Determining Possible Planting Space Suitability in the Austin Area

Treecon Solutions

Project Manager: Griffin Moore

Analysts: Joseph Van Smirren, Ashley Perez, Thomas Shively

Produced for

City of Austin Urban Forestry Program

1 May 2023

Table of Contents

ABSTRACT

Urban Tree Canopy continues to be an environmental goal of American cities in the 21st century. The City of Austin has stated goals that would serve to expand their urban forest with requirements of improvement to climate equity. Treecon has been tasked with assessing the potential planting space with updated 2022 data and identifying immediate actionable public parcels to prioritize in future planting. The possible planting space was calculated with high precision and accuracy. Analysis was conducted concerning equity, ecological risk and planting potential contribution to provide priority parcel identification to the City of Austin. This was completed by way of a basic subjective scoring system based upon the data available. The results of this analysis should provide a stepping stone for more mature considerations to tackle climate equity issues for the City of Austin.

1. Introduction

The City of Austin has been pursuing the expansion of the Urban Tree Canopy (UTC) in the hopes of both improving climate equity and ecological impacts via tree planting. The Climate Equity Plan has goals of achieving net-zero greenhouse gas emissions in the next 20 years and has designs to provide increased UTC to the underserved Austinites. The current tree canopy coverage for Austin sits at about 36% based on a 2018 analysis with percent tree canopy coverage over watershed area being 28%. The Climate Equity Plan has established a vision to attain 50% city coverage by the midcentury. Possible planting space can be defined as all of the ground area in a study area that is not already coded at surface water, tree canopy or impervious cover. By examining the PPS, the most prime spots of potential tree canopy can be estimated and identified so that the local government authority may act in the most efficient manner to attain UTC goals.

1.1 Problem Statement

The City of Austin tasked Treecon to calculate the new 2022 possible planting space. With that output Treecon identified public owned parcels inside the study area that will provide the most benefit to selected ecological attributes and what provides the best climate equity by locations denoted from the City of Austin as being underserved. Treecon was given authority on deciding how to conduct the analysis and what additional variables are to be considered. Data was provided concerning current Tree Canopy, Impervious Surface Layer, Surface water and useful boarder attributes that stretched the width and breadth of the watershed multitudes that serve the Austin area. The analysis was constrained to the extent of this study area and deliverables were presented in May 2023.

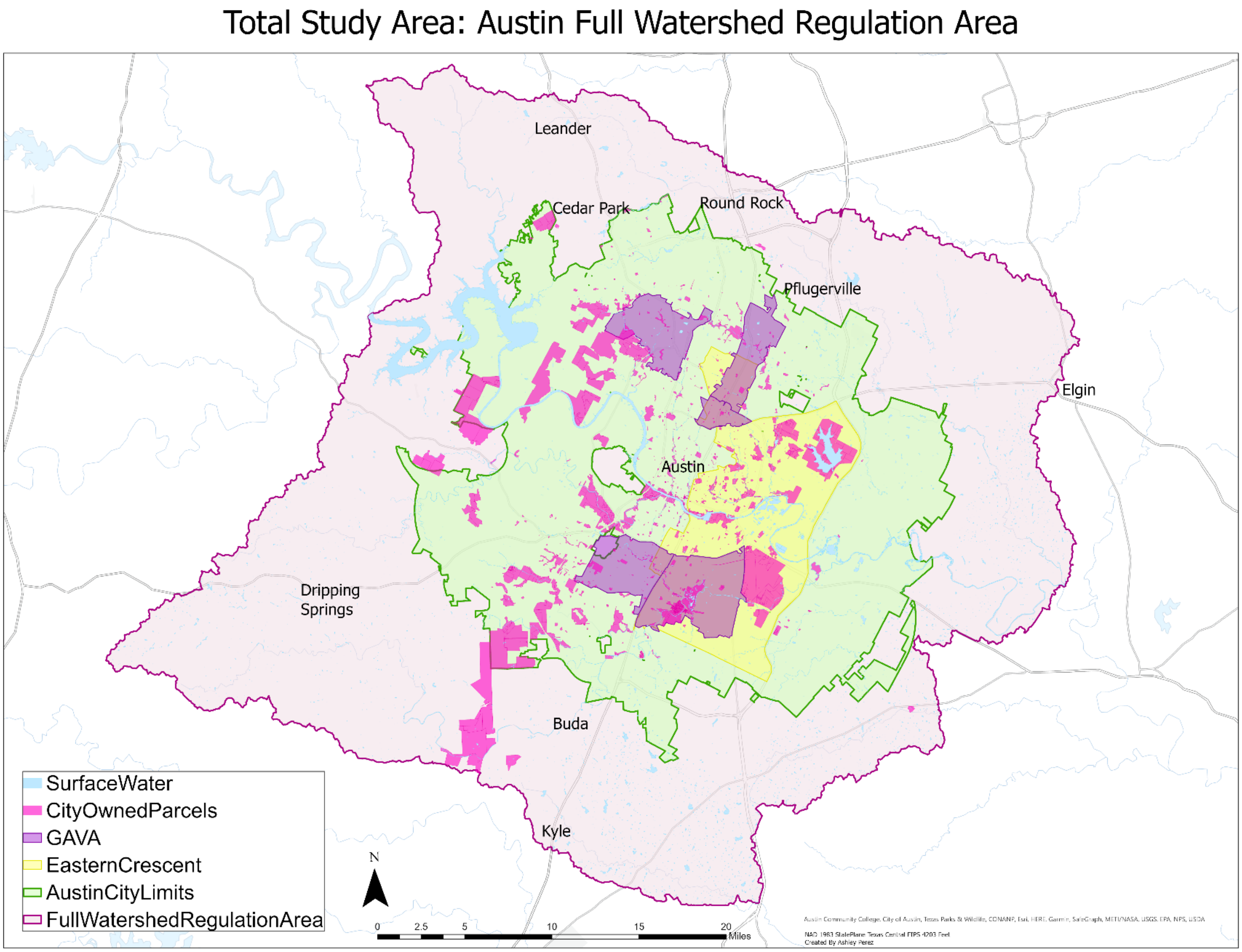


Figure 1. Austin Full Watershed, City Limits

Figure 1 shows the study area, the Austin full watershed regulation area. There is a focus on city owned parcels, GAVA, and the Eastern Crescent. The focus areas have already been identified as areas in need and able to plant in.

2. Data

Table 1. Data Table

Entity/Name	Source	Provided, Found, Deliverable	Data Type	Status
Austin City Limits	COA	Provided	Vector	Current
Austin Watershed Area	COA	Provided	Vector	Current
Austin Watersheds	COA	Provided	Vector	Current
Surface Water	COA	Provided	Vector	Current
Impervious Cover 2021	COA	Provided	Vector	Current
ABIA	COA	Provided	Vector	Current
City of Austin owned parcels	COA	Provided	Vector	Current
Eastern Crescent Outline	COA	Provided	Vector	Current
Tree Canopy 2022	COA	Provided	Vector	Current
Austin Zip Codes	COA	Found	Vector	Current
Census	US Census	Found	Vector	Current
Heat Severity	TPL	Found	Raster	Current
NAIP Imagery	USGS	Found	Raster	Current
City of Austin Flood Risk Zones	COA	Found	Vector	Current
Possible Planting Space Total Cell Size 10	Treecon	Deliverable	Raster	Current
Possible Planting Space Total	Treecon	Deliverable	Vector	Current
Possible Planting Space East Austin	Treecon	Deliverable	Vector	Current
PPS GAVA	Treecon	Deliverable	Vector	Current
PPS Spreadsheet Suitability Scored	Treecon	Deliverable	Vector	Current

In the beginning of the project, we experienced numerous errors attempting to geoprocess the original data. We had some issues with errors attempting to combine the given data so, we used the repair geometry tool on the original data to prevent some possible errors. We recommend not using the full watershed regulation area layer for analysis. We attempted to combine all non-plantable space, ABIA, Impervious surface, and surface water, and subtract it from the complete study area of the Austin full watershed regulation area.

The data used for the original composition of the project's layers were the impervious, Austin watersheds, Austin watershed total area, ABIA not plantable space, Austin city limits, GAVA zip codes, eastern crescent, and Austin owned city parcels. This was the first data downloaded and analyzed by the team. Fortunately, all the original data was given to us by our client or was sourced from Austin's open source datahub. Search & Browse | Page 1 of 470 | Open Data | City of Austin Texas. Once added, the tree canopy, surface water, ABIA, COA owned parcels and Austin City Limits all needed to be repaired for the geometry of the features. Once completed the tool explained whether the geometry could be fixed or not. After that the original files need to be checked for the coordinate system they represent. Tree canopy, watersheds and GAVA zip codes all had a different coordinate system than the other layers, those were projected to a Lambert Conformal Conic, NAD 1983 StatePlane Texas Central FIPS 4203 (US Feet) system. We then matched the layers with the wrong coordinate system to the correct projected coordinate system. the NAD 1983 StatePlane Texas Central FIPS 4203 (US Feet).

A vector to raster conversion did occur for the original files, converting the vector to a 10x10 raster. All attempts to reduce the Austin full watershed regulation area study area to only a vector total possible planting space feature were met with numerous errors. It is suspected that there may be a datum error regarding the provided the Austin full watershed regulation area feature that produces topological errors in all of the geoprocessing tools attempted.

The precision and accuracy of this data is great and does not account for any significant error that the team could recognize. This data made it possible to find the newest version of possible planting space in the Austin area. It was key to create a potential planting space layer to aid the team in the analyzation of the work later. Without the base original files, a PPS layer would not be possible. Along with not being able to calculate a sustainability model without having a PPS layer.

3. Methods

Raster Method

To determine the possible planting space (PPS), we used a geographic information system (GIS) in ArcGIS Pro. Begin with the Full_Watershed_Regulation_Area shapefile. Use the erase tool to remove the following features and produce three new shapefiles. Impervious Layer 2021, Surface Water and Tree canopy 2022. Rasterize those three features at a selected cell size. Then, conduct a raster calculator subtraction and subtract two features from the other raster and the output will be a raster layer of the total PPS.

Vector Method

To determine the vector possible planting space (PPS), we also used ArcGIS Pro. We projected all the layers to be the same projected coordinate system, NAD 1983 StatePlane Texas Central FIPS 4203 (US Feet). We then subtracted the non-plantable surface layers, impervious, surface water, Austin-Bergstrom International Airport (ABIA), and tree canopy, from the total study area, watersheds, to get the Total Possible Planting Space layer. Due to initial errors occurring, we did not conduct an initial dissolve on the watersheds layer. The total PPS layer was based off of the watersheds shapefile and shared the same attribute table. It is recommended that users turn off outlines for all possible planting space layers to avoid the separate watershed outlines. We then made new layers from the PPS layer. We made a PPS layer for the East Austin crescent and a PPS layer for GAVA.

Weighted Overlay

Initially the team attempted to use rasterized features to conduct a weighted overlay analysis of the project, however after many difficulties and attempts to operate the tool, the team acquiesced to completion of a subjective scoring system based on field attributes.

