The Impact of Xeriscaping on Water Use in the City of Beverly Hills, 2009-2020

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Executive summary

The city of Beverly Hills, like much of Southern California, is undergoing prolonged drought conditions. Xeriscaping is a water-saving landscaping method focusing on replacing water-intensive lawn grass with less water-intensive native plants. In this research project, we asked: how much water was saved by the removal of grass in Beverly Hills between 2009 and 2020? Sequenced object-based trained classifications were conducted on two NAIP image mosaics masked to cover the area of Beverly Hills, one from 2009 and one from 2020. Subsequent calculation revealed a loss of approximately 84,863.88 square meters of grass area over this time period. Based on existing studies of the transition from grass to xeriscaping, this likely corresponds to a savings of approximately 156.4 acre-feet of water per year. Notably, this is a relatively small fraction of Beverly Hills' water budget, with the entire eleven-year annualized change less than savings obtained in one year by other water saving metrics. This may indicate relatively low importance of grass to Beverly Hills water management and/or resistance or lack of incentivization for a xeriscaping transition among Beverly Hills' relatively high-socioeconomic status lawn-owners.

Problem statement

How much water was saved by the removal of grass in Beverly Hills between 2009 and 2020?

Introduction

Southern California is undergoing a prolonged period of drought, part of an emerging Western United States “megadrought” substantially boosted by anthropogenic climate change (Williams et al., 2020). In addition to the low Sierra Nevada snowpack, low reservoirs, and increasingly powerful wildfires associated with this megadrought, the Colorado River, one of the primary sources of drinking water for Southern California via the Colorado River Aqueduct, is experiencing severe water shortages. Cuts to Arizona’s water supply, primarily for agriculture, will begin in 2022, and California water districts may see cuts as soon as 2024 (Wilson and James, 2021).

Given this broader situation of water scarcity, in 2014 the Metropolitan Water District of Southern California began a program financially incentivizing local residents to convert their lawns to low-water-intensity xeriscaped land (Pincetl et al., 2019). Notably, the MWD provides 90% of Beverly Hills’ water supply as of 2016 (City of Beverly Hills Public Works Department, 2016b).

Beverly Hills, being a high-income neighborhood, is known for its extremely high residential water use. Local news sources reported that as of 2016, Beverly Hills residents used 135 gallons of water for residential uses only per capita per day, compared to 78 gallons per person per day in Los Angeles. Up to 75% of that water tends to go towards maintaining outdoor landscapes, and the City of Beverly Hills is holding workshops to urge residents to use less water-intensive lawn management methods (Rahhal, 2021). However, as a minor yet interesting point of note,

Beverly Hills is also home to a pioneering “dry garden” composed of less water-intensive native plants, established in the 1990s when xeriscaping was not yet such a prominent idea (Green, 2009).

Background

When estimating water savings due to transition away from grass in Beverly Hills, the goal of this research project, examining the literature on the topic reveals an emergent consensus on standard comparison factors. A widely cited study by Sovocool et al. (2006) drew on 5 years of data on xeriscaping efforts in Las Vegas to calculate that “conversion to xeric landscape produced significant water savings of 55.8 gal/sq ft annually.” This is identical to the figure found by a master’s thesis (Hudak, 2005) published the year before, referencing the same irrigation statistics. This “conversion factor” of 55.8 gallons per square feet saved per year appears to be the most concrete and widely used estimate available, or at least the best found after a preliminary literature review, and will be used for this project.

Methods and Data

I downloaded all available NAIP aerial imagery from 2009 and 2020 for the City of Beverly Hills area, from USGS Earth Explorer. Notably, NAIP Imagery for 2009 was collected in May, while NAIP imagery for 2020 was collected in June. This may result in slight seasonal changes confounding the main comparison.

