Potential Dillo Dirt Application Sites in Austin, Texas

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GEO 327G: GIS and GPS Applications in Earth Science

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Problem Formulation

        Biosolids, which are sewage solids leftover from wastewater treatment processes, can contain pathogens, heavy metal elements, and organic pollutants. The City of Austin composts its biosolids to create a soil fertilizer called Dillo Dirt which is sold for use in lawns, gardens, and parks across the city. Composting can effectively destroy most pathogens present through heat inactivation. As a Class A biosolid, EPA regulations allow for Dillo Dirt to be applied anywhere in lawns and gardens with no further restrictions. However, the potential regrowth of pathogens under favorable conditions after land application could still be a major concern with detrimental effects on public health. I will be performing a suitability analysis on quantifying the areas that would be most appropriate for the safe application of Dillo Dirt within the City of Austin. This information could then be used by City of Austin officials to better plan where to safely apply Dillo Dirt, as well as provide more information to the public about the safety of the product. Seven factors will be used in this analysis to assess the suitability of application areas: land use, slope, soil permeability, precipitation, nearness to creeks, nearness to lakes, and the distance from the Hornsby Bend Biosolids Management Plant where the Dillo Dirt is produced. From these factors, the total area suitable to Dillo Dirt application can be calculated. I hypothesize that the majority of the area of the City of Austin will not be suitable to Dillo Dirt application.

Data Collection

        For this analysis, land use data was obtained from the City of Austin's GIS Data Downloads website as a vector file of land use conditions for the City of Austin and surrounding areas. To calculate the slope, a 30 meter raster DEM of the Austin East Quadrangle was obtained from the Texas Natural Resources Information System. Soil data was collected from the STATSGO Database through the USGS website and contained soil characteristics for the conterminous United States. Precipitation data was obtained as a raster file of annual precipitation across Texas from the U.S. Department of Agriculture Natural Resources Conservation Service Geospatial Data Giveaway. Polylines of creeks in Austin and polygons of Austin lakes were obtained from the City of Austin's GIS Data Downloads website. The coordinates of the Hornsby Bend Biosolids Management Plant were obtained from Google Maps and imported into ArcGIS (Fig. 1). Polygons of Travis County and surrounding counties were obtained from the Capital Area Council of Governments Geospatial Data page. Polygons of all the counties in Texas were obtained from the Texas Parks and Wildlife GIS Data page. A summary of the data files used and their respective sources and original coordinate systems can be seen in Table 1.
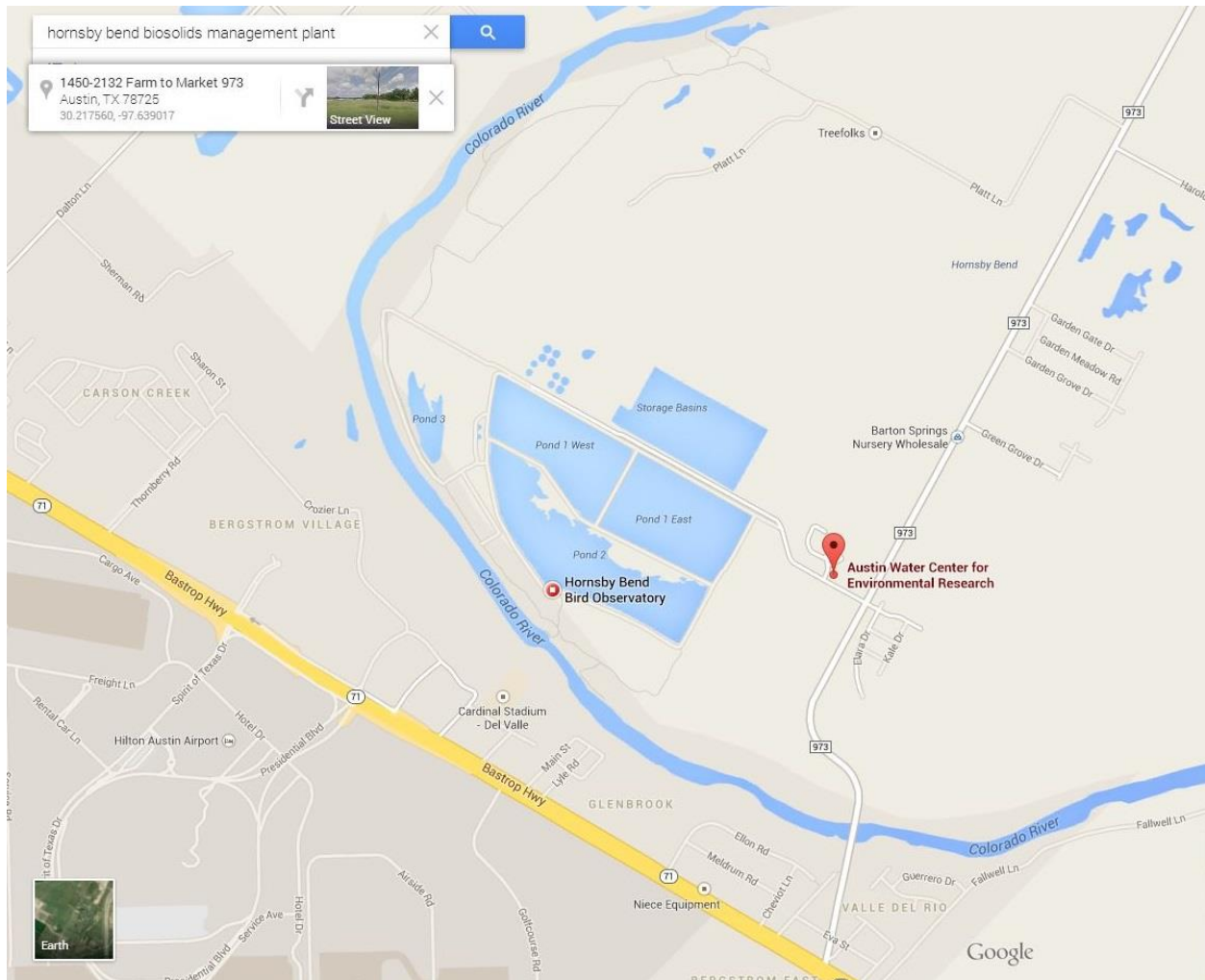
Figure 1: Coordinates of the Hornsby Bend Biosolids Management Plant obtained through Google Maps.