Scoring System

The most important shape file was City of Austin owned parcels. By completing a Summarized Within selection of Vector PPS inside the parcel shapefiles the team had a metric to determine rating based on contributable planting space potential. The team decided that an arbitrary max possible score of 1000 would be appropriate and broke that down by giving the PPS component half of possible points by a max score of 500. This was done by taking the shape area value of the largest summarized PPS in a parcel, or simply the public parcel that stands to provide the most PPS if fully planted. That value was used to compare all other parcels and compute a percentage.

FIELD	VALUE	PercentScoreMod
(PPS_SUM_Within_Area) /	(Largest contributable PPS Parcel Area) * 100	*5

With this metric, the top parcel could be 100% and when computed into score the value of percent contribution compared to the best parcel would be multiplied by 5 to end up with a max of 500 points possible.

The next consideration that the team assessed was to attribute parcel location by climate equity concern. This was simplified into a binary score of if the parcel was inside the GAVA zip code or the Eastern Crescent. If the parcel was inside the GAVA zip code, it scored a base 1, if not it scored a base 0. The same stands for the Eastern Crescent. The score modifier was slightly different as the team placed priority upon whether or not the parcel lied in the Eastern Crescent as it was easy to ascertain that there is greater PPS to gain in the eastern side of the study area.

FIELD Score Modifier

(GAVA Binary) * 100

FIELD Score Modifier

(Eastern Crescent Binary) * 250

The next consideration was the two ecological variables. These included flood risk polygons and urban heat risk polygons. Only the most risky flood zones were included as a polygon, or areas that have a 1% or greater annual risk of flooding compared to the worst flood in the preceding century. The base score could be a 0, 1 or 2. If a parcel was within the flood zone it scored 2, if it intersected but not within it scored 1 and if it didn't touch a boundary at all it scored 0. The heat variables were originall in 5 classes of a raster format from Landsat 8 Thermal ground sensor. Class 1 is a area that is considered mildy hotter than mean and that increases with each class up to 5 which is significantly hotter than mean land surface temperature. The team saw this as a simple metric to tackle urban heat by applying scores once converted to vector format. They were put into 5 polygons for each class on increasing heat severity. Parcels that intersected a 4 or 5 polygon were scored as 2. Parcels that intersected a 1,2 or 3 heat polygon were scored as 1. The team identified scores as follows.

FIELD	Score Modifier
(FloodRisk Withins Binary)	* 25
(Flood Risk Intersect Binary)	* 25

FIELD	Score Modifier
(UrbanHeat Intersect > Class 4 Polygon) *	50
(Urban Heat Intersect < Class 4 Polygon) *	50

The last consideration was to ensure that noncontributing layers do not get final scores. The team identified around 200 parcels that were not contributing any PPS either due to being fully planted or due to fully impervious coverage. A final score was attributed of being 0 if the parcel had no PPS to contribute and 1 if the parcel did have PPS to contribute.

With all of these variables a final computation for score could be conducted as follows

((GAVA base value * 100) + (Eastern Crescent base value *250) + (Urban Heat Risk base value *50) + (Flood risk base value *50) + [(PPS_SUM_Within_Area) / (Largest contributable PPS Parcel Area) * 100 *5] * (contributes or does not contribute base value)).

All of this is available in the “city_of _owned_parcels_scores_spreadsheet” and can be adjusted to the user’s needs if they would like to change scores and score modifiers to influence a different suitability project.

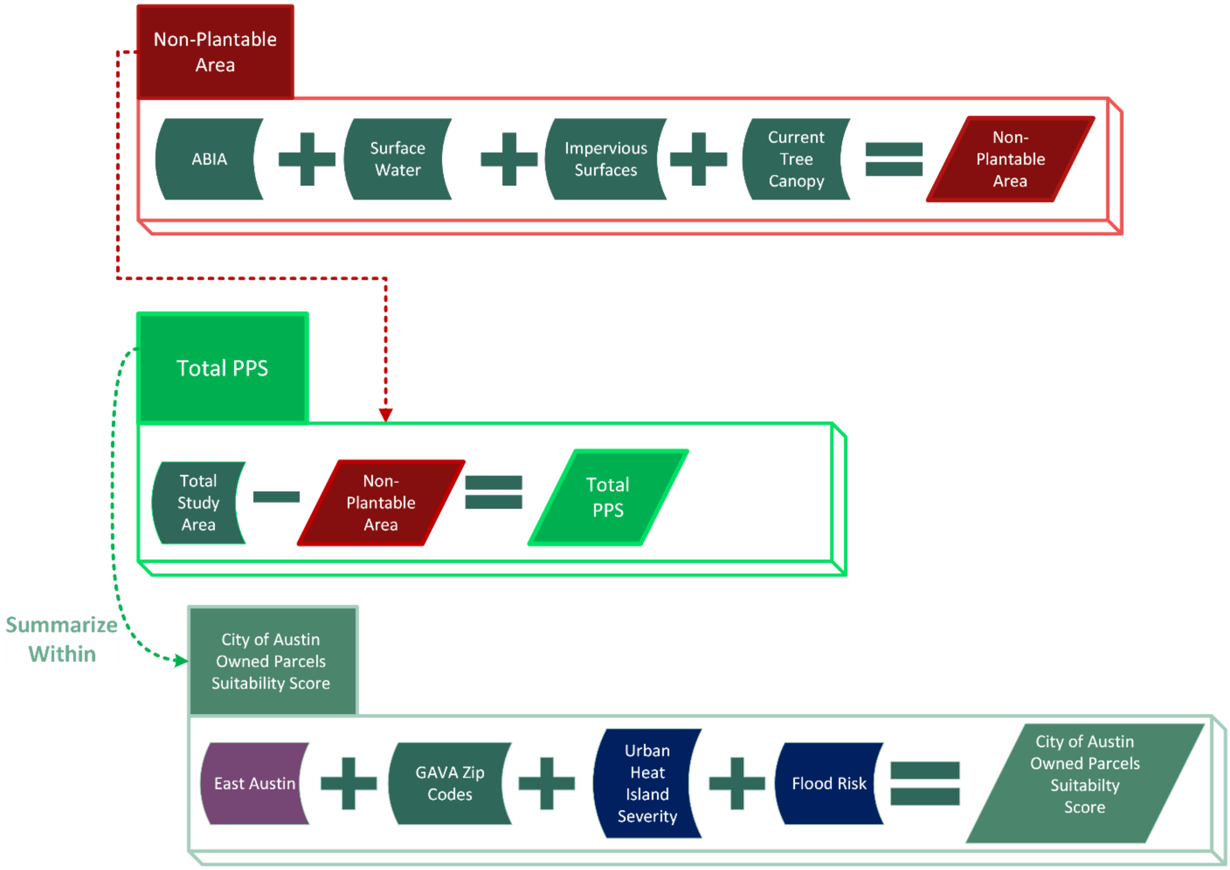


Figure 2. Flow Chart

This chart shows each major step in our analysis phase. PPS, and then to get the scores for each COA owned parcel using total PPS, equity factors, and risk factors.

4. Results and Discussion

This final report is accompanied by a poster with map results included, presentation slides, and a spreadsheet listing Ausin owned properties available for planting. Final maps include total possible planting space in the total Austin area watershed, possible planting space in the Eastern Crescent, possible planting space in GAVA and the prime Austin owned possible planting space. A spreadsheet including the areas we believe to be the most vital parcels of PPS, weighted by factors discussed in Methodology, is provided as a shapefile with respective attribute table.

We did have errors with given data from the City of Austin but, finally had some breakthroughs when we were able to process a possible planting layer in raster format. Then soon after, we found that the full watershed regulation area was causing a major topology error. Instead, we used the watersheds layer and successfully completed the geoprocessing to get possible planting space layers in a vector format. The vector PPS map is shown in Figure 3. Figure 4 serves as a comparison of tree canopy in 2022 to total PPS. The raster PPS map is displayed in Figure 5. The total possible planting space has been computed into a raster layer at a cell size of 10, or 10 foot by 1 0foot. This layer serves as a main feature for the rest of the project's analysis. The percentage of possible planting space has been computed. The full watershed regulation area is 1,534.10 square miles. The total possible planting space calculated from the cell size 10 raster is 728 square miles. The 2022 tree canopy area is 557 square miles with a current percent tree canopy of 36%. We did not include the PPS raster at cell size 1 ft by 1 ft as it does not provide any useful information when viewed at the total study area resolution. In fact there are not enough pixels on the analysis computer monitors to display the raster layer at such fine resolution. Ultimately the team did not utilize the raster layer for the analysis as it was a backup solution for the inability to perform the vector merge.

Figure 6 was produced to denote the totality of known inputs for PPS and the equity aspects for the analysis. Analysis that constrained everything to the Austin ETJ was forgone so that full watershed analysis could be pursued. Figure 7 and 8 both denote the equity variables that were taken into account and display parcels that are inside either the Eastern Crescent or the GAVA zip codes. In those maps the parcels outside those polygons are omitted for simplicity.

Figure 9 demonstrates the public parcel relationship to highest risk flood zones. Figure 10 demonstrates the public parcel spatial relationship to urban heat island polygons.

Figure 11 is a display of the attribute table color coded to denote input scores and useful attribute data. The yellow fields are inputs to the score calculation. Score is denoted in gold as the final score. The red fields are the PPS metrics used to compute the following PPS scores (PPS area / PPS area of best parcel) and (PPS present). It can be edited in the associated shapefile "city_of _owned_parcels_scores_spreadsheet". There were a few parcels that scored zero even though they did contribute PPS, but it was such a low decimal amount that the team rounded them down and grouped them with noncontributing parcels.

Figure 12 is the scored parcels based on Treecon's methodology. The results match expectations as most of the priority parcels are within the eastern crescent even though such a high priority score was given to PPS output area. 0 score output parcels are parcels that contribute no possible planting space either due to being already fully planted by tree canopy or impervious layer coverage. Green parcels are an accumulation sum of either high PPS or high priority location where as red / orange parcels score less and are identified as not in line with achieving the City of Austin's climate equity goals. Figure 13 is an image that demonstrates the scored parcel with the real true color imagery to identify if the metric makes logical sense.

There were some errors when accounting for LiDAR, one of the reasons was after spring break. The computers in ELA 120 were wiped, the creation of LiDAR was deleted. Sadly, it was not stored on an external hard drive because of storage size. The other reason is how to properly summarize the LiDAR data without causing errors in the other fields. This error in the classification caused different feature classifications. Some were mixed into the wrong classifications, for example some buildings were miscategorized. They were classified as unassigned classifications even though there were building classifications.

In figure 14 the error is displayed and describes the issue with the classification of LiDAR. This became an issue when wanting to view the power lines pathway in the area. As you can see in figure 14 there was still success when denoting the pathway of power lines, ignoring the buildings that were miscategorized. In figure 15, the image shows the raw point cloud data for the LiDAR with the exclusion of unwanted classes such as buildings and vegetation, filtering them out. The scene shown shows the point cloud LiDAR points for powerlines. Some low-level shrubbery and features are still accounted for by color on the ground elevation but not the features true elevation. They then create a network of pathways along the roads. The final limitation would be on the time frame of the project and access to Austin Utility data. Because of the accessibility of power lines data, it did make creating the power line paths more difficult, especially if you are quite novice when using LiDAR data.

