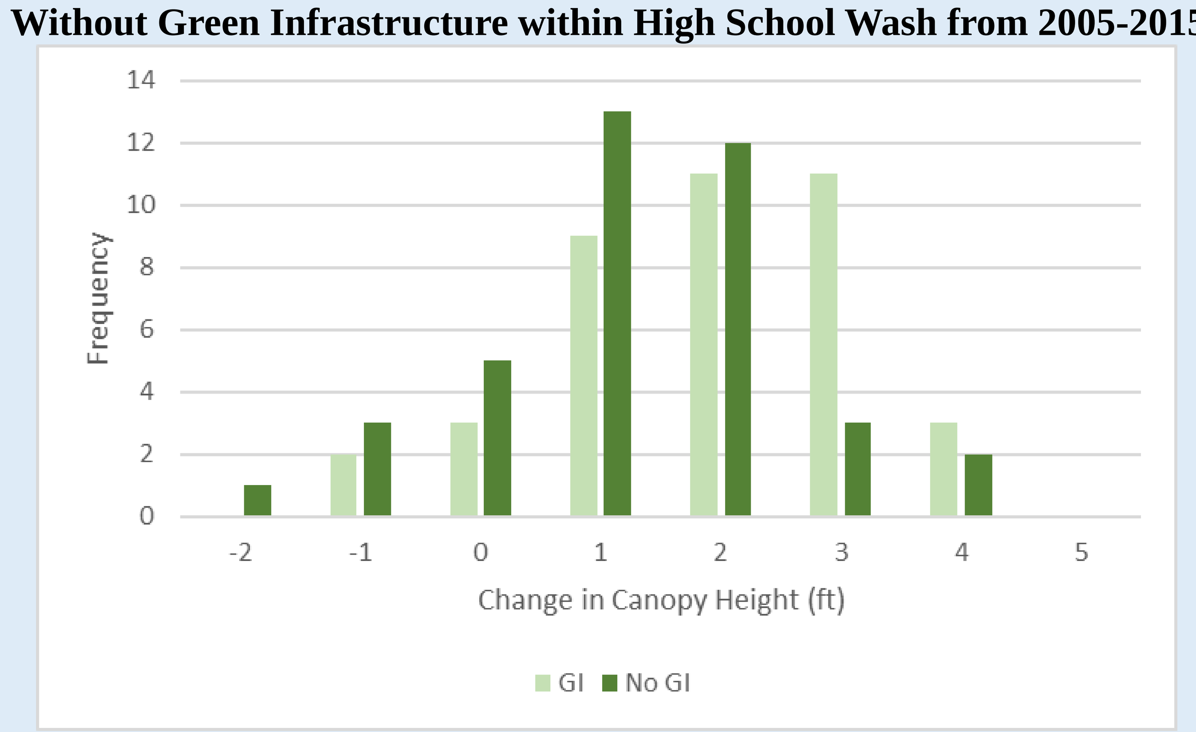


Figure 9. Average Change in Canopy Height for Regions With and Without Green Infrastructure within High School Wash from 2005-2015



Conclusions

Tree growth and loss are seen for regions with and without GI within both Bronx and High School washes. However, greater amounts of tree growth are seen compared to tree loss for both regions. Larger growth measurements are seen more frequently for regions with GI compared to regions without (Figures 5 and 6).

After performing statistical analysis, tree growth proved to be significantly higher for regions with GI only within High School wash. The GI within High School wash was installed before the GI within Bronx wash. It is likely that this had an impact on the results of this project because the GI within High School wash had a longer amount of time to provide a positive impact on the surrounding vegetation.

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