Number	File Name	Description	Coordinate System
1	land_use_2010	Land use for Austin	NAD 83 State Plane Central Texas (Ft)
2	dem_30m_3097	DEM for Austin East Quad	NAD 83 Geographic CS
3	muid0	Soil characteristics of conterminous US	NAD 1927 Albers
4	precipann_r_tx	Annual precipitation in TX	WGS 84 Geographic CS
5	creek_lines	Austin creeks	NAD 83 State Plane Central Texas (Ft)
6	polylakes	Austin lakes	NAD 83 State Plane Central Texas (Ft)
7	Hornsby (Excel)	Coordinates of Hornsby Bend	Google Maps uses WGS 1984
8	capcog_boundaries	Counties within CAPCOG	NAD 83 State Plane Central Texas (Ft)
9	cntys04	Counties within Texas	NAD 83 Lambert Conformal Conic

Table 1: Summary information about each data file used, including the original coordinate system and source.

Number	Source	Type	Age
1	ftp://ftp.ci.austin.tx.us/GIS-Data/Regional/coa_gis.html	Vector - Polygon	1/24/2011
2	http://www.tnris.org/get-data?quicktabs_maps_data=1	Raster	-
3	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml#stdorder	Raster	1997
4	http://datagateway.nrcs.usda.gov/GDGOrder.aspx	Raster	-
5	ftp://ftp.ci.austin.tx.us/GIS-Data/Regional/coa_gis.html	Vector - Lines	9/22/2010
6	ftp://ftp.ci.austin.tx.us/GIS-Data/Regional/coa_gis.html	Vector - Polygon	5/24/2004
7	https://www.google.com/maps/preview	Vector - Point	-
8	http://www.capcog.org/data-maps-and-reports/geospatial-data/	Vector - Polygon	-
9	http://www.tpwd.state.tx.us/landwater/land/maps/gis/data_downloads/	Vector – Polygon	-

Table 1 Continued: Summary information about each data file used, including the original coordinate system and source.

Data Preprocessing

I chose to perform this analysis using the NAD 83 State Plane Central Texas FIPS 4203 Feet as the coordinate system. Austin, TX lies entirely within the Central Texas region, so this projection minimizes the distortion in this area. Additionally, the vector files from the City of Austin were already in this coordinate system. The rest of the data files were thus projected into this coordinate system. The land use vector file was used as the extent for this analysis and was then converted to a raster with a 100 foot cell size using the Polygon to Raster function in ArcGIS (Fig. 2). The 30 meter DEM was projected into the State Plane Central Texas projection (Fig. 3), used to calculate a new raster of the slope of each cell using the Slope function, and then clipped to the Austin land use raster automatically by setting the mask in ArcGIS to the land use raster (Fig. 4). The soil data was downloaded in the e00 interchange format and had to be converted using the Import from e00 tool in order to be able to be used in ArcGIS. The converted coverage was then joined with a table that contained the actual soil characteristics that was downloaded separately (Fig. 5). The soils data was then projected to the State Plane Central Texas projection and clipped to the Austin land use raster using the Extract by Mask tool (Fig. 6). The precipitation data was projected to the State Plane Central Texas projection (Fig. 7) and clipped to the Austin land use raster using the Extract by Mask tool (Fig. 8). The Austin creek data was clipped to the shapefile of the Austin land use, and then a Multiple Ring Buffer was created at distances of 100, 200, and 300 feet. The buffer was then converted to a 100 foot cell size raster using the Polygon to Raster function (Fig. 9). A Multiple Ring Buffer was created from the Austin lake data at distances of 200, 400, and 600 feet. The buffer was then clipped to the Austin land use and converted to a 100 foot raster using the Polygon to Raster function (Fig. 10). The coordinates of the Hornsby Bend Biosolids Management Plant were imported from an Excel file into ArcGIS and projected to the State Plane Central Texas projection by exporting the data with the coordinate system of the data frame. Then, a Multiple Ring Buffer of distances of 4, 8, and 12 miles was created. The buffer was converted to a 100 foot cell size raster using the Polygon to Raster function. Finally, the raster was clipped to the Austin land use raster using the Extract by Mask tool (Fig. 11).
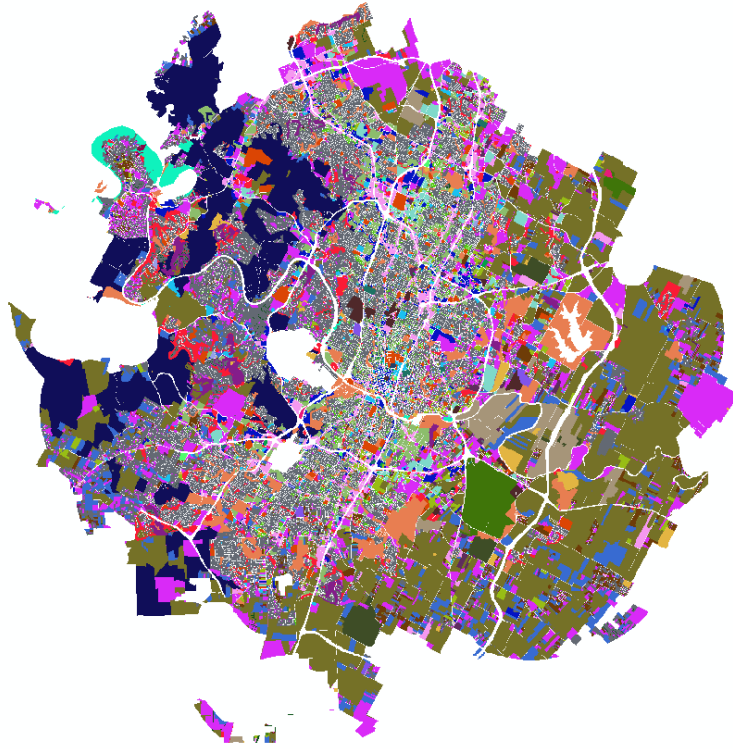
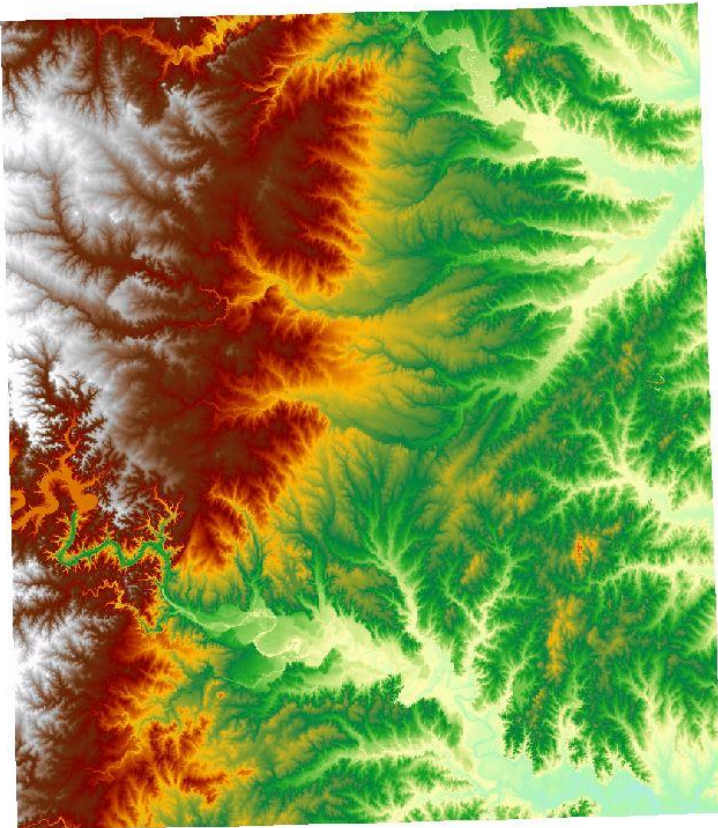Figure 2: Converted raster of City of Austin land use.

