Trees in Urban Areas

Alix Scarborough, *Project Manager*

Melissa Keen, *GIS Analyst*

Matthew Leach, *GIS Analyst*

Chad Sydow, *GIS Analyst*

Watershed and Tree Canopy Association in Austin, TX

Final Report

Prepared by Trees in UrBan Areas

for the City of Austin

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Introduction and Problem Statement

Problem Statement

The increased amounts of impervious cover, which is the hallmark of urbanization, causes storm water runoff to flow more quickly into rivers and other bodies of water. This rapid movement of water eliminates the natural processes which remove some toxins. It also increases the chances of flooding, damages aquatic habitats, and transports urban nonpoint source pollutants directly to streams (Matteo, Randhir, and Bloniarz 2006). The City of Austin's Urban Forestry Program is interested in examining the relationship between tree canopy coverage and the surrounding environment, particularly water quality. To lay the foundations for this type of multivariate analysis, the City of Austin wanted to devise a way to calculate not only the canopy coverage upstream from an Environmental Integrity Index (EII) water quality station, but to also attempt to focus in on areas they could plant and maintain trees in the future. Trees in UrBan Areas (TUBA) was approached to undertake these tasks using geographic information system techniques. With a GIS, we could not only provide the Urban Forestry Program models into which varying temporal data could be implemented, but we had all the tools available to derive necessary data, combine varying thematic layers, and run analyses.

Literature Review

TUBA began by undertaking literature research to decide the best way to approach devising our models. Based on two separate studies conducted by Patrice Melancon and S.N. Miller, we determined to utilize an eight-cell pour point model in constructing stream networks for our study area. In Melancon's paper, which concentrated on developing a water quality model to assist in implementing better land management practices, she went into great detail on the steps she took to create a watershed network. Emphasizing the importance of filling sinks within the digital elevation model so as to maintain continuity of the modeled flow, she discussed the eight-cell pour point method to calculate flow direction as well as upstream accumulation.

Miller's 2005 paper on a simulation model called AGWA (Automated Geospatial Watershed Assessment) also utilized this model in creating input data for computing runoff. "The extraction of stream networks is to accumulate the channel source area upslope of each pixel through a network of cell-to-cell drainage path... the watershed is then further subdivided into upland and channel elements as a function of the stream network density" (Miller 6). Though worded differently, this was the same method as employed in Melancon's work.

Because both authors described in great detail the method they took and the reasoning behind it, TUBA was able to construct a model sequencing these same steps and apply it toward a digital elevation model of our study area for delineating watersheds. Though Melancon's work was based more than a decade ago via ArcView, the principles could be used in ESRI's latest edition of ArcMap through tools within the Spatial Analyst toolbox and its Hydrology tools.

The Ann Arbor Tree Canopy Assessment (2010) was coordinated between multiple government agencies and AMEC Earth Infrastructure to map the existing urban canopy and help prioritize tree planting. The deliverables included a land cover layer, a current urban tree canopy (UTC) image database and a priority tree planting database with UTC calculator. The project used a top down approach beginning with mapping land cover and over laying the categories onto census blocks, and creek sheds, then using UTC metrics to determine where it is biophysically possible to plant trees in the city's differing geographic boundaries. This was useful to TUBA because of the nature of trying to find public areas in an urban area.

The results found that the UTC in the City of Ann Arbor comprised of possible vegetation at (23.7%), other possible UTC (5.1%), and possible impervious UTC (14.6). With 67% of the UTC falling into residential and recreational lands and 16% being public right of ways the results show evidence of that the city's UTC has enough suitable areas to increase the UTC from 33% to 44% coverage. The last step was to prioritize of the areas where increasing the UTC would take place based on four factors: ability to impact energy use from shade, surrounding tree canopy, impervious area, and size. Using these factors to rank the new planting areas, researchers were able to maximize the impact of the new tree growth and determine where to plant new trees. This study aided TUBA with the method of finding the percent coverage of trees in a given watershed. This in turn would help lead to better land management practices.

Process and Goals

Having the techniques and prior research at hand, TUBA began to implement various tools and processes in ArcMap 10 in order to satisfy the Urban Forestry Program's desire for a model to determine canopy coverage in each watershed. The methods included delineating watersheds upstream from EII water quality points, then overlaying the resulting watershed with our canopy coverage layer. By calculating the amount of canopy within a watershed, we determined its percent coverage. The City of Austin is interested in future planting locations, so we also accounted for impervious structures, such as roads, and other locations where trees could not be planted. By removing these from the total area of a watershed, we then calculated the total "plantable" canopy coverage percentage. In the end, we aimed to provide a working model for the City of Austin to use with historical and future data to produce these same calculations, as well as the statistics to prioritize future plantings in each watershed.

Data

Trees in UrBan Areas needed to acquire data for this project from many different sources. The DEMs that we got for the project were from TNRIS and we needed these DEMS to mosaic them together to create one DEM that covered our entire study area. These DEMs were 10 meter resolution giving us the ability to have detailed raster data. This was imperative to our project because we needed to use the mosaicked DEM to create our flow direction, fill, and flow accumulation layers. The most important thing the mosaicked DEM was used for was to create our watersheds after we had made the other layers from it.

Another data layer we had to retrieve was the EII Water Quality points. We received this layer from the City of Austin. This layer was used to help in creation of the watersheds which the study is based around. This layer was needed because without it delineating the watersheds in relation to the water quality stations would have been impossible. We checked the quality of the points by looking against a Google Earth image and seeing it the water quality sites were actually in or next to a stream.

CAPCOG had the building footprints layer which was used to help us find the area in the watersheds that are unplantable. This mattered to our project because we needed to find the area of the watershed that actually mattered to the calculations of the area of canopy coverage. This data is needed because without it we would be giving the percent coverage of the canopy in relation to the watershed area without considering the possibility of there being areas that cannot be planted on because there is already some surface there that inhibits planting. This layer was then added together with other layers we needed to complete an unplantable layer. The layers used to create this layer included the building footprints, the transportation layer, the lakes and ponds layer, and the major lakes layer. T.U.B.A. checked the layer made from merging the previous layers for errors and there were a few areas, when compared to aerial photography, which did match our layer. T.U.B.A. then proceeded to take the layer and edit it to match the real world. Editing the layer was necessary to make the layer match the real world so our calculations would not be flawed.