Overall results closely match expectations. Western located parcels that had lots of room for PPS scored high but most of the parcels that had higher than median scores were located in the

Eastern Crescent identified by the client. The team feels confident in the scoring system due to giving such high precedence to PPS contribution of up to 500 points out of a total 1000 where as parcels that meet the equity condition have a much lower score cap. Had the project gone on longer, the scoring system would likely be overhauled to have more metrics. For example the team would change the simple binary of 0 or 1 for a parcel being inside the GAVA or Eastern Crescent polygon into a distance metric. The same would apply to the ecological risk factors used and an additional metric would be included to further constrain PPS by how much a tree takes up and excludes area on the ground. The score system that we did utilize is very basic and most certainly adds some error to the project as small parcels are typically selected against in favor of larger parcels. With additional time, a raster analysis using the weighted overlay instead of arbitrary scoring based on a subjective design with a greater range of variables to influence score.

Utilization of a GIS for this project was paramount as it allowed for visual and statistical analysis to be quickly processed in conjunction with multiple spatial variables. The GIS provided essential deliverables that can readily be used for the client's next phase of the project. That being said we were unable to use the GIS for LiDAR utility line rectification, and this would likely be the same difficulty to conduct an in situ data collection in and around top score parcels, something that the GIS cannot do. If Austin could provide a utility shapefile than this process would be streamlined via a GIS, but there remains security concerns of the infrastructure data that prevents this.

In terms of data quality, the original data provided and the computed PPS layers in both raster and vector are complete, representative, highly accurate and precise. At the very least the next step will have solid input data to complete an analysis. The thematic scores that Treecon computed are very basic in design and it should be interpreted as such. Treecon focused on climate equity goals while maintaining importance to PPS output from parcels and compared those parcels to each other. The equity components are just based on spatial location and do not account demographics or complex socioeconomic variables as the components are simplified to what the client directed the team towards. The ecological components are also basic in design only taking into account the most hazardous of flood zones and a simplified version of urban heat zones. Luckily the design of the deliverable parcel file will allow any analyst to input their own metrics as the PPS summarized within field for the parcels is highly accurate, precise and representative when the other scores are less so.

The results align with expected outcomes, but is a simplification of what climate equity improvement is. The client highlighted a zone that is deemed as underserved by the local city government and the analysis was conducted as such. However should the parcels have action completed, it is unknown whether the Austin populace would be accurately served by planting trees in high score zones

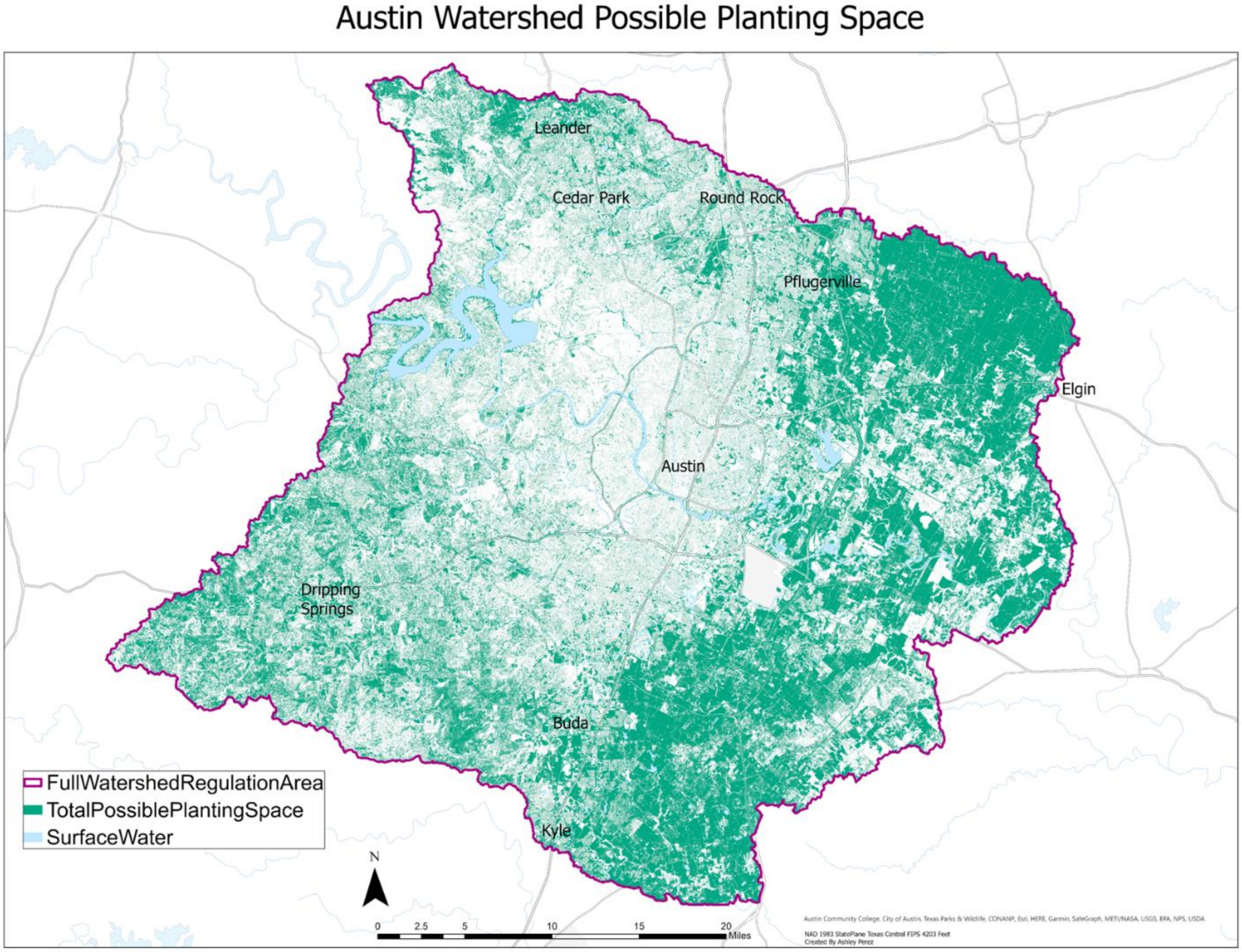


Figure 3. Total Possible Planting Space Vector

Figure 3 establishes the total possible planting space in the Austin watershed area. There still may be open spaces identified as possible planting space but that need to remain open because there could be utilities such as power lines, or sports fields or other reasons not to plant in the area but these were unable to be accounted for.

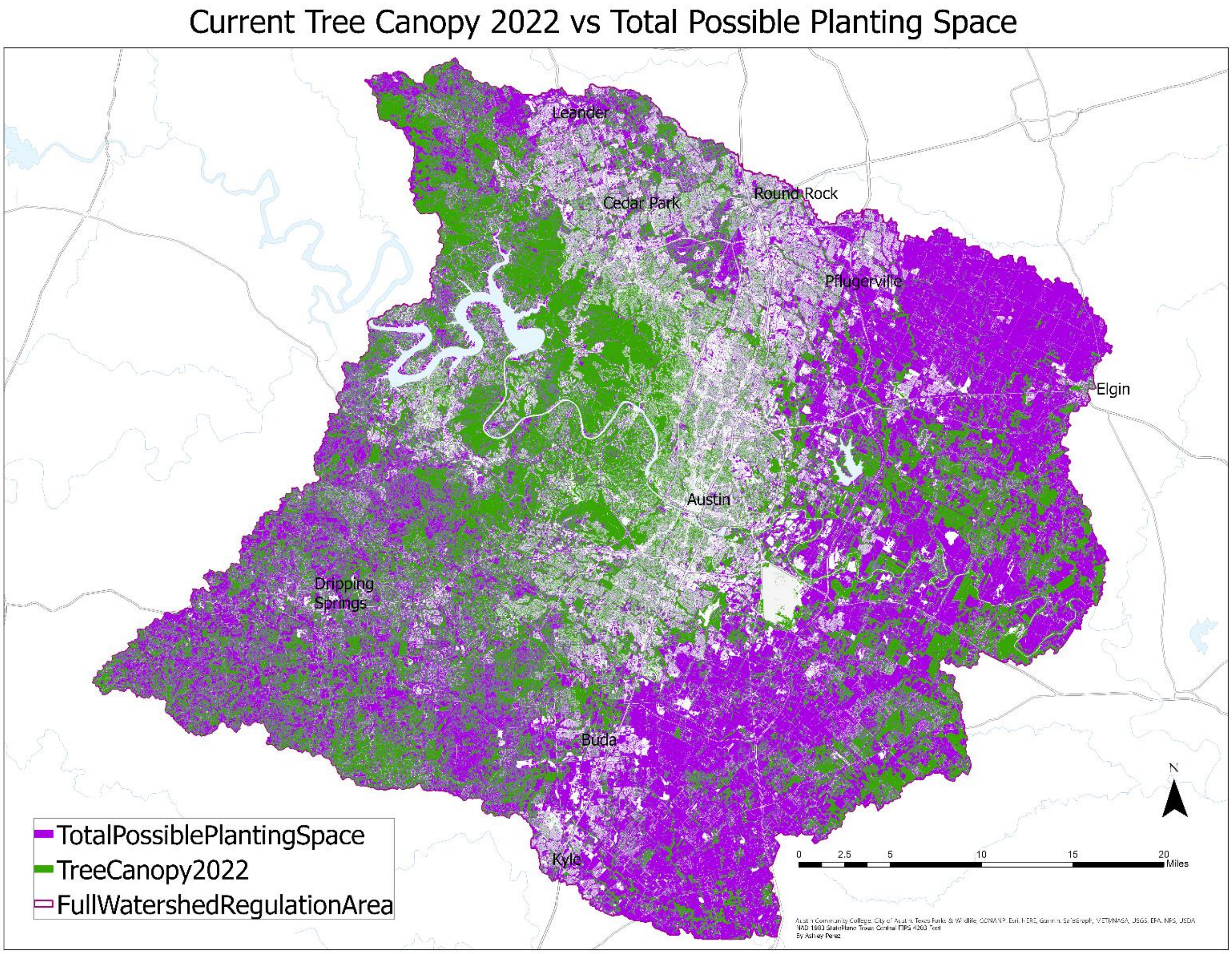


Figure 4. Current Tree Canopy 2022 compared to Total Possible Planting Space

Figure 4 compares the current tree canopy from 2022 to the total possible planting space calculated based on the available data.