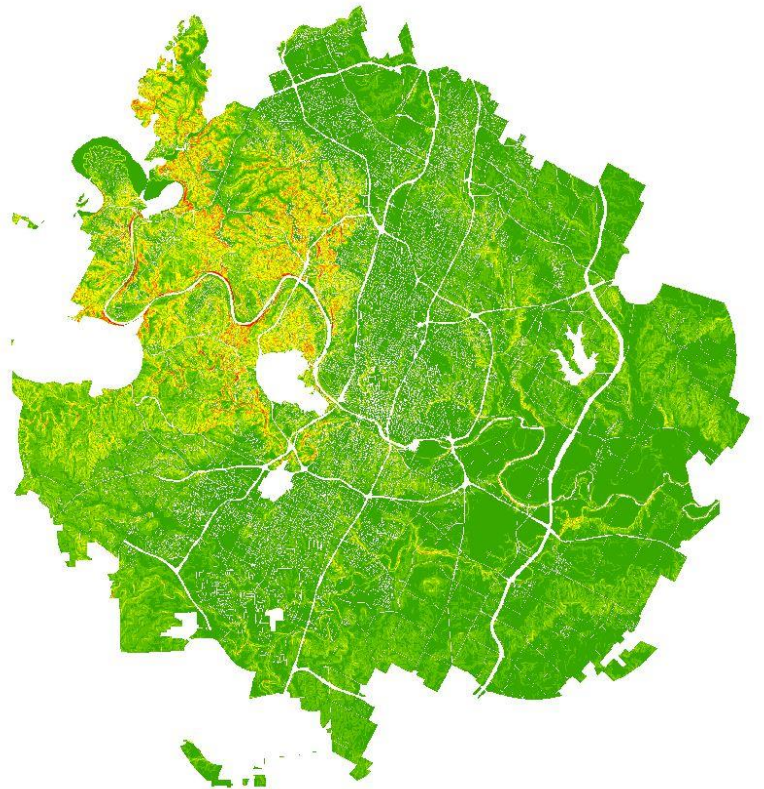Figure 3: 30 Meter Digital Elevation Model of the Austin East Quad.

Figure 4: Slope raster calculated from the DEM and clipped to the land use raster.

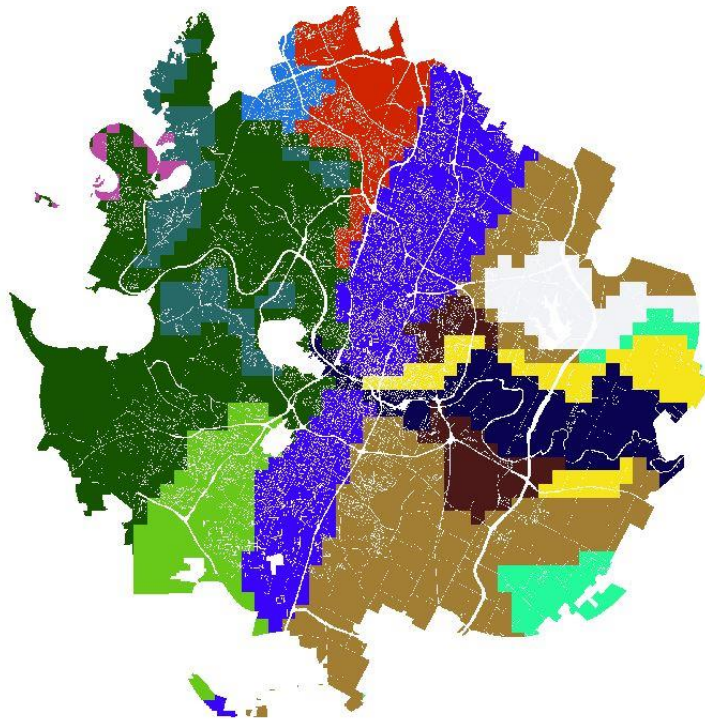Figure 5: Soil permeability for conterminous United States.

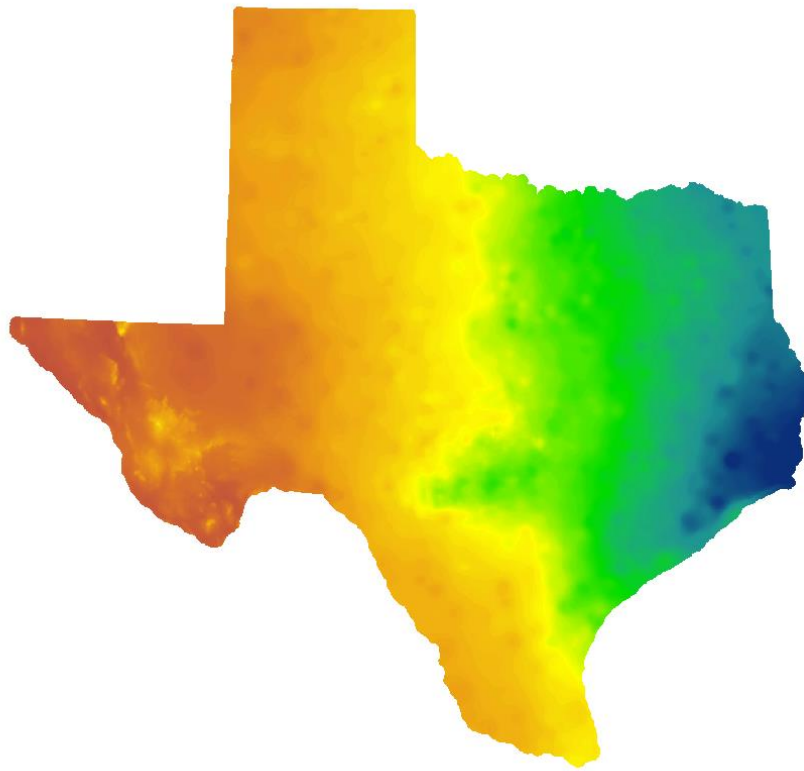Figure 6: Soil permeability raster clipped to the Austin land use raster.