T.U.B.A. also downloaded the Canopy layer from CAPCOG. This layer was necessary because we were looking for the percent coverage of the canopy in the watersheds. This was in Texas State Plane Central Lambert Conformal Conic projection. This allowed the area to be in square feet making calculations easier. The canopy was clipped to the watershed

T.U.B.A. used the DEM mosaic to create the fill, flow direction, and the flow accumulation layers. These layers were created by running the respective tools, the fill tool, the flow direction tool, and the flow accumulation tool. We needed these layers to create the watersheds for our study. After creating the watersheds for our study area we then proceeded to change the watersheds from raster to vector. This was done to allow us to clip the canopy to the watersheds. The watersheds were also projected into Texas State Plane Central Lambert Conformal Conic US Feet. Projecting the watershed to this projection allowed T.U.B.A. to calculate the area in square feet. Doing so made the comparison with the canopy layer easier since both layers would be in square feet.

Methods

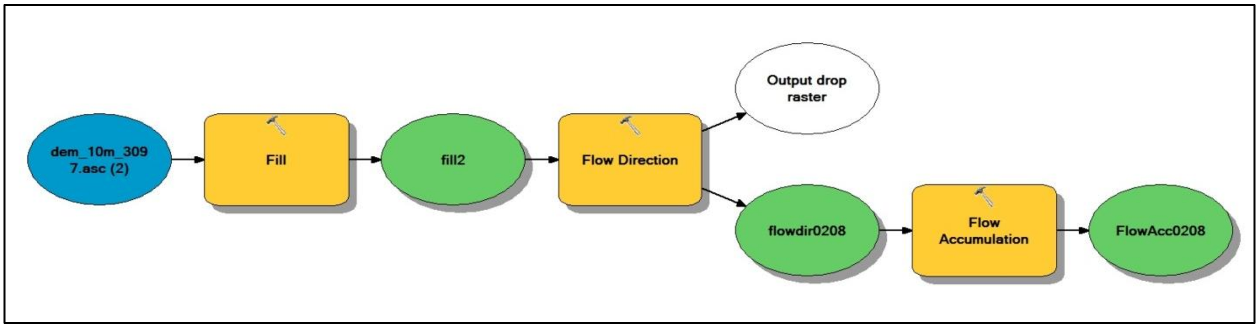
Developing DEM's

The first step involved acquiring the Digital Elevation Models (DEM), which were needed to determine flow direction to the EII stations resulting in a picture of the upstream area feeding water to the EII points. The DEMs were downloaded from the Texas Natural Resource Information System (TNRIS) website, one from the area of East Austin and one from West Austin. Both were needed to cover all the EII points and their potential watersheds. The acquired DEMs were projected onto ArcMap and to prevent gaps between rasters, we projected and mosaicked the rasters into a new DEM raster.

Hydrologic Model

Then we clipped the mosaicked raster to our scope area being the Austin watersheds. This was done to speed up processing time which was increased by eliminating areas outside our zone of study. With our raster clipped the next step was to fill it. This tool was used to remove small imperfections in the data that would impede true flow direction and accumulation. After the fill was completed, a flow-direction tool was used to create a raster of flow direction from each cell to its steepest downslope neighbor. Following the flow direction creation the flow accumulation tool was employed to produce a raster of accumulated flow into each cell, which would establish that the EII stations were in high accumulation lines (rivers, creeks, streams).

These steps of creating fill, direction, and accumulation raster's were the first part of our hydrologic model, shown in the figure below.



<u>EII Station Integrity</u>

The next phase was to use our accumulation layer to a build a stream network to established accurate flow accumulations of the EII sites. The perimeters used were any cell with 300 or more upstream cells feeding into it would be classified as a stream. These criteria were determined to fit the industry standard of being a stream. Next we introduced the EII station points, which are water quality reading stations along streams and rivers in the City of Austin. This data was provided by the City of Austin Parks Department in the form of a points shape file. This file includes 121 points with location and water quality information. We projected these points and after seeing that all the sites were in fact on real world stream locations next we moved on to building the watersheds. We placed all the EII points into their own geodatabase so as to run an iterator using the object ID; this would produce an outcome of a shape file for each individual point. We were forced to split the points into their own shape files because ArcMap wouldn't run delineations of different points within the same shape files. With the EII points in an individual geodatabase and split into different shape files we could then use the individual points to delineate watersheds.

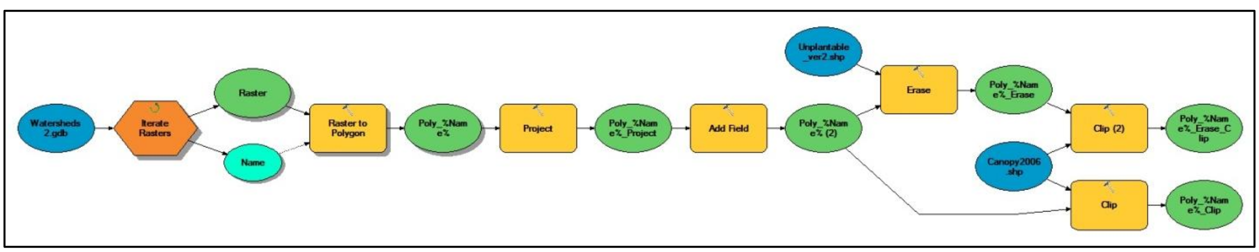
Building Watersheds

We proceeded then to use the iterator feature class tool with our point's geodatabase to build watersheds based on the object IDs of our points. Each point file was made in order of there object ID with the output being a raster for each delineated EII point watershed sent to there own geodatabase. The watershed tool was used to show the contributing area of drainage above each EII station point. The watershed delineations were successful because the drainage was visualized into each watershed raster. The EII point watersheds were then entered into a iterate raster tool. This tool ran through the geodatabase and converted all of the raster watersheds to polygons to help with our future analysis of the tree canopy and unplantable layers.