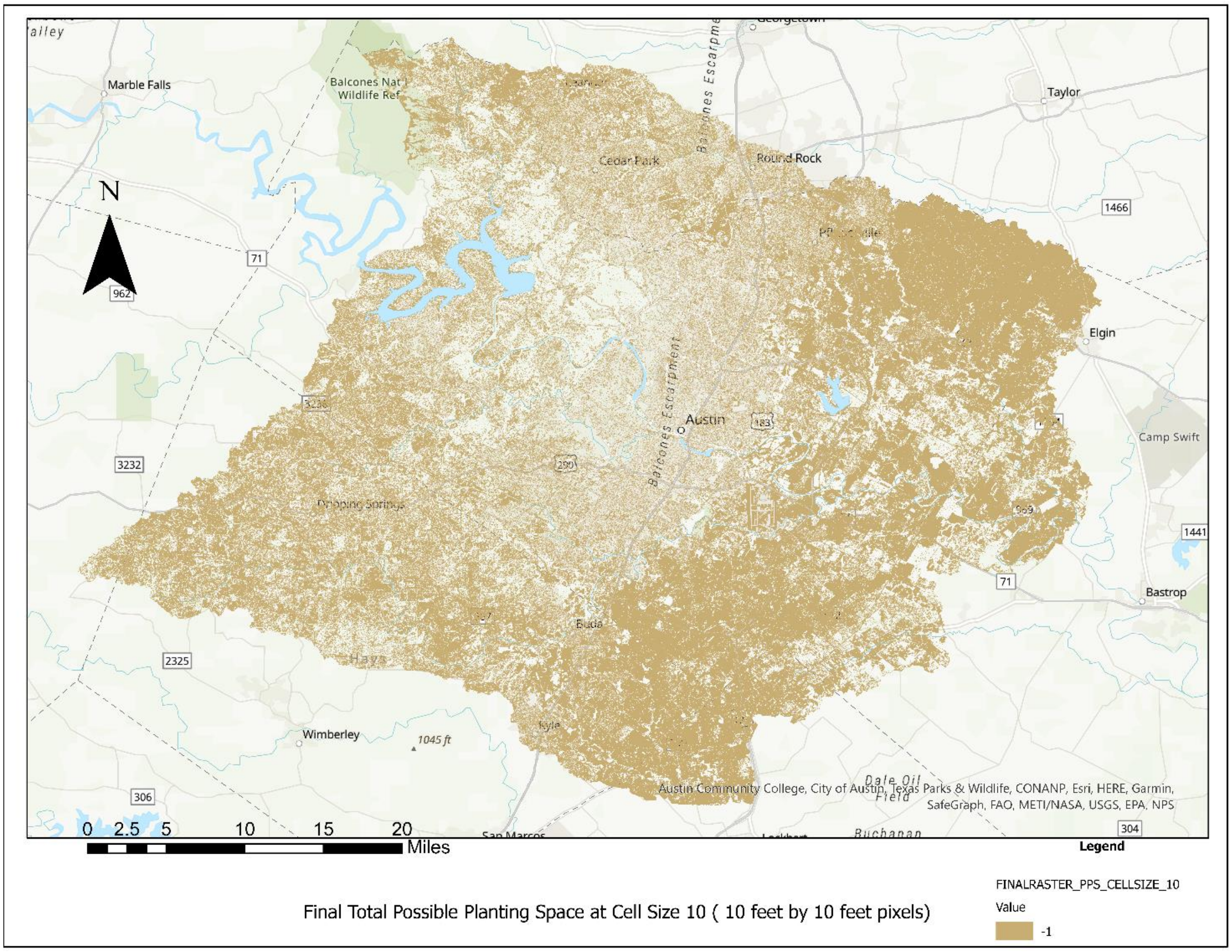


Figure 5. Total Possible Planting Space Raster

Figure 5 denotes the end result of raster calculation subtractions from respective rasters of erasures from the Full Watershed Regulation Area file of the following: Impervious Layer 2021, Tree Canopy 2022, and Surface Water.

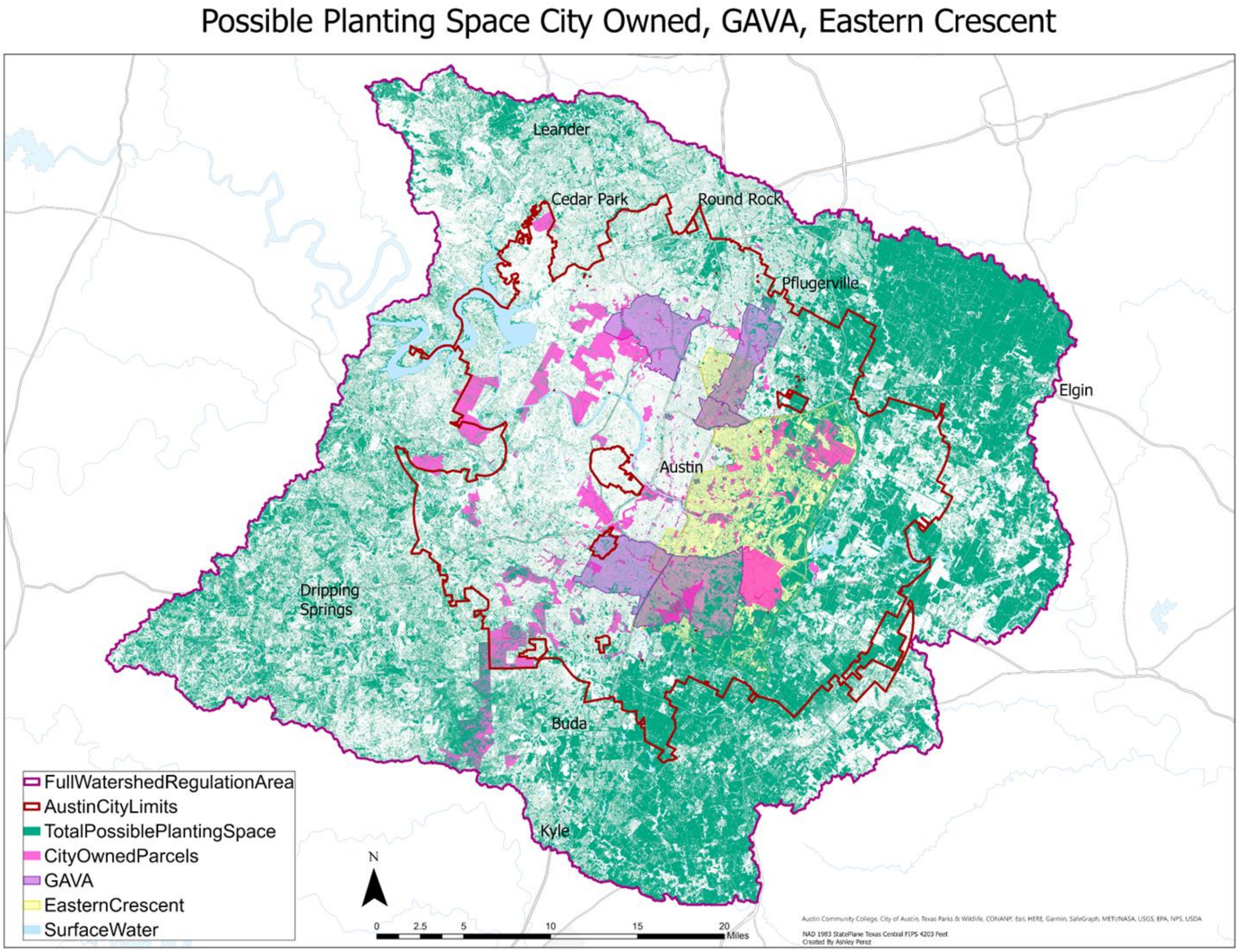


Figure 6 Possible Planting Space, Featuring City Owned Parcels, GAVA, Eastern Crescent

Figure 6 exposes the possible planting space in all of the focus areas. There seem to be some good overlapping areas that have all or multiple of the areas of interest. These areas should be evaluated more closely to determine if immediate planting is feasible.

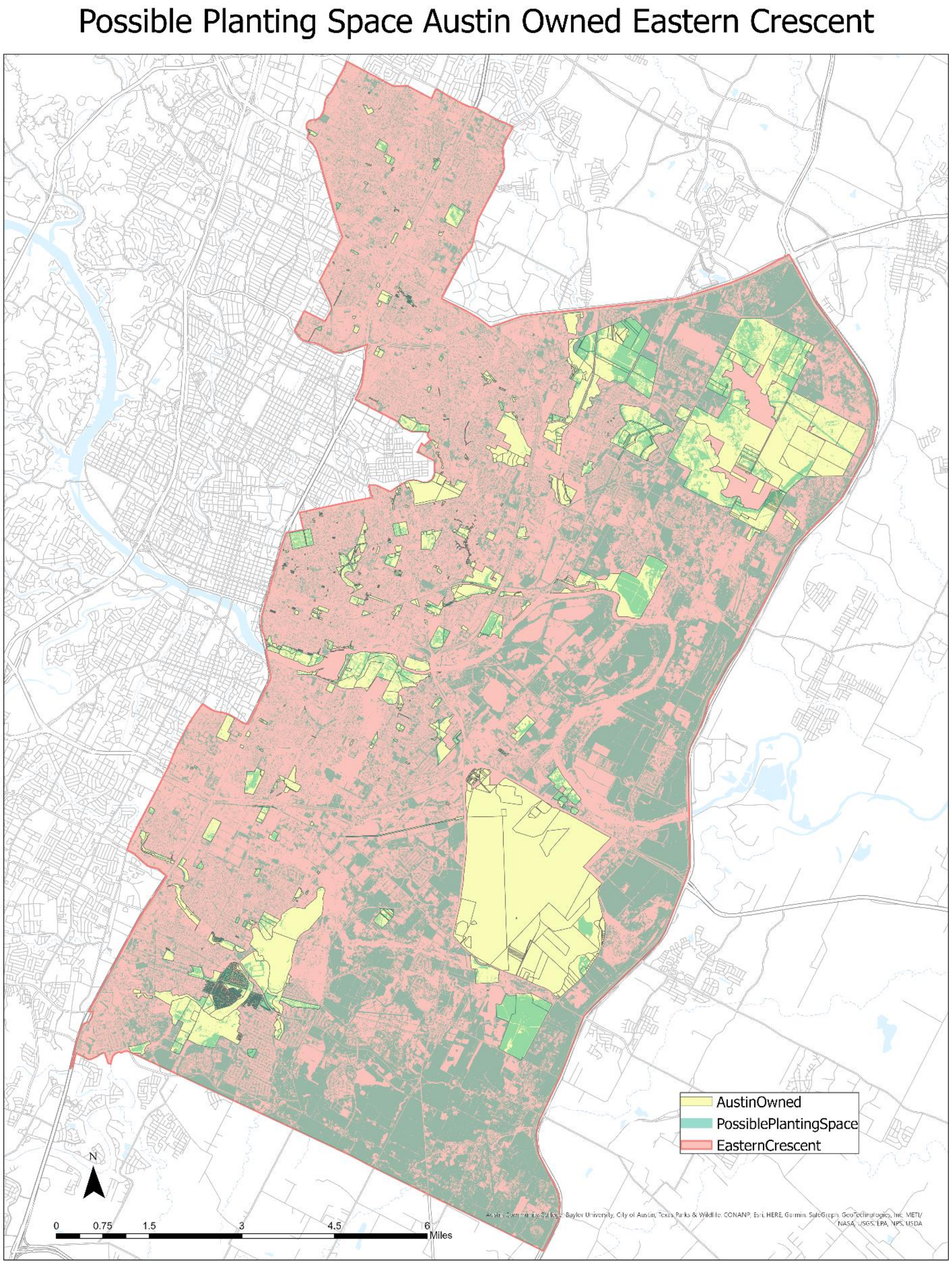


Figure 7. Possible Planting Space Austin Owned Eastern Crescent

Figure 7 shows possible planting in the Eastern Crescent and Austin owned. This is an important focus area with many underserved plantable areas.