I then used the Create a Mosaic Dataset followed by Add Rasters to Mosaic Dataset workflow, as recommended by ESRI, to mosaicize together the two NAIP images for the City of Beverly Hills in 2020, and then the two NAIP images for the City of Beverly Hills in 2009. I then used

the Extract by Mask geoprocessing tool to extract a portion of the 2020 mosaic corresponding to the Beverly Hills municipal boundaries polygon footprint (previously extracted from this dataset of LA County metropolitan area boundaries).

I repeated this workflow for the mosaic of all NAIP imagery from the City of Beverly Hills in 2009, resulting in two "Beverly Hills-shaped" raster mosaics, one from 2009 and one from 2020. At this point, I could begin a supervised object-based classification for each raster mosaic with the ArcGIS Pro Image Classification Wizard.

My areas of interest (any patch within Beverly Hills with human-cultivated grass as land cover) were often very small, consisting of backyards, parks, athletic fields, roadside verges, and even tinier isolated patches such as those around lampposts. Furthermore, Beverly Hills has several tree- and shrub-covered areas, distinct from grass but with a similar shade of characteristically vegetative green. Given this need for specificity in the analysis, I set the minimum segment size in pixels to 1, the lowest available value, and both spatial and spectral detail to the 20, the highest available value. I then edited the NLCD 2011 classification schema to focus on five categories best representing the Beverly Hills landscape: Water, Developed, Trees, Bare Ground and Brown Shrubland, and finally Human-Cultivated Grass (our land cover of interest). For each raster mosaic, I manually drew appropriate training data samples and used a Support Vector Machine classifier. This resulted in a classified raster image, and a quick visual survey and comparison with the underlying original mosaic seemed to indicate a high level of fidelity to real world results-i.e. where there was grass in the classified image, there was grass in the original photo.

I then used the Raster to Polygon geoprocessing tool to create multipart polygon features for each Raster class in the classified image. (Notably, I did *not* select the option to simplify the polygons, instead keeping every detail from the original rasters). The resulting attribute tables gave the area of the Human-Cultivated Grass class in square meters.

Results

This workflow resulted in finding that in **2009**, the Beverly Hills landscape had an estimated **2113018.92 square meters** of human-cultivated grass, or approximately (i.e. rounded) 2.113 square kilometers or 0.8158 square miles. In **2020**, the Beverly Hills landscape had an estimated **2028155.04 square meters** of human-cultivated grass, or approximately 2.028 square kilometers or 0.783 square miles.

These figures also pass a quick “reality check,” as being reasonable results, given that the total area of Beverly Hills is approximately 5.71 square miles.