Tree Canopy Overlay

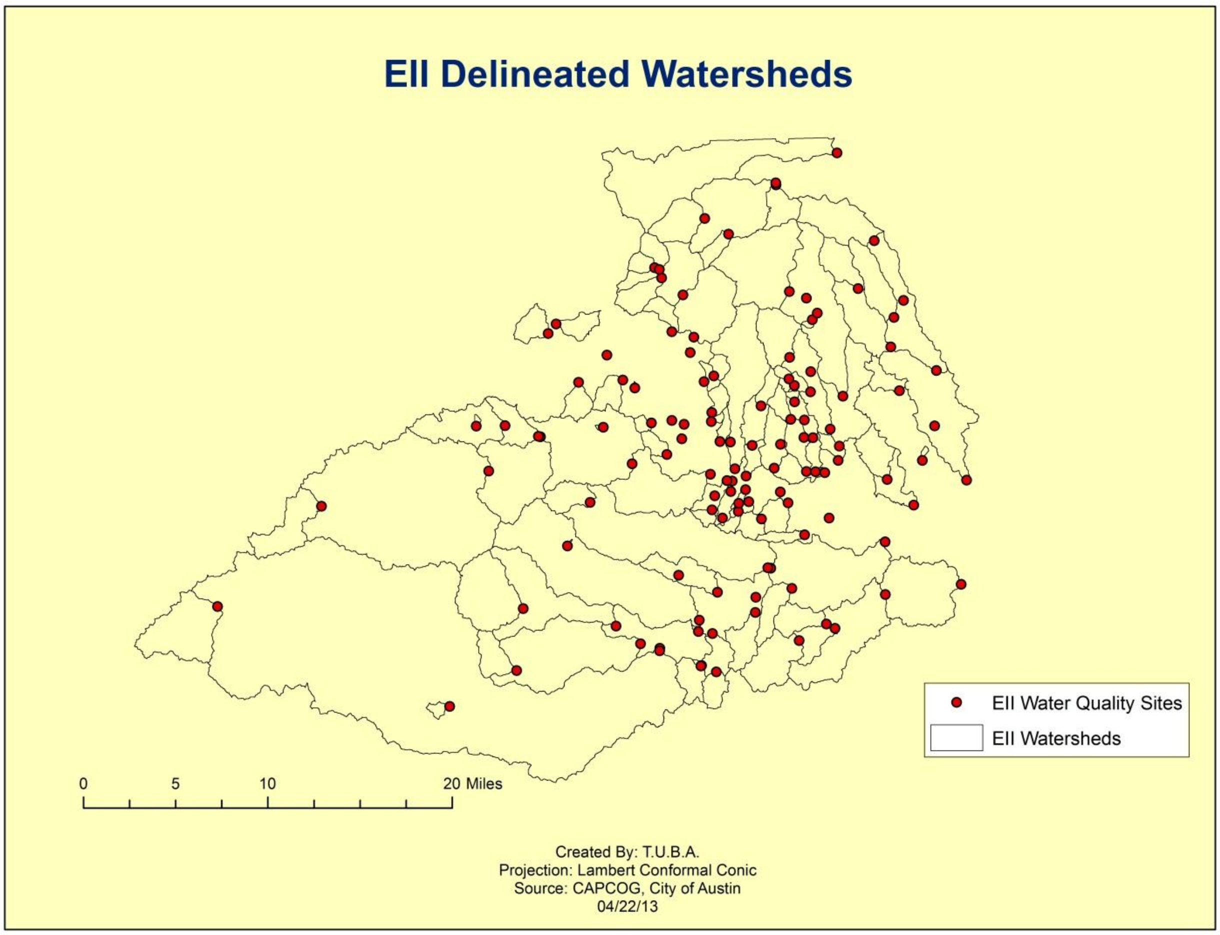
Following that we re-projected the watershed polygons to Texas State Plane Lambert Conformal Conic so they could be more easily measured in square feet. Then a new field was added to the watersheds attribute tables to consolidate watersheds that had multiple polygons per watershed. This new field made it possible to dissolve the multiple polygons within a watershed into one polygon. Next the polygon watersheds were merged together to make one shape file with all 121 watersheds. This was done to cut down on processing speed and ease the data interpretation allowing us to open one shape file instead of 122. Next we projected the City of Austin 2006 canopy layer to determine canopy coverage of each watershed. This data was acquired from the City of Austin GIS Department website and has the entire 2006 tree canopy in Austin. This could be used to determine the canopy coverage of our delineated watersheds. Then with our single watershed shape file we used the iterate feature selection tool with the point name and canopy layer to perform a clip of the canopy from the watershed layer. The result being a canopy clip shape file for all our watersheds into there own geodatabase. With the canopy clip shape files we could then calculate geometry canopy area using each files attribute table.

Next using the attribute table in each watershed polygon determined area. With these two numbers we divided the clip tree canopy area by the watershed polygon area, multiplied by a hundred and got canopy coverage in the each watershed. With the canopy percentage determined we then returned to the geodatabase containing all the EII watershed polygons and projected an unplantable layer to determine percentage coverage of area in each watershed that trees can't be planted (specifically imperious surfaces and bodies of water). This file made by merging city building layers, road and parking lot shape files and bodies of waters which were acquired from the City of Austin.



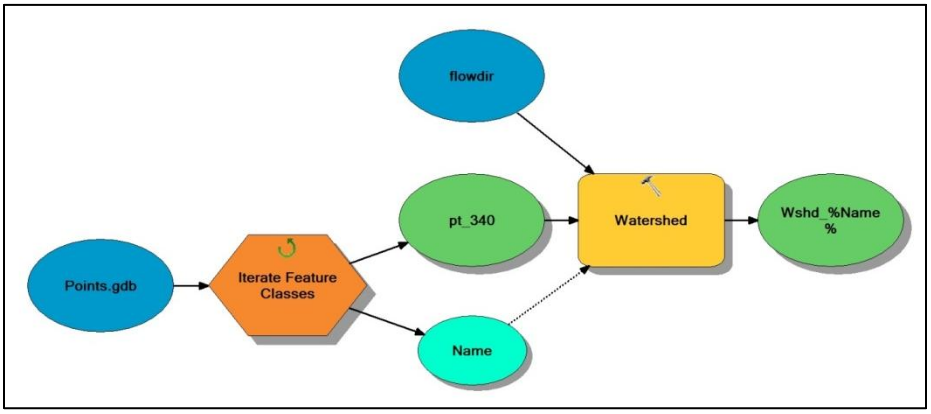
Erasing Unplantable Layer

After merging these files imperfections in the unplantable layer were filtered out by confirming accuracy with Google Earth. Next an erase of the unplantable was performed on the EII watersheds resulting in the unplantable areas being eliminated from our watersheds. With the these areas erased from our watershed a dissolve was performed the based on the point names. This tool was used to consolidate the erase output which build over 234 polygons. This dissolve function put the polygons back together based on their point names giving a correct account of the area for each erased watershed. After the watersheds were dissolved the size of the plant able area could be determined by dividing the area of the original watershed by the area of the erased watershed, then multiplying the result by one hundred to get percentage coverage. With canopy coverage and plantable area percentages determined for each EII watershed, we have provided a tool to analyze water quality in Austin.