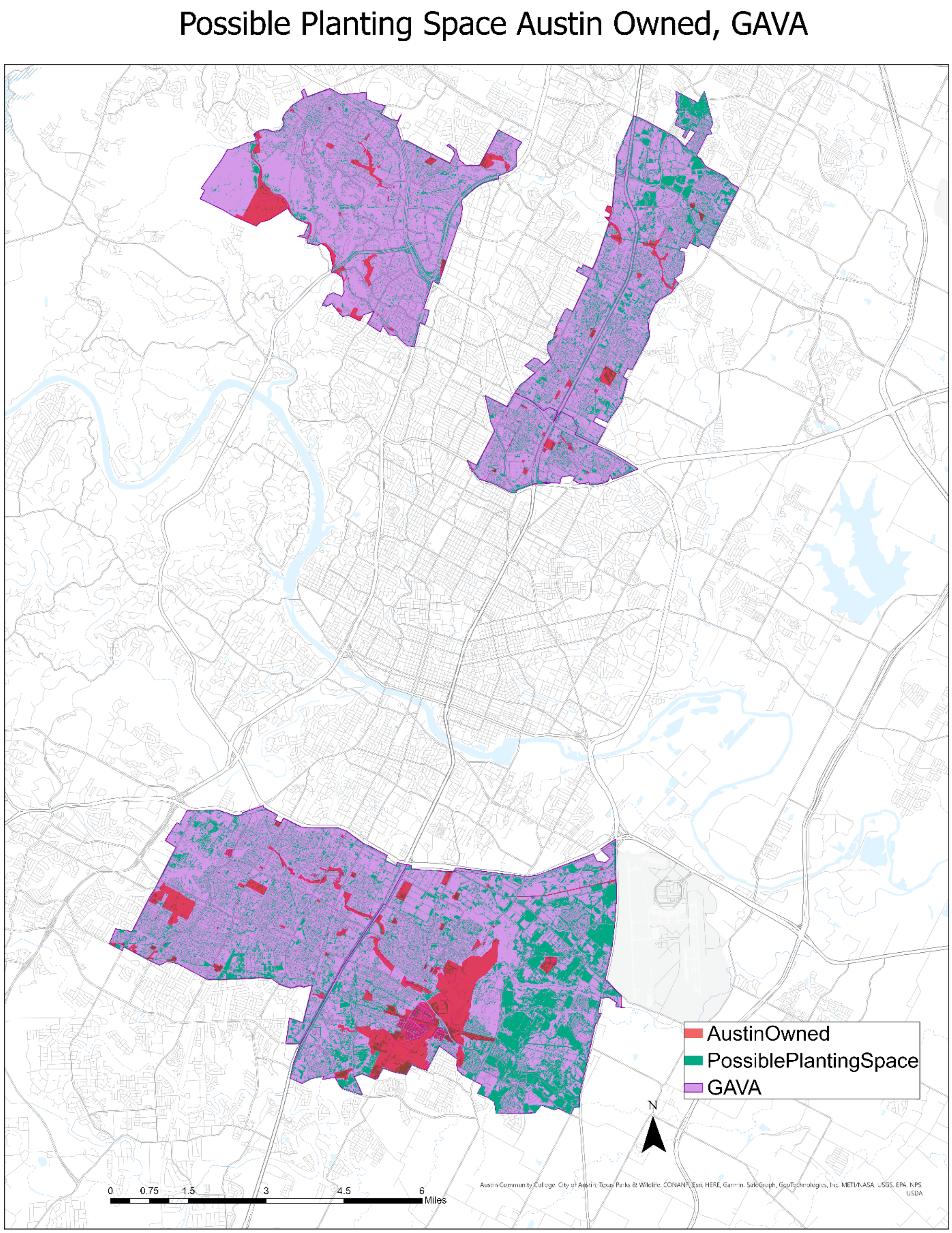


Figure 8. Possible Planting Space Austin Owned GAVA

Figure 8 examines the possible planting space in GAVA that is Austin owned. The GAVA communities are underserved and would benefit from more tree canopy.

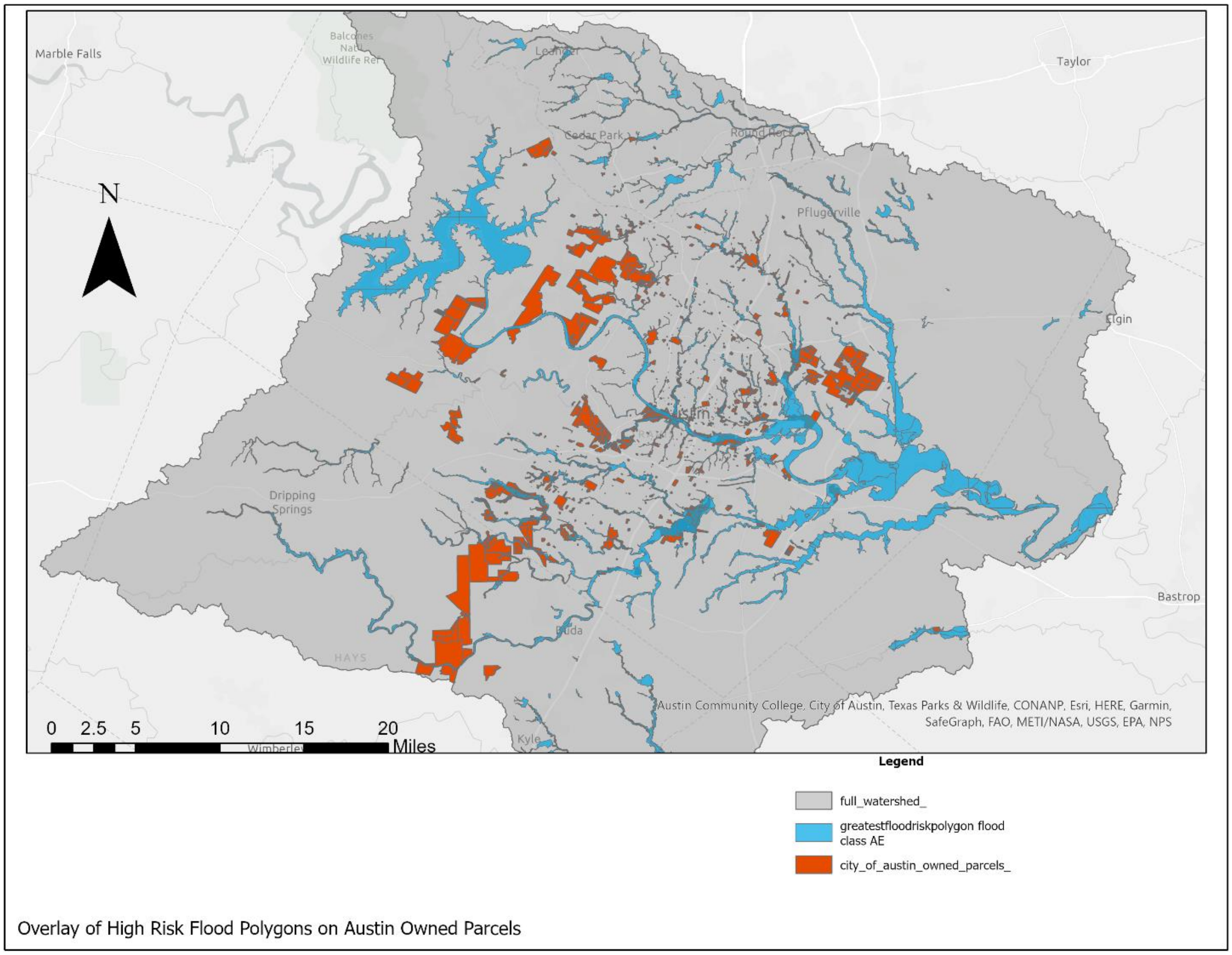
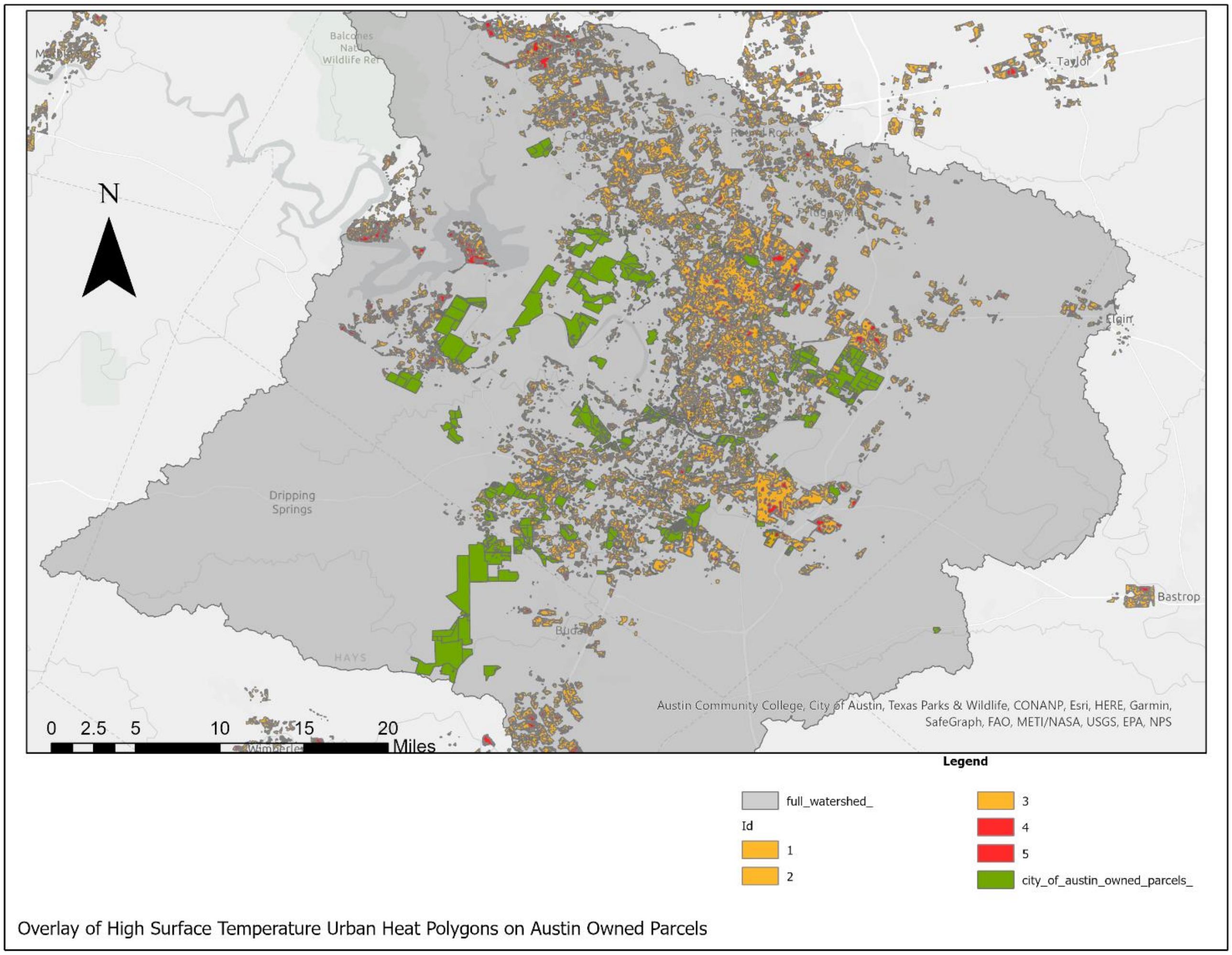


Figure 9 – Flood Risk Map

Figure 9 details the high risk flood zones that are present in the Austin Watershed. The relationship is denoted on how public parcels are upon or near these flood zones.