Beverly Hills 2009 Classified Raster

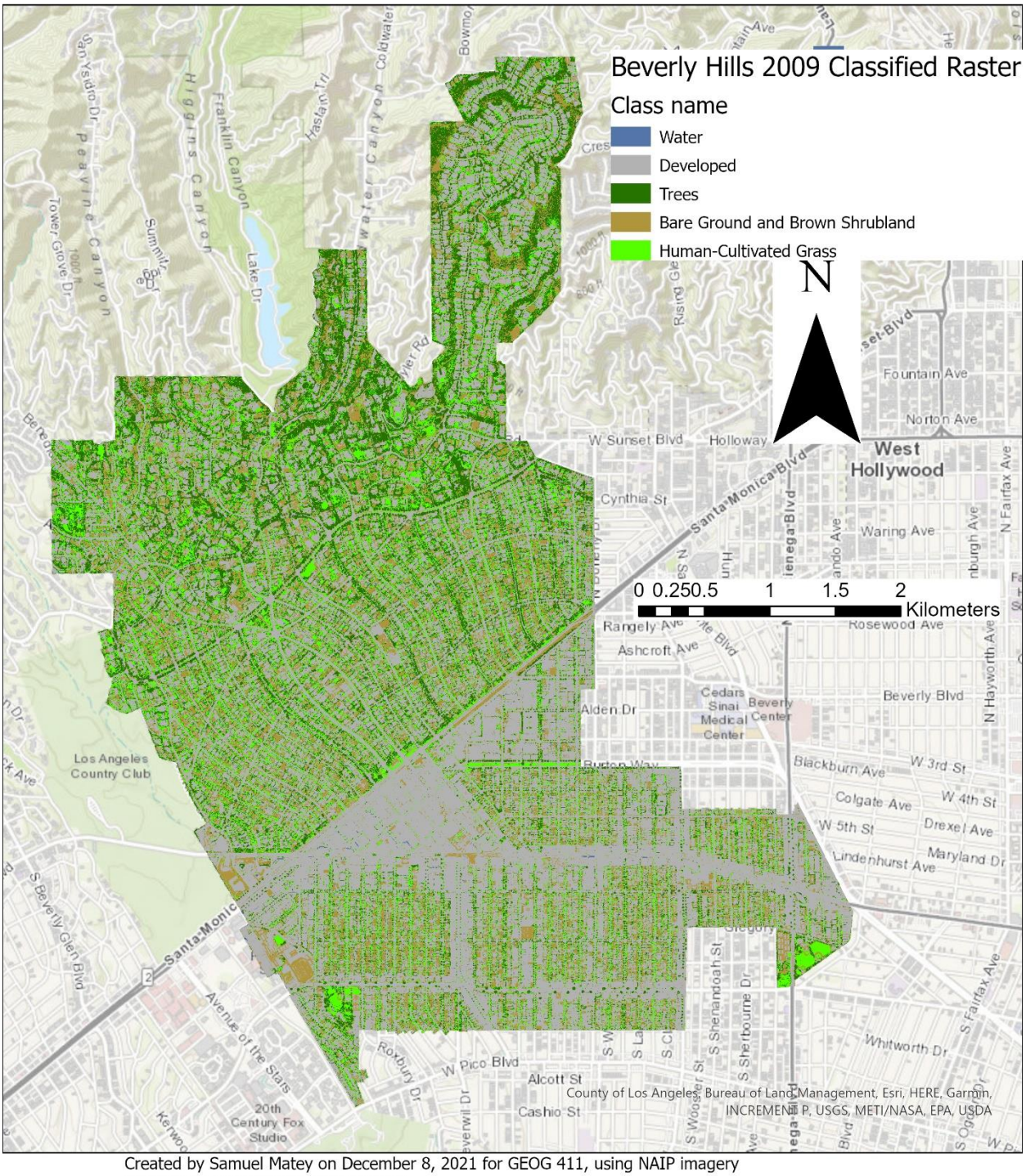