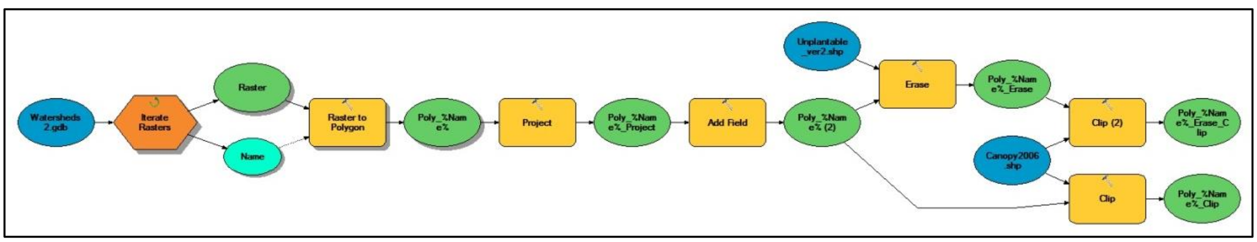


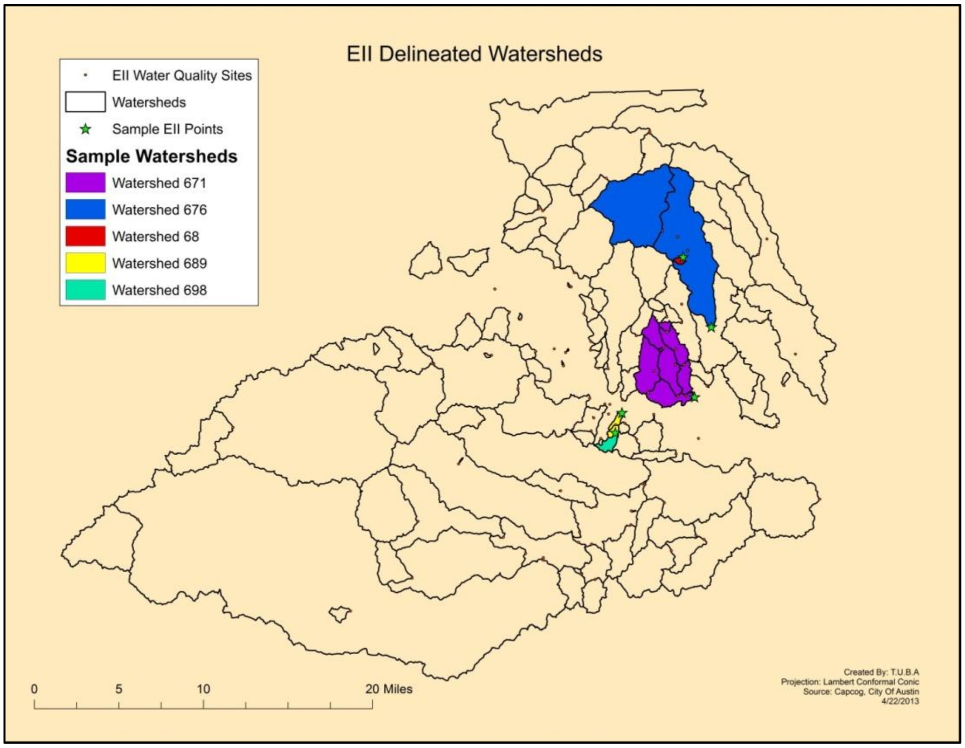
Results

After retrieving all of the data required for this study T.U.B.A proceeded to use a model to create the watersheds from our flow direction layer and the EII water quality points.

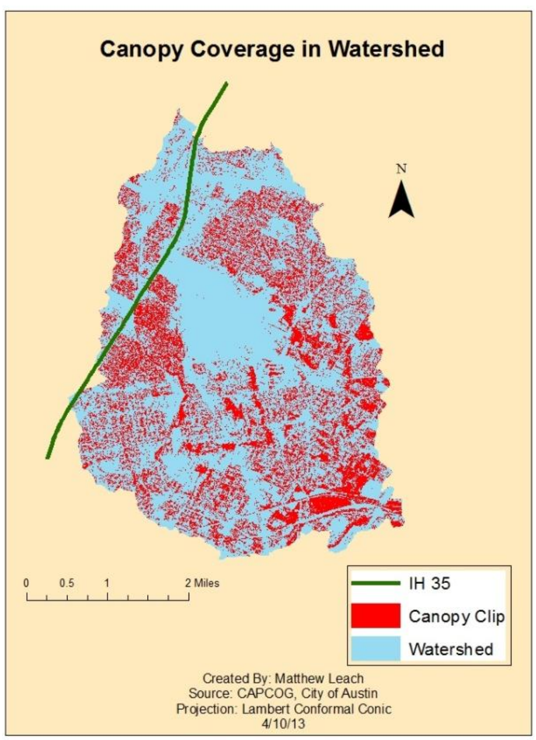


After the watersheds were created and projected we then clipped the canopy layer to the watersheds and the plantable watershed layers.





These layers helped Trees in UrBan Areas to find the percent coverage of the canopy in each watershed.



For a comprehensive list of the results from this study, see Appendix I. This table shows the area of the watersheds in square feet and also the area of the canopy in square feet for each watershed. There are also columns for the percent coverage of the watershed, percent coverage of the plantable watershed, percent of the watershed which is plantable, and percent of the watershed which is unplantable.