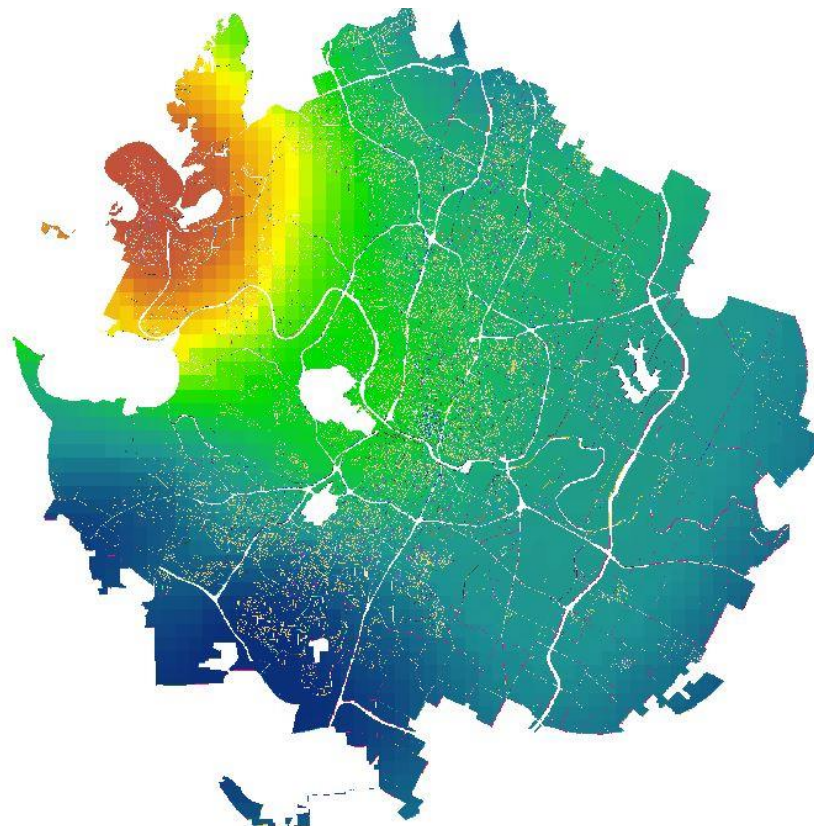Figure 7: Annual precipitation data from 1981-2010 for the state of Texas.

Figure 8: Annual precipitation raster clipped to the Austin land use raster.
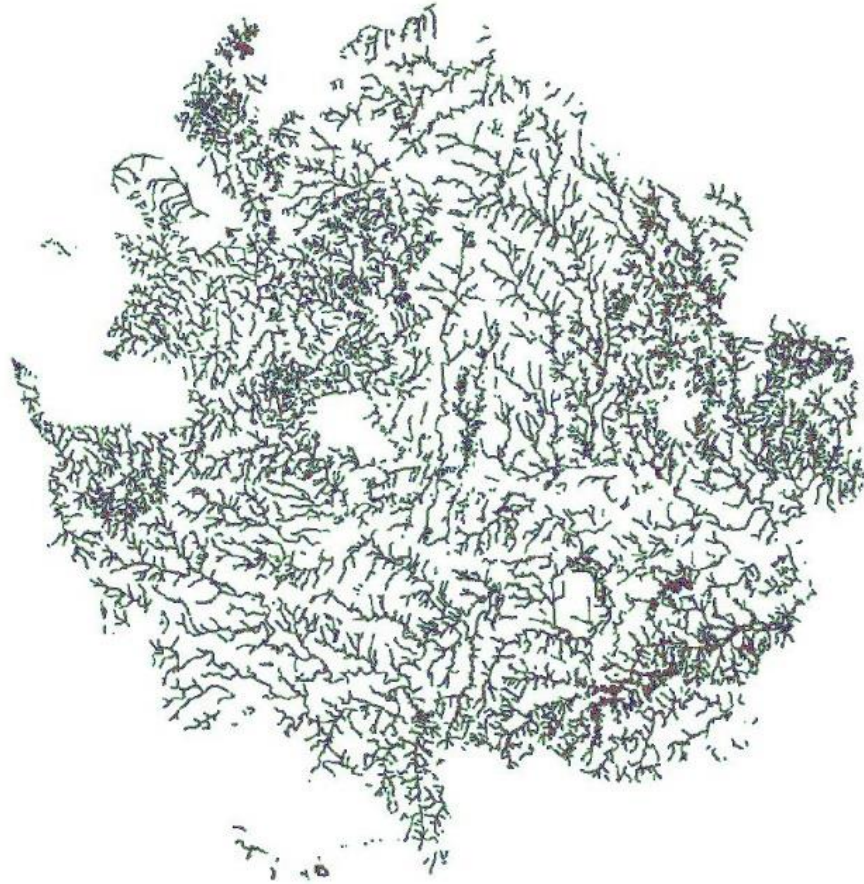
Figure 9: Multiple ring buffer of Austin creeks clipped to the Austin land use raster.

Figure 10: Multiple ring buffer of Austin lakes clipped to the Austin land use raster.
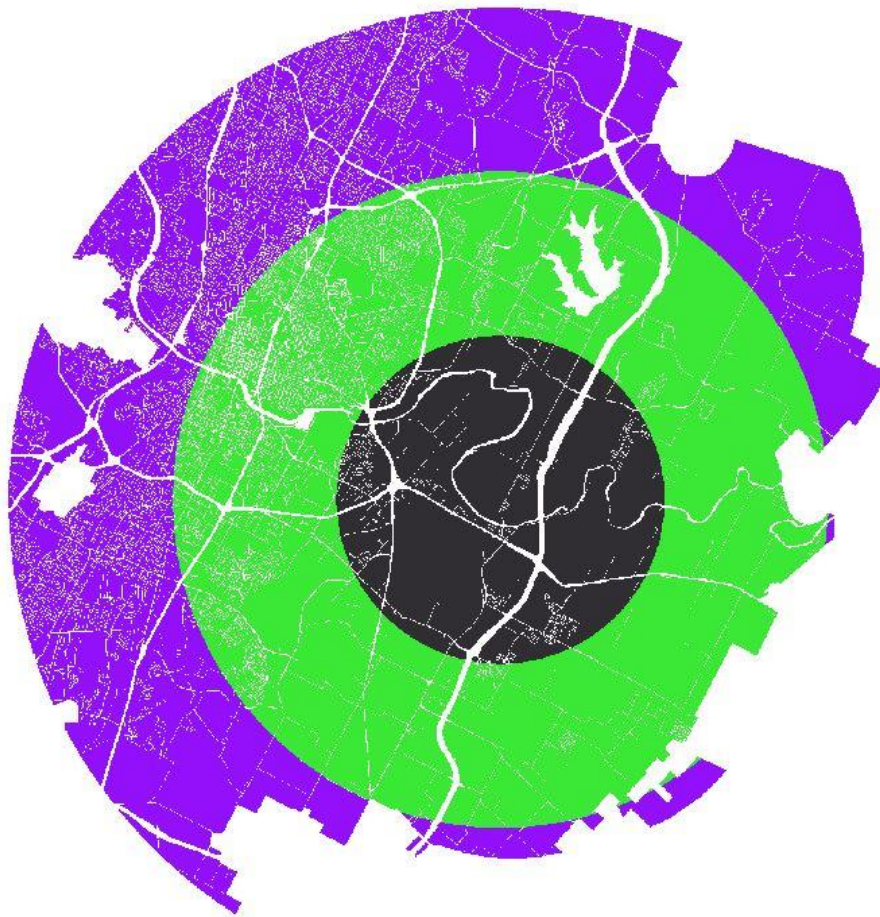
ArcGIS Processing