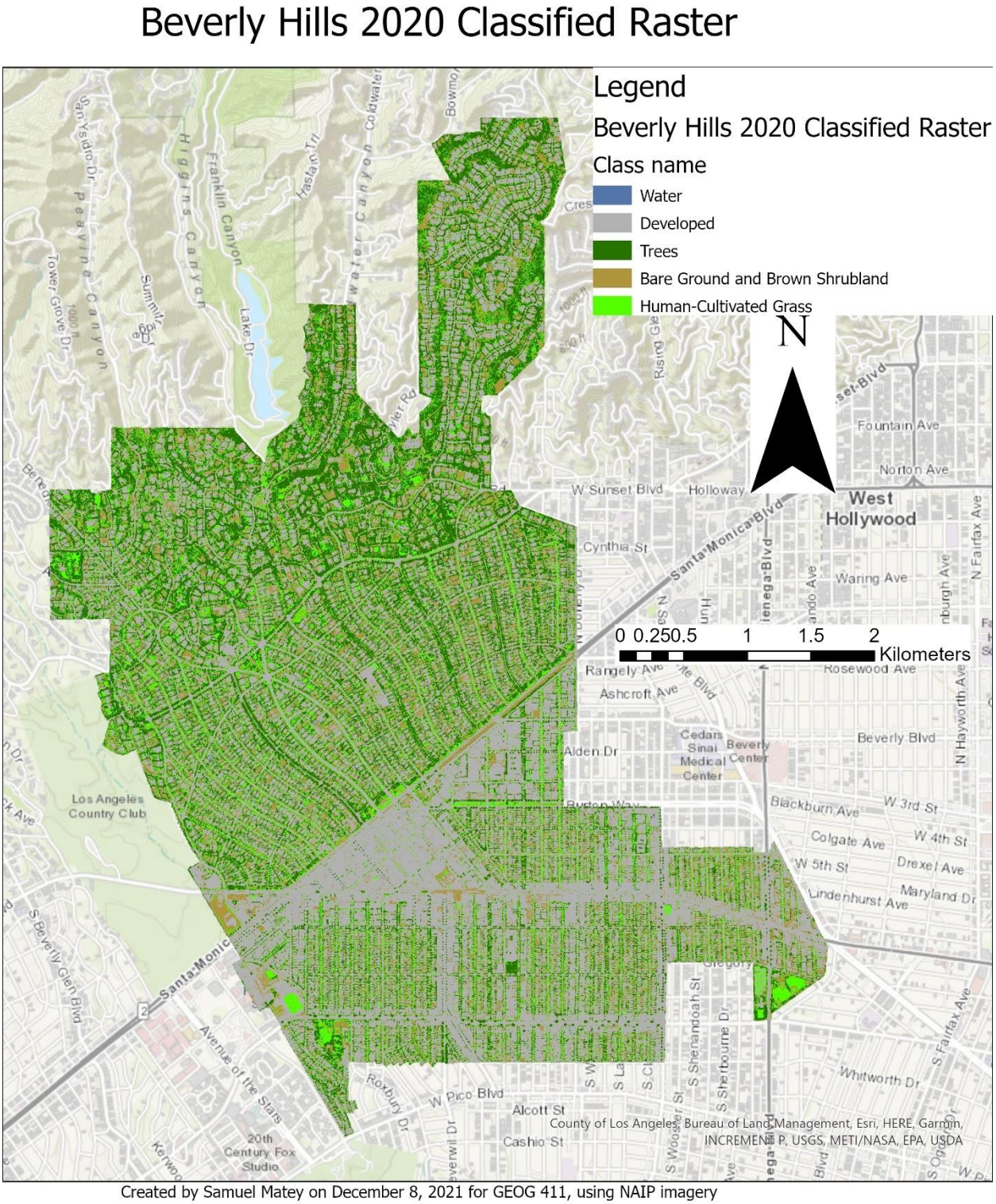