Discussion

This project has successfully created a model for watershed delineation from a collection of points. In addition, we have developed a method to calculate percentage of tree canopy coverage within a delineated watershed. The first purpose of this project was to create watersheds and calculate canopy for the data given to us by the client. The results of this task were presented in the previous section.

The secondary purpose of this project was to develop a methodology enabling the client to replicate and expand this project in the future. We have done this by saving our models in ModelBuilder. This ArcGIS tool allows users to easily modify models and run them on new data. The implications of this are that the client can continue to use our framework for future data and analysis. For example, we were given tree canopy data from 2006. While we expect that this has not significantly changed in the past seven years (given the scale of our study area), it is likely that at some point the City of Austin will produce an updated tree canopy layer. At this point, the Urban Forestry Program will be able to run this new data through the model to update the calculations.

Our project produced two sets of calculations – percent of canopy in watersheds, and percent of canopy in plantable watershed areas. This second calculation acknowledged the fact that trees cannot be planted on all surfaces in a watershed; therefore, the percent of canopy coverage might be a misleading figure for someone wanting to prioritize new plantings. To correct this, we removed "unplantable" surfaces from the watersheds. More detail on how this was done is available in our Methods section. What is important to note here, however, is that the unplantable surfaces we removed included polygons from the following datasets: buildings, transportation features (such as parking lots and roads), and lakes and ponds. These impervious surfaces and water bodies do not necessarily represent a comprehensive list of unplantable areas in Austin. Determining all the unplantable surfaces in Austin was beyond the scope of this project, but using our models, the client will be able to add to this list or update the previously mentioned datasets.

An unexpected issue arose in this second round of calculations. We found that some watersheds resulted in a tree canopy coverage that was greater than 100%. Since this cannot be true, we began looking for possible oversights in our methodology. Our hypothesis is that polygons in the tree canopy layer represent not only trees on the ground, but also leaves and branches that extend beyond the trees' trunks. This means that some tree canopy overhangs roads, parking lots, and lakes – all of which are features that were removed from the watershed area calculation as part of the "unplantable" layer. The next step to correct this problem could be to erase the unplantable layer from the tree canopy layer, so that unplantable areas and their occasional foliage overhang are not considered on either side of the calculation.

One unusual result we obtained from delineating the watersheds from EII points was that some watersheds were strangely small. For example, the watershed created from EII point 2 has an area of 983 square feet. It is possible that these sampling points are located at natural springs, or that they are inaccurately places. During the course of this project, we did check to ensure that all points were located on accumulation lines (where water flowing downhill accumulates). However, the EII point shapefile did not contain metadata, and we have very little information on the data quality or collection methods used for these points. In expanding on this research, it will be important to verify the accuracy of points as well as examine the specific environment and context of each sampling location.

Overall, we are pleased to have delineated 122 watersheds from 122 EII sampling points. This verifies that, despite the minor issues noted above, our methodology and model work.

Conclusions

As with any GIS task, this project has encountered unexpected challenges. However, these were all learning opportunities, and many instigated new ideas. Our group learned a lot about model builder, hydrological modeling, raster analysis, and teamwork this semester.

This project was successful in achieving its objectives in the anticipated time span. We believe it will provide the City of Austin Urban Forestry Program with a usable model for further analysis of tree canopy and other possible water quality factors.

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Appendix I: Results Charts

Point Name	Area Plantable Watershed (Sq. Ft.)	Area Full Watershed (Sq. Ft.)	Canopy Coverage Area (Sq. Ft.)	Full Watershed Percent Canopy Coverage	Plantable Watershed Percent Canopy Coverage	Percent of Watershed Which is Plantable	Percent of Watershed Which is Unplantable
Wshd_pt_101	9,077,260,663.03625	9,584,713,077.52352	3,036,432,541.51566	31.7%	33.5%	94.7%	5.3%
Wshd_pt_109	18,938,508.50357	38,025,899.95097	8,688,963.12586	22.9%	45.9%	49.8%	50.2%
Wshd_pt_1196	12,713.59621	18,698.92231	13,775.13883	73.7%	108.3%	68.0%	32.0%
Wshd_pt_1198	46,557,237.91053	72,427,849.85947	28,098,966.28396	38.8%	60.4%	64.3%	35.7%
Wshd_pt_121	269,774.93417	310,929.83335	166,621.14509	53.6%	61.8%	86.8%	13.2%
Wshd_pt_1292	675,326,943.34258	695,331,978.19674	168,504,611.74370	24.2%	25.0%	97.1%	2.9%
Wshd_pt_1293	3,545,885.59779	3,773,274.44940	2,328,975.87159	61.7%	65.7%	94.0%	6.0%
Wshd_pt_1295	637,096,511.86269	642,863,631.42022	215,688,146.00547	33.6%	33.9%	99.1%	0.9%
Wshd_pt_1297	9,128.28028	21,660.16498	3,479.27794	16.1%	38.1%	42.1%	57.9%
Wshd_pt_1315	13,951,361.80504	22,062,795.45459	7,517,853.61254	34.1%	53.9%	63.2%	36.8%
Wshd_pt_1317	2,950.72694	2,950.72694	1,122.30715	38.0%	38.0%	100.0%	0.0%
Wshd_pt_1318	1,028,302.00132	1,237,835.43322	45,273.16052	3.7%	4.4%	83.1%	16.9%
Wshd_pt_1319	5,698,494.87183	13,713,037.49632	2,117,225.46487	15.4%	37.2%	41.6%	58.4%
Wshd_pt_1363	648,892,997.77132	659,597,901.16116	246,052,078.30647	37.3%	37.9%	98.4%	1.6%
Wshd_pt_138	362.92700	984.43927	535.19262	54.4%	147.5%	36.9%	63.1%
Wshd_pt_1418	25,603,117.38268	35,584,234.99042	17,317,183.00586	48.7%	67.6%	72.0%	28.0%
Wshd_pt_1431	68,956,322.90230	146,512,558.76365	25,625,079.46953	17.5%	37.2%	47.1%	52.9%
Wshd_pt_1474	172,252,850.27445	185,895,944.19688	45,125,364.66281	24.3%	26.2%	92.7%	7.3%
Wshd_pt_1481	393,926,775.14689	509,571,693.13361	143,384,326.67669	28.1%	36.4%	77.3%	22.7%
Wshd_pt_1488	93,429,747.76604	97,411,734.37710	3,663,020.13672	3.8%	3.9%	95.9%	4.1%
Wshd_pt_1489	205,093,721.43667	211,740,168.31885	4,314,216.61873	2.0%	2.1%	96.9%	3.1%
Wshd_pt_1494	81,000,266.73342	89,935,617.79867	38,261,108.56159	42.5%	47.2%	90.1%	9.9%
Wshd_pt_1501	3,202,903,211.96616	3,338,508,287.79004	1,468,659,701.04327	44.0%	45.9%	95.9%	4.1%
Wshd_pt_1522	92,095,631.49359	92,155,069.97512	22,856,612.49125	24.8%	24.8%	99.9%	0.1%
Wshd_pt_1537	296,384,084.48588	297,933,058.39433	98,097,807.06342	32.9%	33.1%	99.5%	0.5%
Wshd_pt_1700	1,665,289.20171	2,219,159.61965	1,448,466.91873	65.3%	87.0%	75.0%	25.0%
Wshd_pt_1703	202,796,647.12233	361,673,635.86278	114,871,133.98596	31.8%	56.6%	56.1%	43.9%
Wshd_pt_1808	74,661,397.23064	80,298,590.20380	48,271,286.96659	60.1%	64.7%	93.0%	7.0%
Wshd_pt_1814	28,491,355.89138	33,735,113.62458	19,214,973.80395	57.0%	67.4%	84.5%	15.5%
Wshd_pt_1815	41,280,195.34411	51,844,050.71461	27,495,223.10573	53.0%	66.6%	79.6%	20.4%