I decided that the seven factors to be used for this analysis were not of equal importance to influencing the application of Dillo Dirt and thus had to be renormalized. I decided that the most important factor affecting Dillo Dirt is the land use. Dillo Dirt should only be applied to natural lands and grasses such as lawns, gardens, parks, and golf courses. I then decided that the slope, soil permeability, and precipitation were the next most important factors. The amount of rain falling on the land, the slope of the land, and how permeable the soil is affect how much water falls on the Dillo Dirt and becomes runoff. These runoff processes should be minimized to

lower the potential for the leaching of pathogens and excess nutrients from the compost. The nearness to major bodies of water such as the creeks and lakes were the next most important factors. This was due to the reasoning that the factors that influence how runoff would get to surface waters were more important than how close the surface waters actually were. These distances would want to be maximized in order to avoid the inputs from runoff. Finally, the distance from the Hornsby Bend Biosolids Management Plant was the least important factor. The City would ideally want to minimize its transportation costs when taking the Dillo Dirt to the application areas, but public safety is far more important than simple cost reduction.

Once these general relationships were established, I determined the relative importance of each factor to each of the other factors as can be seen in Table 2. Each value was then divided by the column total to create Table 3. I then calculated the average of each row to determine the final weight of each factor to be used for the raster analysis in Table 4.

	Creeks	Lakes	Precipitation	Slope	Land Use	Hornsby	Soil
Creeks	1	1	0.666666667	0.666667	0.333333	1.333333	0.666667
Lakes	1	1	0.666666667	0.666667	0.333333	1.333333	0.666667
Precipitation	1.5	1.5	1	1	0.5	2	1
Slope	1.5	1.5	1	1	0.5	2	1
Land Use	3	3	2	2	1	4	2
Hornsby	0.75	0.75	0.5	0.5	0.25	1	0.5
Soil	1.5	1.5	1	1	0.5	2	1
Sum	10.25	10.25	6.833333333	6.833333	3.416667	13.66667	6.833333

Table 2: Relative importance of each factor to each of the other factors.

	Creeks	Lakes	Precipitation	Slope	Land Use	Hornsby	Soil	Average
Creeks	0.097561	0.097561	0.097560976	0.097561	0.097561	0.097561	0.097561	0.097561
Lakes	0.097561	0.097561	0.097560976	0.097561	0.097561	0.097561	0.097561	0.097561
Precipitation	0.146341	0.146341	0.146341463	0.146341	0.146341	0.146341	0.146341	0.146341
Slope	0.146341	0.146341	0.146341463	0.146341	0.146341	0.146341	0.146341	0.146341
Land Use	0.292683	0.292683	0.292682927	0.292683	0.292683	0.292683	0.292683	0.292683
Hornsby	0.073171	0.073171	0.073170732	0.073171	0.073171	0.073171	0.073171	0.073171
Soil	0.146341	0.146341	0.146341463	0.146341	0.146341	0.146341	0.146341	0.146341
Sum	1	1	1	1	1	1	1	1

Table 3: Renormalization of the importance of each factor to each of the other factors.

	Creeks	Lakes	Precipitation	Slope	Land Use	Hornsby	Soil
Final Weight	0.097561	0.097561	0.146341463	0.146341	0.292683	0.073171	0.146341

Table 4: Final weight of each factor to be used in the suitability analysis.

Each raster was then reclassified into intervals as can be seen in Table 5. For the land use raster, the land use categories were ranked based on the level of human contact with the areas. Agricultural areas would be the safest, followed by preserves and camp grounds since they are not visited by humans as frequently. Parks, greenbelts, golf courses and individual homes would be the next most appropriate places to apply Dillo Dirt. The rest of the land uses would not be appropriate for spreading Dillo Dirt at all (Fig. 12). The slope, precipitation, and permeability rankings were all based off of the minimum and maximum values. For the slope raster, shallow slopes would be the safest application areas, while the steepest slopes would be the least appropriate (Fig. 13). For the precipitation raster, low levels of annual precipitation would be the most desirable, while highest levels of precipitation would be the least (Fig. 14). For the soil permeability, low values would be the most desirable as one would want the soil to transmit the least amount of water. Thus high values would be the least appropriate (Fig. 15). The distances from the creeks, lakes, and Hornsby Bend were chosen based on what I thought were reasonable values that made physical sense at this mapping scale. For the creeks and lakes rasters, a large distance from the bodies of water would be the most suitable areas to apply Dillo Dirt, while areas close the water features would be the least suitable (Fig. 16 and 17). For the distance from the Hornsby Bend Biosolids Management Plant raster, areas close to the plant would be the most desirable so as to minimize transportation costs. Thus the areas further from the plant would be the least desirable (Fig. 18).