Overlay of High Surface Temperature Urban Heat Polygons on Austin Owned Parcels

Figure 10 High Urban Heat Risk Map.

Figure 10 displays five classes of increasing heat that was converted from a raster to a polygon. It was using this relationship that the team placed higher scores for classes 4 and 5 and lower scores for classes 1 through 3.

PROPERTY name	GENERAL land mgmt	SPEC land mgmt	Address	PPS sum area sq ft	PPS %	GAVA	East Austin	Flood risk	Heat risk	PPS area/PPS area of best parcel	PPS present	Score	PPS %	Total Parcel Shape area SQ ft
Barton springs clean drinking wtr-may98prop2_wqpl	Conservation	Water quality protection land	4410 bliss spillar road	46152154	61	0	0	1	0	100	1	525	61	75763888
Landfill site	Facility		10108 FM 812 rd.	11710089	92	0	1	1	2	25	1	500	92	12791794
	Utility			45305519	69	0	0	0	0	98	1	490	69	65328611
Gustavo "gus" L. Garcia district park	Park	Mixed	1201 E rundberg ln.	856853	41	1	1	1	2	2	1	485	41	2078581
Bergstrom RR spur	Other			433608	63	1	1	1	2	1	1	480	63	689252
Onion creek soccer complex	Park	Special use	5600 E william cannon dr.	975567	22	1	1	2	1	2	1	460	22	4519813
T.A. Brown school park	Park	Active use	520 northway dr.	55927	56	1	1	0	2	0	1	450	56	100022
Dedicated drainage ditch	Unknown	Unknown		140	1	1	1	2	1	0	1	450	1	25567
Salt springs neighborhood park	Park	Natural area	6401 E william cannon dr.	230441	100	1	1	2	1	0	1	450	100	231504
Salt springs neighborhood park	Park	Natural area	6400 spring fever trl.	8662	97	1	1	2	1	0	1	450	97	8906
	Other	Undefined	7309 N IH 35 svrd NB	4462	2	1	1	0	2	0	1	450	2	231407

Salt springs neighborhood park	Park	Natural area	6401 E william cannon dr.	24418	100	1	1	2	1	0	1	450	100	24448
St. John's pocket park	Park	Special use	889 wilks ave.	24960	66	1	1	0	2	0	1	450	66	37629

Figure 11 : Highest Scoring City of Austin Owned Parcels

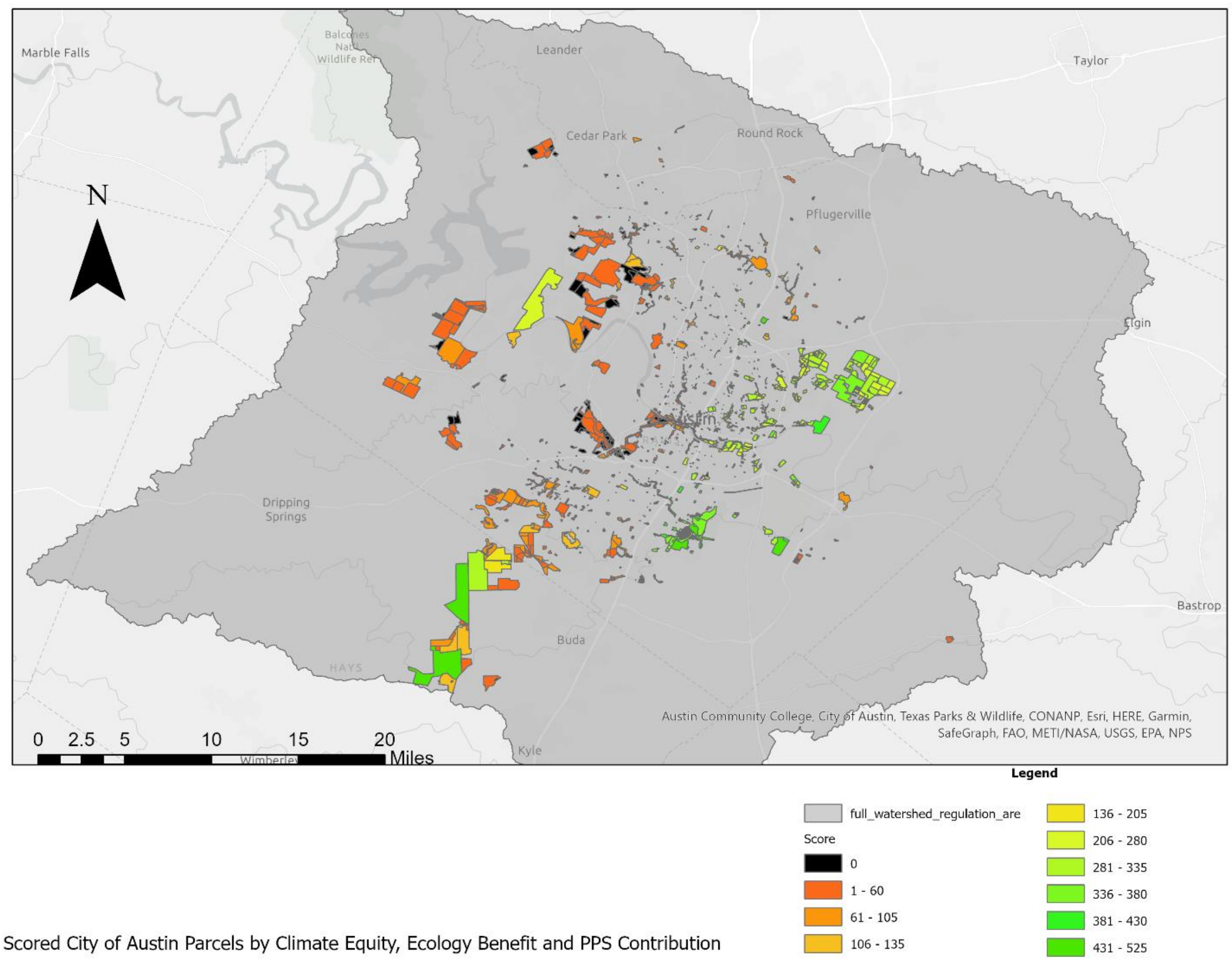


Figure 12 Scored Parcels

Figure 12 denotes Austin Public Parcels within the Full Watershed Regulation Area when scored by Treecon's methodology. 0 Score parcels denote that no PPS is contributable from that parcel.

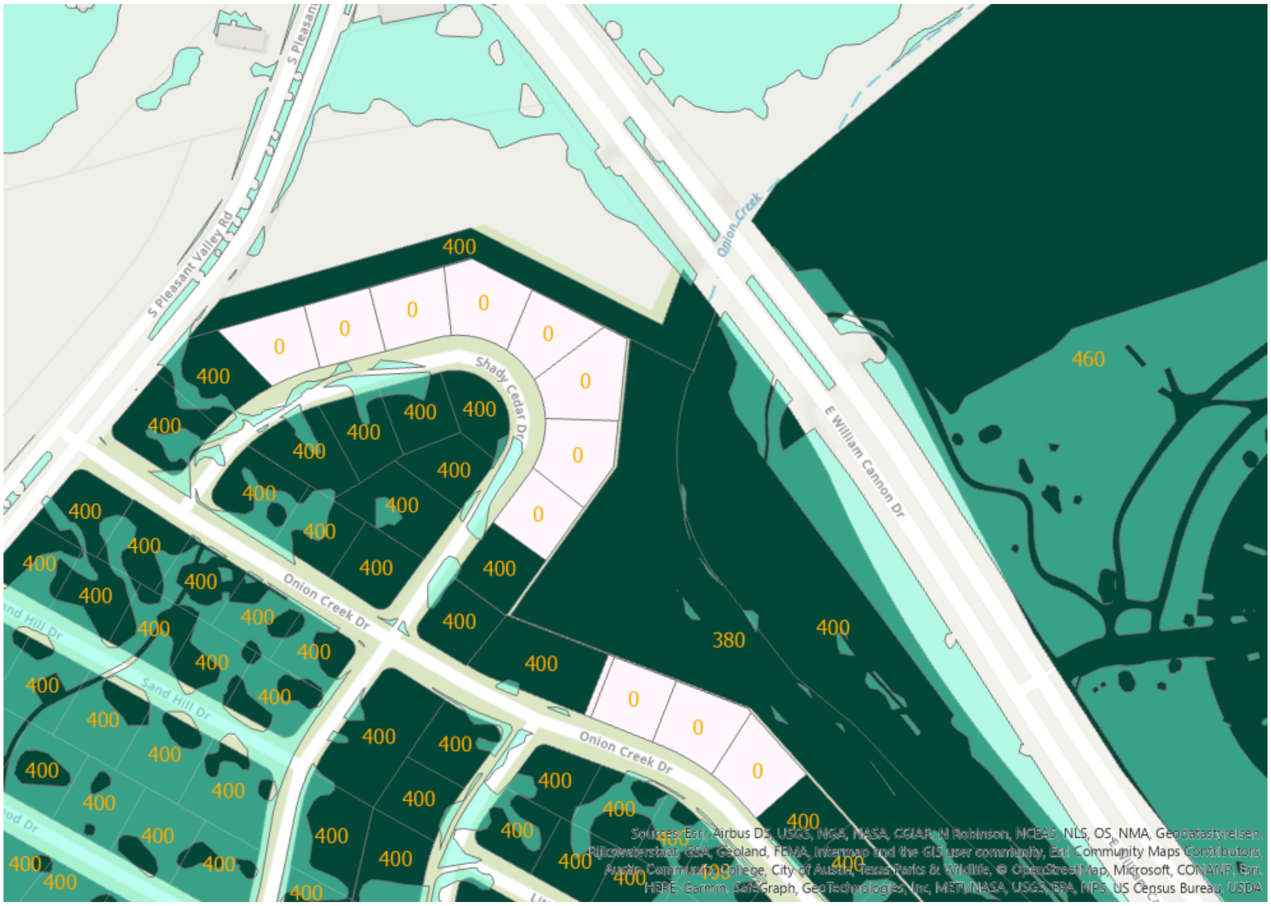


Figure 13 : Ground images of COA owned scored parcels

Figure 13 displays the Scores of COA owned parcels. We can see both high scores at 400 and 0 scores. This area off of East William Cannon Drive is both within the GAVA, and East Austin boundaries, allowing the scores to be high, if PPS is present in the parcel. We can see that the parcels in white scored 0 have no possible planting space.