Wshd_pt_1832	305,755,122.30232	305,755,122.30250	134,094,729.19631	43.9%	43.9%	100.0%	0.0%
Wshd_pt_1903	6,542,349,659.49558	6,592,122,429.83860	2,249,670,170.62492	34.1%	34.4%	99.2%	0.8%
Wshd_pt_1940	1,045,379,488.86850	1,487,088,706.08230	393,995,387.95751	26.5%	37.7%	70.3%	29.7%
Wshd_pt_1978	74,371,999.66876	76,844,256.61044	1,211,186.74348	1.6%	1.6%	96.8%	3.2%
Wshd_pt_2	394.72113	983.01584	229.33672	23.3%	58.1%	40.2%	59.8%
Wshd_pt_205	4,108.41059	6,900.50434	1,262.32597	18.3%	30.7%	59.5%	40.5%
Wshd_pt_206	1,037.02854	1,968.07594	1,858.87326	94.5%	179.2%	52.7%	47.3%
Wshd_pt_208	8,470.73465	8,850.59440	4,704.69231	53.2%	55.5%	95.7%	4.3%
Wshd_pt_210	61,491,870.29855	69,321,151.06591	39,030,679.30058	56.3%	63.5%	88.7%	11.3%
Wshd_pt_223	1,011,069,571.83120	1,053,642,006.19675	53,799,807.68115	5.1%	5.3%	96.0%	4.0%
Wshd_pt_224	675,528,812.04752	704,254,236.82917	23,855,007.62919	3.4%	3.5%	95.9%	4.1%
Wshd_pt_228	176,474,564.77030	183,357,926.31731	5,403,498.34032	2.9%	3.1%	96.2%	3.8%
Wshd_pt_229	247,280,766.56538	257,262,964.39527	7,717,248.22864	3.0%	3.1%	96.1%	3.9%
Wshd_pt_230	87,315,786.63379	91,974,558.45244	3,129,737.35488	3.4%	3.6%	94.9%	5.1%
Wshd_pt_232	77,197,910.92494	79,728,040.73602	1,226,004.02156	1.5%	1.6%	96.8%	3.2%
Wshd_pt_233	56,634,052.81602	58,097,616.56785	862,733.04438	1.5%	1.5%	97.5%	2.5%
Wshd_pt_234	1,289,232.32589	1,348,586.90264	1,079,356.99608	80.0%	83.7%	95.6%	4.4%
Wshd_pt_235	56,927,540.35591	62,061,941.86802	33,077,163.79885	53.3%	58.1%	91.7%	8.3%
Wshd_pt_236	51,797,713.23670	58,655,173.28076	34,082,643.81746	58.1%	65.8%	88.3%	11.7%
Wshd_pt_241	91,924,536.50668	101,065,719.56706	28,471,893.09893	28.2%	31.0%	91.0%	9.0%
Wshd_pt_243	86,862,633.15347	89,035,564.91038	5,090,979.05741	5.7%	5.9%	97.6%	2.4%
Wshd_pt_250	1,580,607.04768	1,726,896.10910	1,165,362.45003	67.5%	73.7%	91.5%	8.5%
Wshd_pt_251	335,400.34965	361,638.70108	75,783.77736	21.0%	22.6%	92.7%	7.3%
Wshd_pt_255	784,220,090.47903	913,580,461.68910	133,466,692.21121	14.6%	17.0%	85.8%	14.2%
Wshd_pt_256	150,110,562.44912	205,891,396.07919	25,007,676.73181	12.1%	16.7%	72.9%	27.1%
Wshd_pt_257	131,933,462.86911	147,069,621.68079	18,222,566.95438	12.4%	13.8%	89.7%	10.3%
Wshd_pt_259	50,603,493.41056	59,048,684.78106	4,221,675.78765	7.1%	8.3%	85.7%	14.3%
Wshd_pt_261	89,886,419.68385	106,910,479.85232	16,113,253.57111	15.1%	17.9%	84.1%	15.9%
Wshd_pt_263	255,812,322.21281	291,094,482.39456	46,593,484.70436	16.0%	18.2%	87.9%	12.1%
Wshd_pt_274	59,091,054.94033	60,179,346.13653	37,286,237.51464	62.0%	63.1%	98.2%	1.8%
Wshd_pt_278	84,974,573.30363	133,191,471.50822	46,705,011.19533	35.1%	55.0%	63.8%	36.2%
Wshd_pt_292	541,247.00071	744,424.96256	193,661.73133	26.0%	35.8%	72.7%	27.3%
Wshd_pt_302	459,600.11432	495,407.07231	139,438.56015	28.1%	30.3%	92.8%	7.2%
Wshd_pt_312	63,303,539.75010	92,733,327.02530	31,534,110.85461	34.0%	49.8%	68.3%	31.7%