Figure 1: Beverly Hills 2009 Classified Raster



Created by Samuel Matey on December 8, 2021 for GEOG 411, using NAIP imagery downloaded from USGS EarthExplorer.

Figure 2: Beverly Hills 2020 Classified Raster

Thus, the difference in grass cover (a decrease, so indicating removal of grass) in Beverly Hills between 2009 and 2020, as estimated by a supervised object-based classification of NAIP data, is approximately **84,863.88 square meters**, or **913,467.2 square feet**. That's a decrease of **4 percent**. (Note how the classified rasters from 2009 and 2020 in Figures 1 and 2 above are almost indistinguishable without carefully scanning for small changes in details; this corresponds to the idea that land cover in Beverly Hills has changed relatively little in this eleven-year period).

GIS analysis could give me the difference in grass area in Beverly Hills between 2009 and 2020. However, it could not provide the water usage; we must rely on existing research for that. If we use the Sovocool et al. calculation factor of grass to xeric landscape conversion saving 55.8 gal/square feet annually, we may simply calculate that Beverly Hills' loss of grass in this 11-year period saves 50,971,469.76 gallons of water per year-over 50 million gallons, or **156.4 acre-feet**! (One acre-foot of water is approximately 325,851 gallons, or over 1.233 million liters).

Discussion

Taking this result at face value, there are a wide range of possible inferences to draw.

First, we should compare the potential water savings to Beverly Hills' overall water budget. According to the City of Beverly Hills Public Works Services Department (2016a), Beverly Hills as a whole used 707 acre-feet of water in March 2016, a 24.2% reduction from the 932.4 acre-feet used in March 2015. Another memorandum quantified the approximate benchmark for Beverly Hills water usage as one acre-foot per single-family home per year (City of Beverly

Hills Public Works Services Department, 2016b). Notably, this means that water-saving methods applied over one year saved more water on a month-to-month basis than all changes in grass cover over eleven years are estimated to have saved annually, only amounting to about 156 homes' worth! This impression of the impact from changes in grass water use being treated as fairly marginal in Beverly Hills is supported by the fact that city memoranda seemed to identify residential and commercial leakage, such as broken sprinkler valves or constantly-refilling pools or water heaters, as a major priority for reducing water wastage, as a higher priority.

This minor role played by the change in grass water use compared to other water saving methods, added to the fact that grass cover was only an estimated 4% less in 2020 than in 2009, may indicate a failure to address the problem of grass water use in Beverly Hills. This may be due to entrenched socioeconomic power of residents with a cultural preference for lawns, or it may be simply a lack of incentivization. For example, the MWD's 2014-15 program offered USD $2 per square foot of lawn removed (Pincetl et al., 2019) and this may not have weighed very heavily with those able to afford real estate in Beverly Hills.

Furthermore, loss of grass may not be a perfect proxy for xeriscaping, and in the Beverly Hills context may not translate into such high water savings as the simple grass loss-gallons saved calculation used in the Results section above suggests. For example, Las Vegas, the source of the studies giving the xeriscape water savings conversion factor used above, has a subtropical hot desert climate (Köppen classification BWh) while Beverly Hills has a substantially wetter warm-summer Mediterranean climate (Köppen classification Csb). The associated native plant fauna are substantially different, suggesting that even a perfectly xeriscape-suitable suite of native

plants in Beverly Hills might require more water to survive than an equivalent group of different plant species native to Las Vegas, particularly given the recent drought conditions.

Beyond that, error may have been introduced during the geospatial analysis phase itself. Unfortunately, a standard raster classification accuracy assessment would be difficult to conduct in this case, given that NAIP imagery is generally the highly accurate background against which to measure the classification lower-res satellite photos but for this project was the basis of the classification training data. Attaining further detail would likely require laborious "ground-truthing" with site visits.

In addition to the slight seasonal difference in NAIP imagery collected and the potential regional differences in xeriscaping's water use already discussed, there are several other potential sources of error. One of the most potentially profound is the spectral similarity between grass and non-grass plants, potentially including trees and shrubs used for xeriscaping. While random visual checks to compare the classified rasters with original mosaics seemed to indicate high-fidelity discrimination between grasses and trees, it is difficult to be certain, especially given that xeriscaping sometimes uses other grasslike species.

Conclusion

Approximately 156.4 acre-feet of water annually was saved by an estimated 4% decrease in grass cover in Beverly Hills between 2009 and 2020. However, it is possible that this is something of an overstatement, perhaps due errors in the raster analysis or "real-world" factors such as differences in plants used in xeriscaping. In any case, this is a relatively small amount of water saved for Beverly Hills; compared to other water conservation measures and the yearly or even monthly water budget.

Overall, grass removal over this 11-year period does not appear to have been particularly far-reaching or transformative, in terms of either proportion of grass removed or effect on the Beverly Hills water budget. This may be due to more profound impacts on water use from other areas (e.g. the leakage concerns expressed in city memoranda), Beverly Hills' residents socioeconomic power leading to continued investment in and advocacy for traditional water-intensive lawns, or simply a lack of strong enough campaigning, incentivization, or public advocacy in favor of xeriscaping.

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