Rank	Land Use	Slope (°)	Precipitation (in)	Permeability (in/hr)	Creeks (ft)	Lakes (ft)	Hornsby (mi)
0	All of the rest	-	-	-	-	-	-
1	Single Family and Large-Lot Single Family	6.51-21.72	34.08-35.30	2.86-3.83	0-100	0-200	>12
2	Parks/Greenbelts and Golf Courses	4.34-6.51	32.86-34.08	1.91-2.86	100-200	200-400	8.0-12.0
3	Preserves and Camp Grounds	2.17-4.34	31.65-32.86	0.95-1.91	200-300	400-600	4.0-8.0
4	Agricultural	0-2.17	30.43-31.65	0-0.95	>300	>600	0-4

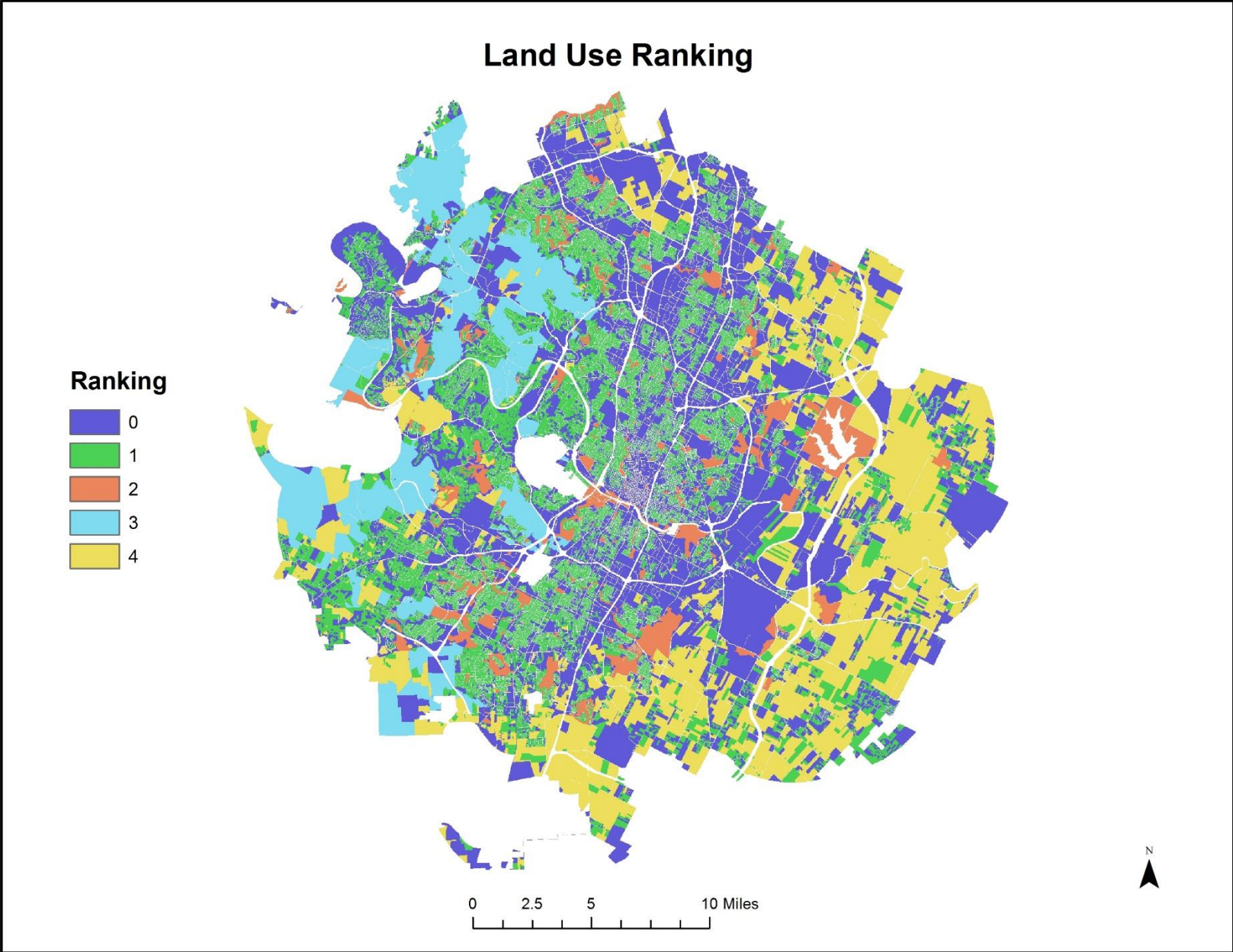Table 5: Reclassification intervals for each factor to be used in the suitability analysis.

Land Use Ranking

Ranking
- 0
- 1
- 2
- 3
- 4

0   2.5   5   10 Miles

N

Figure 12: Reclassification of the land use raster into intervals.

Slope Ranking

Ranking
- 1 (red)
- 2 (orange)
- 3 (yellow-green)
- 4 (green)