Wshd_pt_317	20,212,077.48584	29,569,351.37020	14,315,228.37795	48.4%	70.8%	68.4%	31.6%
Wshd_pt_321	211,851,158.44371	219,263,793.90225	98,014,834.06874	44.7%	46.3%	96.6%	3.4%
Wshd_pt_333	46,074,165.04151	47,722,861.88236	29,384,658.77602	61.6%	63.8%	96.5%	3.5%
Wshd_pt_335	22,101,308.61720	34,349,440.05298	5,808,676.68410	16.9%	26.3%	64.3%	35.7%
Wshd_pt_339	15,206,708.52324	17,550,041.61272	10,707,173.70654	61.0%	70.4%	86.6%	13.4%
Wshd_pt_340	331,436.51191	411,342.23219	235,872.44464	57.3%	71.2%	80.6%	19.4%
Wshd_pt_341	26,850,659.05274	35,878,391.78525	18,705,551.67716	52.1%	69.7%	74.8%	25.2%
Wshd_pt_342	39,515,735.79761	52,709,439.07891	29,673,809.54947	56.3%	75.1%	75.0%	25.0%
Wshd_pt_344	14,121.21744	16,748.36200	6,147.16169	36.7%	43.5%	84.3%	15.7%
Wshd_pt_345	755,623,418.58950	851,194,561.58709	313,846,560.75266	36.9%	41.5%	88.8%	11.2%
Wshd_pt_356	855.16927	984.76965	849.53844	86.3%	99.3%	86.8%	13.2%
Wshd_pt_410	24,986,739.76335	42,525,647.92228	12,584,287.57855	29.6%	50.4%	58.8%	41.2%
Wshd_pt_425	23,344,850.40157	46,335,488.34879	8,094,371.20429	17.5%	34.7%	50.4%	49.6%
Wshd_pt_445	61,329,286.76144	94,743,982.84417	27,733,511.86520	29.3%	45.2%	64.7%	35.3%
Wshd_pt_446	8,560,220,643.30626	8,994,564,411.45158	2,976,837,631.78768	33.1%	34.8%	95.2%	4.8%
Wshd_pt_45	286,048.70181	295,369.81007	210,066.33246	71.1%	73.4%	96.8%	3.2%
Wshd_pt_453	2,465,558,583.60228	2,506,847,195.35320	992,059,721.50618	39.6%	40.2%	98.4%	1.6%
Wshd_pt_46	73,153,225.71174	111,797,162.91672	34,403,513.47372	30.8%	47.0%	65.4%	34.6%
Wshd_pt_464	62,118,469.12020	114,364,882.84984	33,696,938.14225	29.5%	54.2%	54.3%	45.7%
Wshd_pt_47	71,625,398.97619	108,651,670.03099	22,979,880.75126	21.2%	32.1%	65.9%	34.1%
Wshd_pt_497	1,070,496,064.91457	1,517,496,955.68255	404,072,518.20510	26.6%	37.7%	70.5%	29.5%
Wshd_pt_505	312,594,279.25323	360,595,137.65795	206,700,403.72022	57.3%	66.1%	86.7%	13.3%
Wshd_pt_51	75,680,586.76230	83,881,429.70397	12,396,444.03896	14.8%	16.4%	90.2%	9.8%
Wshd_pt_524	1,189,365,763.03189	1,331,947,316.45563	208,941,127.45391	15.7%	17.6%	89.3%	10.7%
Wshd_pt_528	285,909,037.27391	412,647,944.10663	110,670,206.08330	26.8%	38.7%	69.3%	30.7%
Wshd_pt_530	14,978,799.50135	23,757,672.47662	9,747,083.56439	41.0%	65.1%	63.0%	37.0%
Wshd_pt_531	36,467,975.71731	59,443,875.14747	17,926,435.13404	30.2%	49.2%	61.3%	38.7%
Wshd_pt_534	203,717,647.11494	363,974,078.14166	86,816,727.43553	23.9%	42.6%	56.0%	44.0%
Wshd_pt_536	12,127,164.55767	26,159,392.82369	4,038,152.73172	15.4%	33.3%	46.4%	53.6%
Wshd_pt_552	25,900.30730	33,459.33018	7,705.38889	23.0%	29.8%	77.4%	22.6%
Wshd_pt_553	5,386,072.34640	9,159,258.21267	2,945,044.86317	32.2%	54.7%	58.8%	41.2%
Wshd_pt_556	27,981,491.67091	45,719,633.50991	14,059,713.36478	30.8%	50.2%	61.2%	38.8%
Wshd_pt_595	17,065,867.98305	17,065,867.98305	7,438,144.52752	43.6%	43.6%	100.0%	0.0%
Wshd_pt_671	242,848,575.93196	361,580,900.25486	102,818,032.88961	28.4%	42.3%	67.2%	32.8%