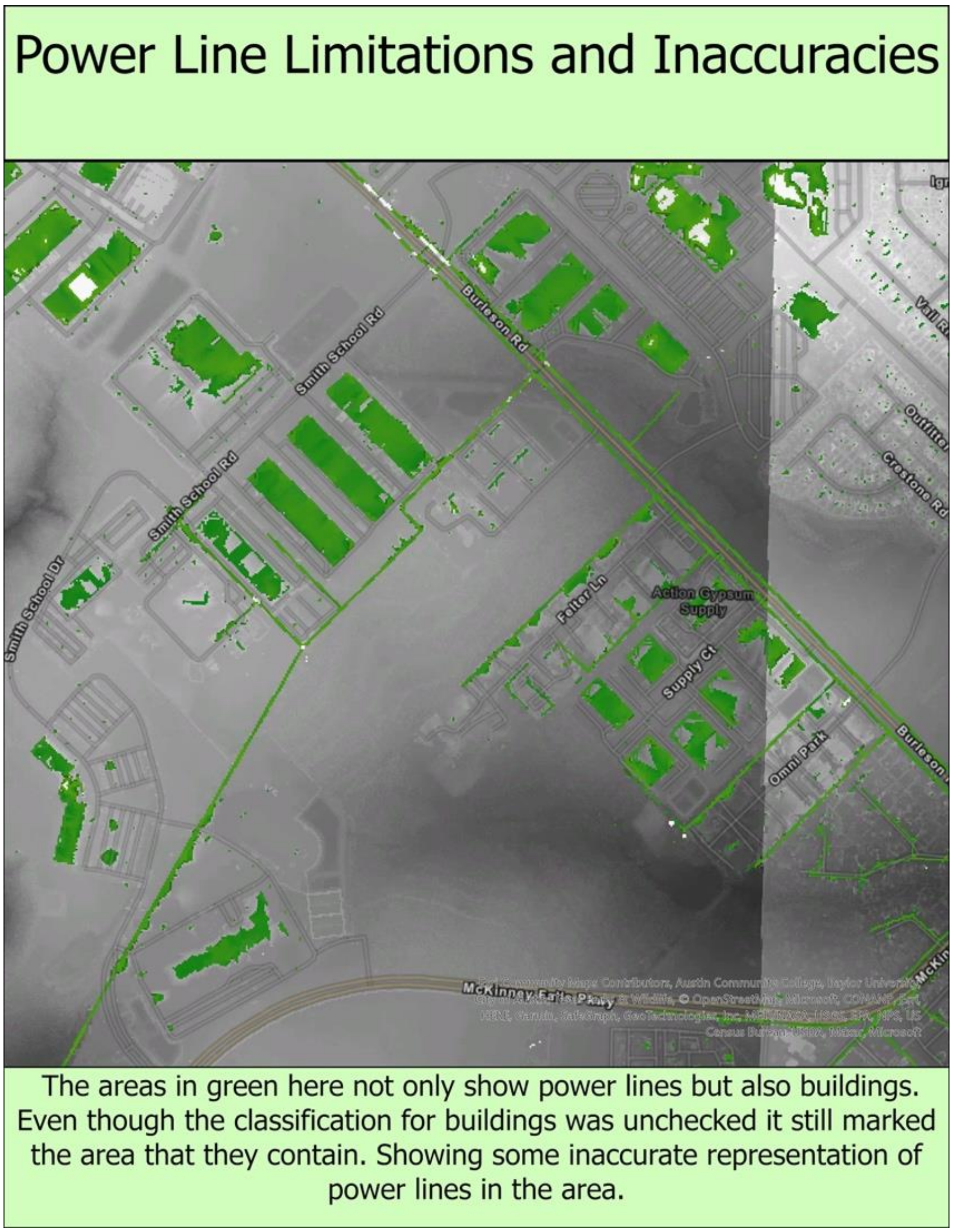


Figure 14. Power Line Limitations and Inaccuracies

Figure 14 establishes the errors that occurred while classifying the LiDAR.

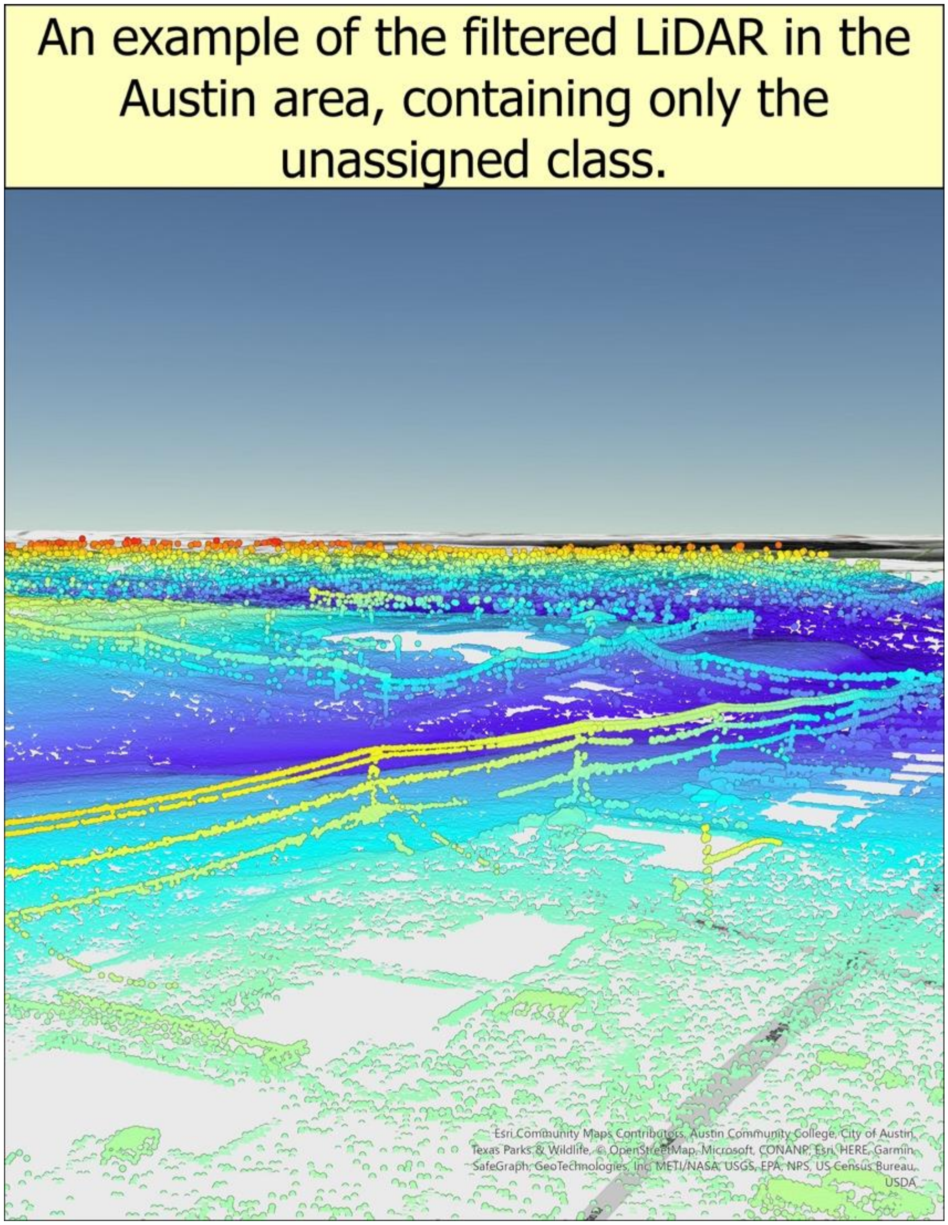


Figure 15. Filtered LiDAR data showing power lines

Figure 15 does show the points that are unassigned, after calculating they show the power lines elevations in the area.

5. CONCLUSIONS

The team was able to meet the goals laid out by the client. Expected deliverables of a possible planting space layer in both raster and vector formats were developed in high fidelity. The spreadsheet that ranks Austin owned parcels has been completed and provided to clients and is fully adjustable for their own purposes. Calculations of PPS to gain should public parcels be 100% utilized have been completed.

The team learned that results are as expected from knowledge of where potential planting space is. It was already known that the majority of PPS was in the eastern half of the watershed and this fit well with the computed PPS for 2022. So far there has been an increase in tree canopy percentage as denoted in our results and marks a substantial increase for the full watershed that will hopefully end in Austin reaching its tree canopy goals by mid-century.

The team was satisfied with how PPS was computed to both raster and vector outputs but was disappointed in the inability to complete a raster weighted overlay. The score system based on field attribute manipulation is likely more customizable than a weighted overlay. Ultimately the score was subjective based on how much score modifiers the team believed were important to the City of Austin's goals. The team would have liked to create a more in depth analysis of scoring but unfortunately no more time was available, and so hopes that the client or next team will be able to use the field table to produce a more mature score system.

For future analysis, LiDAR was identified as a potential system of rectification on public parcels. This would be very time intensive and require manual analyst decisions and processing to define how to make a surface polygon/polyline out of the LiDAR point cloud. Although we were unable to conduct this analysis, it is the team's opinion that LiDAR analysis would be of great benefit to the City of Austin's public right of way data.

Looking forward, the project provided at least gives a form of production of PPS in both raster and vector at high fidelity. Utilization of that PPS can be subject to almost any spatial analysis that a GIS user wants to accomplish. The team believes that the field score spreadsheet tied to the file "city_of _owned_parcels_scores_spreadsheet" is a demonstration of how flexible the requirements of this project are. The only regret is that the team was unable to produce a web map application that allowed one to both check scored parcels and manipulate the scoring system.

Identifying issues with tree canopy in an ever-growing city like Austin will be a problem if not addressed. While trees are being planted, there are trees and forests being cleared for residential and commercial properties at the same time. With urbanization comes adaptation, the need to plant trees accordingly and accurately to fit the environment ecologically and equitably will be a common task to tackle. Along with climate change, the importance of proper planting is key to keep a city like Austin like Austin and not like the concrete jungle of Houston or Dallas.