0 2.5 5 10 Miles

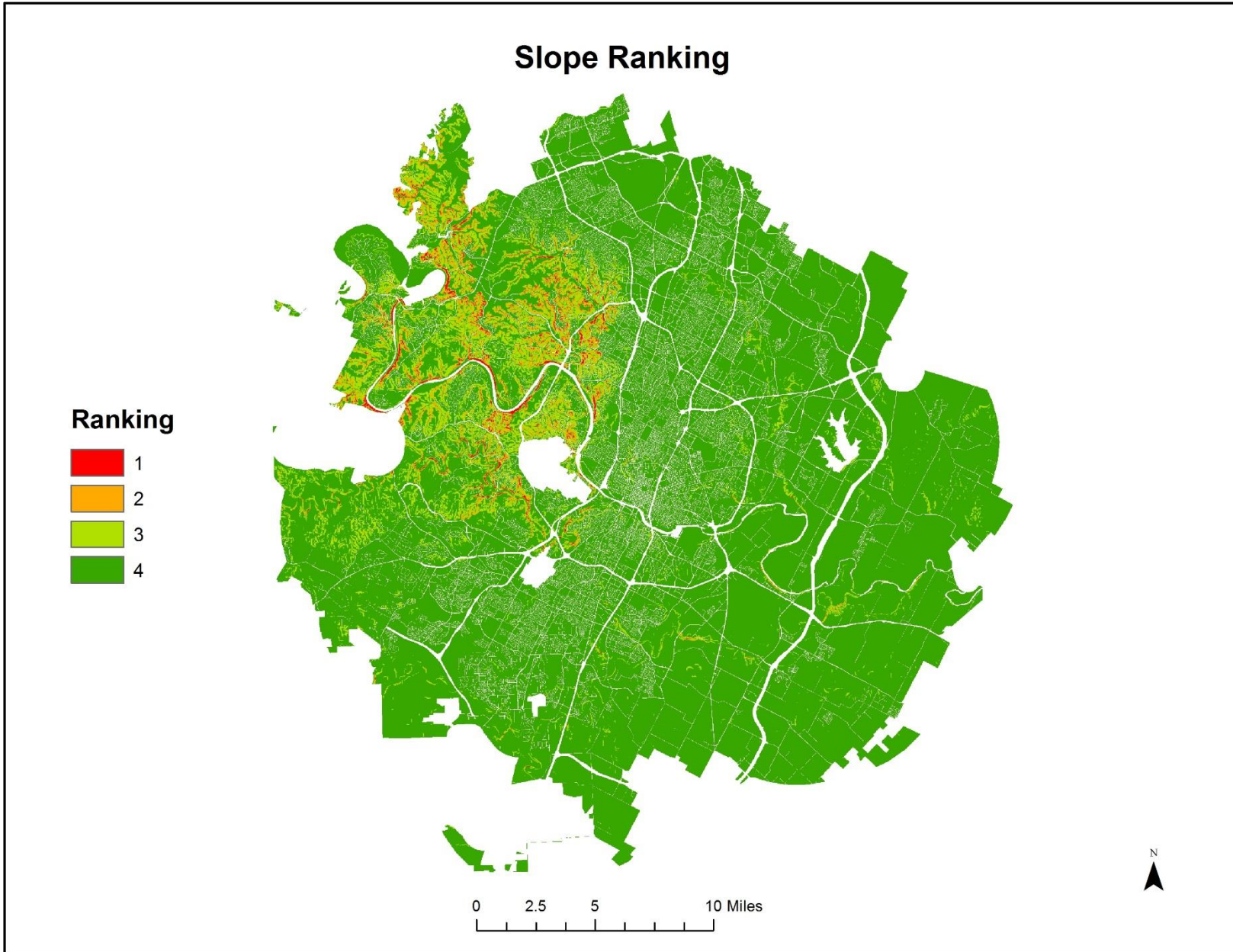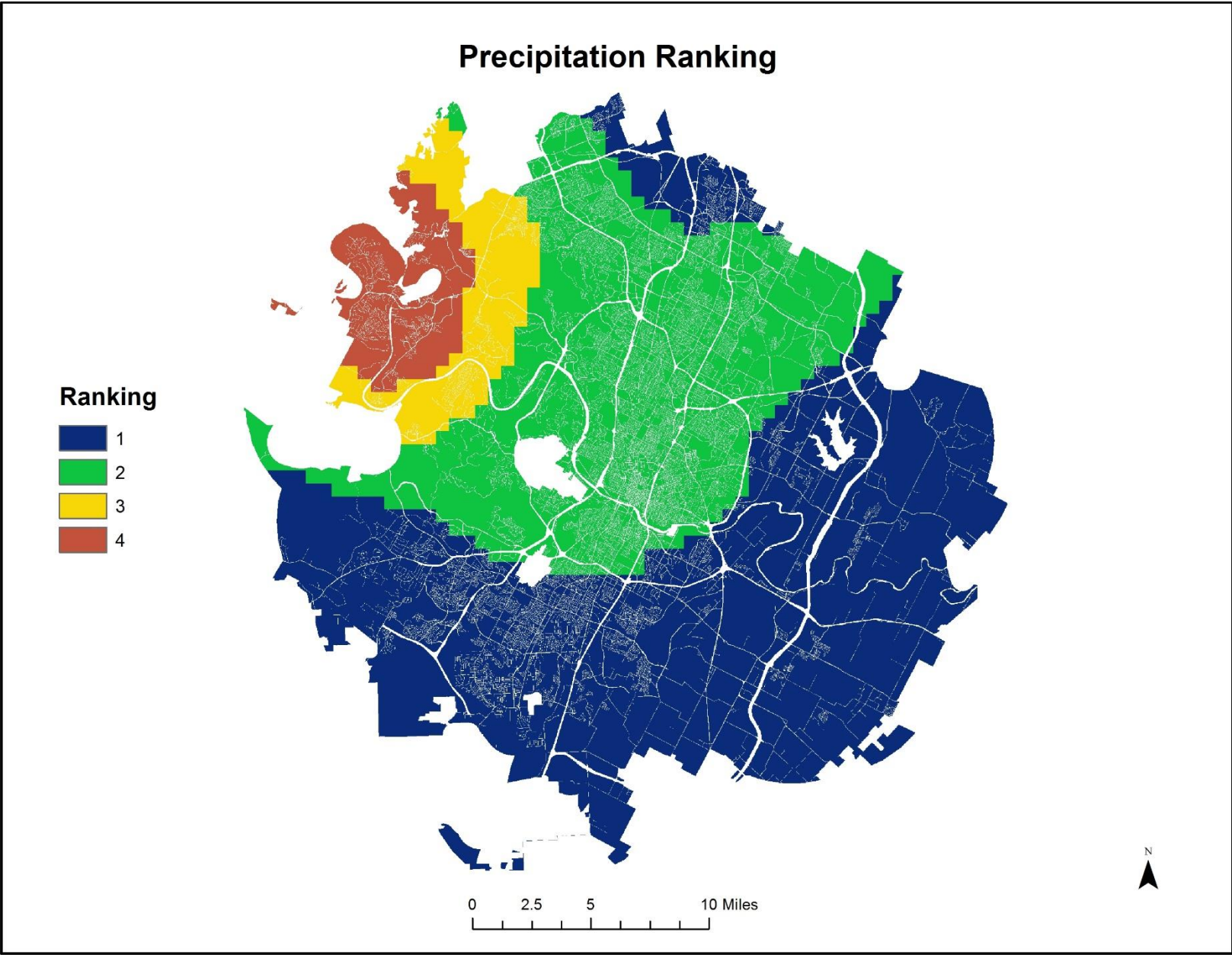Figure 13: Reclassification of the slope raster into intervals.