Wshd_pt_676	635,531,530.59709	893,456,264.82460	250,006,491.85051	28.0%	39.3%	71.1%	28.9%
Wshd_pt_68	3,994,021.93092	5,997,456.40123	2,227,740.18991	37.1%	55.8%	66.6%	33.4%
Wshd_pt_689	24,236,213.97366	38,818,492.66494	14,650,465.21703	37.7%	60.4%	62.4%	37.6%
Wshd_pt_698	12,692,963.68626	20,944,497.31345	5,948,736.57590	28.4%	46.9%	60.6%	39.4%
Wshd_pt_699	18,466,688.60700	29,369,412.04002	9,631,822.26802	32.8%	52.2%	62.9%	37.1%
Wshd_pt_707	2,948.94691	2,948.94691	1,845.59515	62.6%	62.6%	100.0%	0.0%
Wshd_pt_724	977.45701	984.52152	984.52152	100.0%	100.7%	99.3%	0.7%
Wshd_pt_725	925,141.61563	1,787,362.17659	308,624.93304	17.3%	33.4%	51.8%	48.2%
Wshd_pt_735	530,518,481.79771	628,878,234.62267	361,360,267.45821	57.5%	68.1%	84.4%	15.6%
Wshd_pt_738	79,416,343.52010	151,978,980.59878	40,622,498.05536	26.7%	51.2%	52.3%	47.7%
Wshd_pt_746	95,869,246.14608	125,158,011.64158	54,263,651.34353	43.4%	56.6%	76.6%	23.4%
Wshd_pt_752	4,569,810.91888	6,948,534.00487	2,547,377.64433	36.7%	55.7%	65.8%	34.2%
Wshd_pt_758	5,903.66828	5,903.66828	5,903.66828	100.0%	100.0%	100.0%	0.0%
Wshd_pt_76	718.53231	3,932.40286	27.23660	0.7%	3.8%	18.3%	81.7%
Wshd_pt_8	4,660,556.49959	4,791,328.15976	678,013.51126	14.2%	14.5%	97.3%	2.7%
Wshd_pt_801	1,802,824,296.91627	1,820,002,959.11885	676,187,147.69806	37.2%	37.5%	99.1%	0.9%
Wshd_pt_802	2,937,490,831.02022	3,018,784,075.15915	1,287,163,226.70778	42.6%	43.8%	97.3%	2.7%
Wshd_pt_814	1,359.14166	1,967.92342	247.05401	12.6%	18.2%	69.1%	30.9%
Wshd_pt_815	179,627,442.87190	179,627,442.86731	64,005,655.57157	35.6%	35.6%	100.0%	0.0%
Wshd_pt_850	304,244,105.21850	321,768,986.37186	136,415,728.45065	42.4%	44.8%	94.6%	5.4%
Wshd_pt_862	3,668,430.10901	8,527,260.86504	1,280,690.53364	15.0%	34.9%	43.0%	57.0%
Wshd_pt_868	630,668,314.23677	845,951,988.44624	311,842,663.04324	36.9%	49.4%	74.6%	25.4%
Wshd_pt_875	5,039,848,036.11924	5,050,509,285.87731	1,720,887,544.96947	34.1%	34.1%	99.8%	0.2%

Appendix II: Group Members Contributions

- Literature Review Articles
  - Alix – USDA Forest Service article
  - Matthew – Gray/Hanou and Matteo/Randhir/Bloniarz articles
  - Chad – Verweij article
  - Melissa – Melancon and Miller/Miller/Hernandez/Miller/Semmens articles
- Logo
  - Created by Melissa
- Initial Data Acquisition
  - DEM
    - Melissa initially attempted to gather and mosaic DEM quads from TNRIS, but there was a duplicate file
    - Ryan then gathered the DEMs from the previous project and put them on the W: drive
    - Matthew ran them through the mosaic tool and projected them
  - Tree Canopy
    - Acquired through an e-mail to Alix from CoA
    - Projected by Matthew
  - EII Water Quality Points
    - Acquired through an e-mail to Alix from CoA
- Proposal
  - Report Sections
    - Alix – Cover, Table of Contents, Literature Review, Conclusion, Participation, Editing, Compiling of Report
    - Melissa – Data, Methodology, Implications, Literature Review
    - Matthew – Scope Map, Literature Review, Budget, Timetable, Methodology, Literature Review
    - Chad – Summary, Purpose, Scope, Final Deliverables, Literature Review
  - Slides
    - Alix – Introduction, Objectives, Conclusion, Compiling/formatting slides
    - Melissa – Data, Methodology, Implications
    - Matthew – Budget, Timeline, Final Deliverables
    - Chad – Scope, Literature Review
- Models for Project
  - Chad crafted and continuously edited the final model (derived from the pilot project model) as we ran into issues
  - Matthew developed the pilot project models and created maps from the resulting layers
- Hydrologic Model
  - Matthew filled sinks and mosaicked the DEMs and created an flow direction and flow accumulation layer for determining watersheds
- EII Points

    - Divided equally between the four members to verify and manually move locations to the nearest accumulation layer
    - Ryan recommended snapping the points as a solution to manually moving the points
    - Chad attempted to verify by converting the flow accumulation layer to vector and snapping the points, but this appeared to not work
    - Matthew and Chad fiddled with the symbology, showing the points were indeed accurately located
- Satellite Image Comparison
    - Alix and Melissa both searched various online depositories for adequate satellite imagery to utilize
    - Each member compared their divided EII points and the accumulation layer with satellite images to validate location due to comments in the attribute table
- Progress
    - Report Sections
        - Alix – Introduction, Project Description, Conclusion, Compiling Report
        - Matthew – Pilot Project
        - Chad – Model Development, Next Period
        - Melissa – Current Period
    - Slides
        - Alix – Project Review, Project Overview, Conclusion
        - Matthew - Pilot Project Steps
        - Chad – Model Development, Next Steps
        - Melissa – Verification of EII Points (Current Period)
- Model Implementation
    - Chad worked with Ryan to include iterators in our final model, as well as moving points and watersheds into their own geodatabase. He then ran the model to clip the canopy layer to our watersheds and worked with Ryan to make a unique watersheds layer.
- "Unplantable" Layer
    - Alix acquired the data layers (lakes/ponds/building footprints/impervious surfaces) after contacting our client on precisely which factors to include
    - Melissa combined in ArcMap and compared to satellite imagery as a method for validating layer data (example – small islands inside lakes and rivers being excluded from the "unplantable" layer)
    - Matthew took Melissa's "unplantable" layer and used it for pilot maps
    - Chad integrated the layer into the final model
- Maps
    - Matthew compiled final maps for the poster and final report
- Tables/Calculations
    - Created by Chad for the poster and final report
- Poster
    - Maps, tables, logos, and text compiled and edited by Melissa
- Manifold
    - Matthew
- Metadata
    - Alix
- Final Presentation
    - Report Sections

        - Alix – Discussion, Conclusion, References, Metadata, Compiling Report
        - Matthew - Methods
        - Chad – Data, Results
        - Melissa – Introduction and Problem statement, Contributions
    - Slides
        - Alix – Discussion, Conclusion
        - Matthew – Methods, Compiled Slides
        - Chad – Results, Deliverables
        - Melissa – Introduction and Problem Statement
    - Final CD of Data/Deliverables
        - Chad
- Website
    - Alix
        - Set deadlines for members to turn in their respective portions and compiled them together
        - Prepared the documents from our various reports/presentations to be used on the site

Appendix III: Metadata

See individual files for full metadata.