6. REFERENCES

Adobe Creative Cloud Plans, pricing, and membership. (n.d.). Retrieved February 20, 2023, from https://www.adobe.com/creativecloud/plans.html

ArcGIS pro pricing. Buy Now. (n.d.). Retrieved February 20, 2023, from https://www.esri.com/en-us/arcgis/products/arcgis-pro/buy

Bravo-Bello, J. C., Martinez-Trinidad, T., Valdez-Lazalde, J. R., Romero-Sanchez, M. E., & Martinez-Trinidad, S. (2020). Analyzing Potential Tree-Planting Sites and Tree Coverage in Mexico City Using Satellite Imagery. *Forests*, *11*(4). https://doi - org.libproxy.txstate.edu/10.3390/f11040423

Burghardt, K. T., Avolio, M. L., Locke, D. H., Grove, J. M., Sonti, N. F., & Swan, C. M. (2023). Current street tree communities reflect race-based housing policy and modern attempts to remedy environmental injustice. *Ecology*, *104*(2), 1–11. https://doi - org.libproxy.txstate.edu/10.1002/ecy.3881

Compare all Microsoft 365 plans. Microsoft. (n.d.). Retrieved February 20, 2023, from https://www.microsoft.com/en-us/microsoft-365/business/compare-all-microsoft-365-business-products-b?&ef_id=EAIaIQobChMIis7K2oWb_QIV5hXUAR3erwQqEAAYASAAEgL3uPD_BwE%3AG%3As&OCID=AIDcmm409lj8ne_SEM_EAIaIQobChMIis7K2oWb_QIV5hXUAR3erw

QqEAAYASAAEgL3uPD_BwE%3AG%3As&lnkd=Google_O365SMB_Brand&gclid=EAIaIQobChMIis7K2oWb_QIV5hXUAR3erwQqEAAYASAAEgL3uPD_BwE

Kondo, M. C., McIntire, R. K., Bilal, U., & Schinasi, L. H. (2022). Reduction in socioeconomic inequalities in self-reported mental health conditions with increasing greenspace exposure. *Health and Place*, *78*. https://doi -org.libproxy.txstate.edu/10.1016/j.healthplace.2022.102908

Fletcher, D.H.; Garrett, J.K.; Thomas, A.; Fitch, A.; Cryle, P.; Shilton, S.; Jones, L. Location, Location, Location: Modelling of Noise Mitigation by Urban Woodland Shows the Benefit of Targeted Tree Planting in Cities. Sustainability 2022, 14, 7079. https://doi.org/10.3390/su14127079

Lin, J., Wang, Q., & Li, X. (2021). Socioeconomic and spatial inequalities of street tree abundance, species diversity, and size structure in New York City. *Landscape and Urban Planning*, *206*. https://doi -org.libproxy.txstate.edu/10.1016/j.landurbplan.2020.103992

Raciti, S.; Galvin, M. F.; Grove, J. M.; O'Neil-Dunne, J. P. M.; Todd, A.; Clagett, S. 2006. Urban Tree Canopy Goal Setting: A Guide for Chesapeake Bay Communities, United States Department of Agriculture, Forest Service, Northeastern State & Private Forestry, Chesapeake Bay Program Office, Annapolis, Md.

Salary.com, S. built by: (n.d.). *GIS manager salary in Austin, TX*. Salary.com. Retrieved February 20, 2023, from https://www.salary.com/research/salary/benchmark/gis-manager-salary/austin-tx

Salary.com, S. built by: (n.d.). *GIS technician/analyst I salary*. Salary.com. Retrieved February 20, 2023, from https://www.salary.com/research/salary/alternate/gis-technician-analyst-i-salary

Salary.com, S. built by: (n.d.). *Webmaster I salary*. Salary.com. Retrieved February 20, 2023, from https://www.salary.com/research/salary/alternate/webmaster-i-salary

Speak, A. F., Montagnani, L., Solly, H., Wellstein, C., & Zerbe, S. (2021). The impact of different tree planting strategies on ecosystem services and disservices in the piazzas of a northern Italian city. *Urban Ecosystems*, 1–12. https://doi -org.libproxy.txstate.edu/10.1007/s11252-021-01158-8

U.S. Department of Agriculture, Forest Service. 2019. Urban tree canopy assessment: a community's path to understanding and managing the urban forest. FS–1121. Washington, DC. 16 p.

Wang, J., Zhou, W., & Jiao, M. (2022). Location matters: Planting urban trees in the right places improves cooling. *Frontiers in Ecology and the Environment*, *20*(3), 147–151. https://doi.org/10.1002/fee.2455

Werbin ZR, Heidari L, Buckley S, Brochu P, Butler LJ, Connolly C, et al. (2020) A tree - planting decision support tool for urban heat mitigation. PLoS ONE 15(10): e0224959. https://doi.org/10.1371/journal.pone.0224959

APPENDIX I.

Griffin Moore (GIS Analyst)

- Score analysis
- Spreadsheet deliverable
- Report contributions
- Poster/presentation power points
- Maps produced
- GIS layers produced
    - city_of_austin_owned_parcels_scores_spreadsheet

- Total_PPS_HotSpots
- Total_PPS_OptimizedHotSpotAnalysis

Ashley Perez (GIS Analyst)

- Research
- GIS Troubleshooting errors
- Vector Computation of Possible Planting Space, City Owned Possible Planting Space, GAVA Possible Planting Space, Eastern Crescent Possible Planting Space
- Contributions to poster: design creation
- Contributions to presentation PowerPoint: design creation
- Report contributions in data, methods, results, editing
- Maps produced: Total Study Area: Austin Full Watershed Regulation Area; Possible Planting Space City Owned, GAVA, Eastern Crescent; Possible Planting Space Austin Owned Eastern Crescent; Possible Planting Space Austin Owned, GAVA
- Art produced: Treecon logo, photographs

Thomas Shively (GIS Analyst)

- Writer/Editor
    - Primary publication researcher. Literature Review.
    - Introduction writer on all reports.
    - Lead writer on Progress and Final Report.
    - Organized the compositions of all written reports.
- Raster Computation of Possible Planting space analysis in both cell sizes 10x10 ft and 1 x 1 ft. Methodology and discussion of raster operations.
- Assisted Griffin with suitability score analysis, justification and methodology.
- Presentation and poster contributions:
    - Assisted Ashley in presentation organization.
    - Primary background researcher.
    - Limitations and issues of Raster analysis and production.

- Bibliography.
- Challenges of progress report presentation analysis.

- Maps produced
  - Raster PPS maps at both cell size 10 and cell size 1.
  - Thematic maps of initial data for proposal presentation.
  - Thematic map of scored parcels.
  - Thematic map of flood risk and heat risk

Joseph van Smirren (GIS Analyst)

- Creation of written Metadata files
- LiDAR: Overall LiDAR computation from TNRIS and analysis for goal of finding power line pathways
- Presentation: LiDAR error, Conclusion
- Poster contributions:
- Report contributions: LiDAR limitations, Conclusion, Data, Metadata
- Maps produced: LiDAR of Austin area, assistance to Griffin and Tom's thematic maps.
- Assisted aide for Tom and Griffin in researching and problem solving.
- Created budget and timetable for initial presentation.

APPENDIX II. METADATA

Table. 2

Filename	**Metadata Description**
ABIA_Not_Plantable_Metadata.html	Area that contained unplantable space near airport.
Austin_City_Limits_Metadata.html	Area that contains the City of Austin.
City_of_Austin_Owned_Parcels.html	Area that contains land the city owns such as public parks.
Eastern_Crescent_Boundary.html	Area that contains East Austin, the surrounding housing area east of Interstate-35.

Full_Watershed_Regulation_Area.html	Areas that contain water that flow into a watershed area in the area Austin.
Impervious_Cover_Metadata.html	Areas that contain impervious cover like houses in the city of Austin.
GAVA_Zip_Codes_Metadata.html	Area that contains GAVA zip codes in Austin.
Tree_Canopy_2022_Metadata.html	Area that contains whole tree canopy in Austin from 2022.
Heat_Severity_2021_Metadata.html	Area that contains the heat index of each city in the United States of America
GAVA_PPS_Metadata.html	Area that contains GAVA zip codes with merged PPS layer
Eastern_Crescent_PPS_Metadata.html	Area that contains the Eastern Crescent with merged PPS layer
Total_PPS_Metadata.html	Area that contains full study area with PPS
City_of_Austin_Owned_Parcels_Scores_Spreadsheet_Metadata.html	Area that contains weighted suitability for public owned parcels.
Raster_PPS_Cell_Size_10_Metadata.html	Area that contains possible planting space in a 10x10 raster.
Floodplain_Austin_INLANDWATERS_FEMA_Metadata.html	Area that contains floodplain analysis for Austin

APPENDIX III.

Literature Research

Begin with broad definitions of what your client is looking for. Then seek out similar projects or manuals that have successfully brought about the result that the client desires. Check their methods and research considerations to then compare to your own project, and read everything the client provides.

Raster computation of total possible planting space

Raster computation is fairly straightforward. Start with the study area polygon and individual erase the impervious layer, tree canopy and surface water into 3 separate outputs. Raster to feature each of those at a selected cell size, for our purposes we chose both cell size 10 and later cell size 1 to provide the most precise fidelity. 3 raster layers are output, and one can simply run the raster calculator subtracting them from one another in sequence to display the total PPS layer in a raster format.

Vector computation of total possible planting space

It is essential to ensure that when conducting erasures for the purposes of rendering spatial data to all things "not" defined to pay attention to base data projections. One of the largest hiccups in the project was the inability for the team to erase all of the layers from the study area polygon. It was only after completion of a full cell size 1 square foot raster which took days of processing that the solution to the vector computation was in the projected coordinate system of the impervious layer of WGS (DD) 1984. This was matched to the watersheds polygon of the same coordinate system and all subsequent erasures were projected to this so that the Vector PPS layer could be completed.

Working with LiDAR.

A LiDAR breakdown. Download the stratmap images and DEM data from Texas Natural Resources Information System known as TNRIS.org. You are able to download different tiles of the Austin area. Each tile was made with different sub-tiles that were coded by letter and a number from 1-4. Add Strapmap to ArcGIS, right click the strapmap on the content tab and click properties, go the LAS Filter tab. The next step is to convert the .laz stratmap into a .las file. It is now useable to be used to calculate the heights of different features in the area. Along with being able to view the LiDAR from a 3-D view. When calculating the LAS Dataset to Raster you want to make sure to uncheck all except the *unassigned* for the filter, for the return values choose *last, first of many, single and one.* Leave the rest as is. Next is to take the LiDAR DEM file we downloaded for the tile and use the raster calculator; we are going to subtract the LAS file from the DEM .tiff file to get an accurate elevation for the features. Once you have calculated the elevation for the scene, change the symbology to the classify aid and set 8 classes. Code the classification in elevation ranging from 10, 15, 20, 25, 35, 45, and 65 feet. The classes are now shown on the map for the different elevation of the features on the map. The final step is to Extract by Attributes, for this case we are going to set where the value is greater or equal to 15 but less than or equal to 45 ft, for some with more hilly elevation we chose 20 to 45 feet. Once extracted the values show a given range for the poles from 15 to 45 feet. Change the classification to discrete and view the data on the map. We estimated that power line poles are between 15 and 45 feet above the ground elevation.

Convert LAS ----> LAS Dataset to Raster -----> Raster Calc. (subtract Dem from Lidar Las layer to get height of features in the area) -------> Extract by attributes (Set parameters as greater or equal to 15 or 20 depending on location and less than or equal to 45 feet)

Choosing Suitability scores.

The Climate equity plan that Austin has initiated prioritizes both the expansion of Urban Tree Canopy as well as climate equity. The team determined that additionally an ecological factor should be considered when establishing. To provide a climate equity score, the team simply used the polygons that denoted the GAVA zip codes and the Eastern Crescent polygon. If parcels resided in those polygons then points were added to the score. These were justified based off of goals issued to us by our client. The team was free to track down an ecological aspect to tack on and so chose both flood risk and urban heat index with parcels closer or within those thematic polygons gaining more score points than those that simply intersect. The final aspect was to apply a score based on potential planting space that the parcels offer. To obtain this the team judged that the parcel that provided the most PPS would be the comparison parcel. All other parcels' PPS was divided by that area to give a score based on percent gain of PPS compared to the most prime PPS.