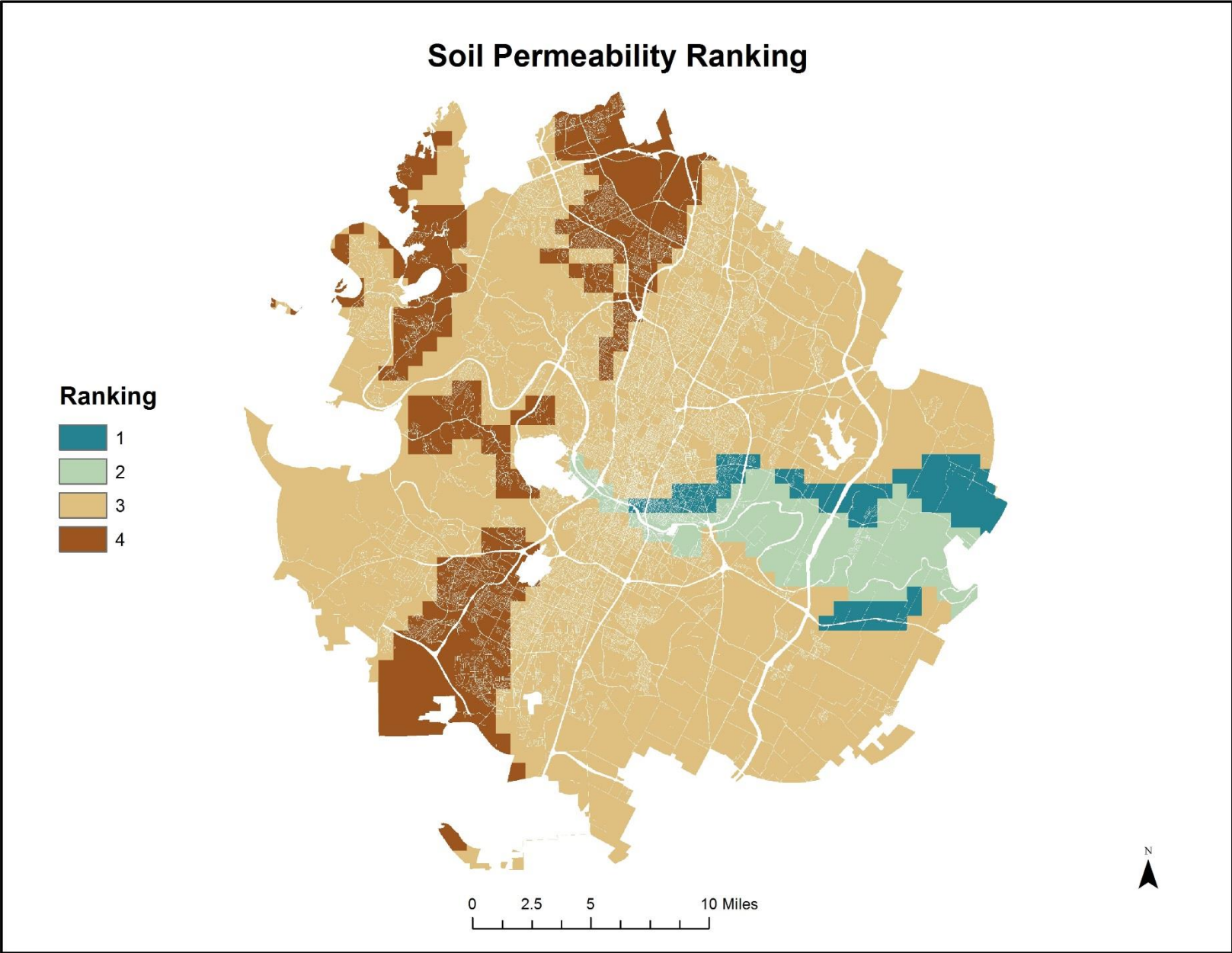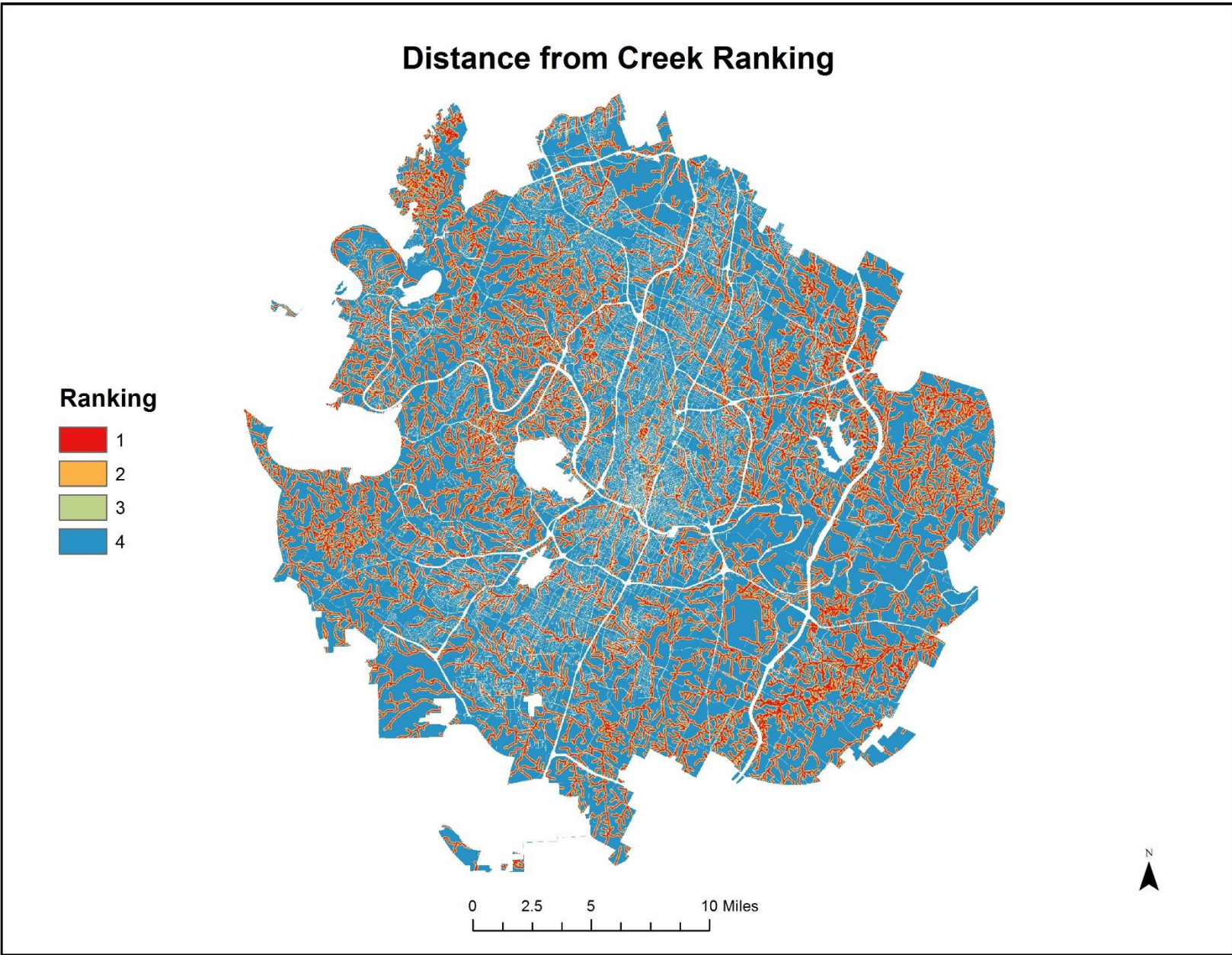**Figure 14: Reclassification of the precipitation raster into intervals.**

Soil Permeability Ranking

Ranking
- 1
- 2
- 3
- 4

0   2.5   5   10 Miles

Figure 15: Reclassification of the soil permeability raster into intervals.

Distance from Creek Ranking

Ranking
- 1
- 2
- 3
- 4

0   2.5   5   10 Miles

N

Figure 16: Reclassification of the distance from creek raster into intervals.

Distance from Lake Ranking

Ranking
- 1
- 2
- 3
- 4

0   2.5   5   10 Miles

N
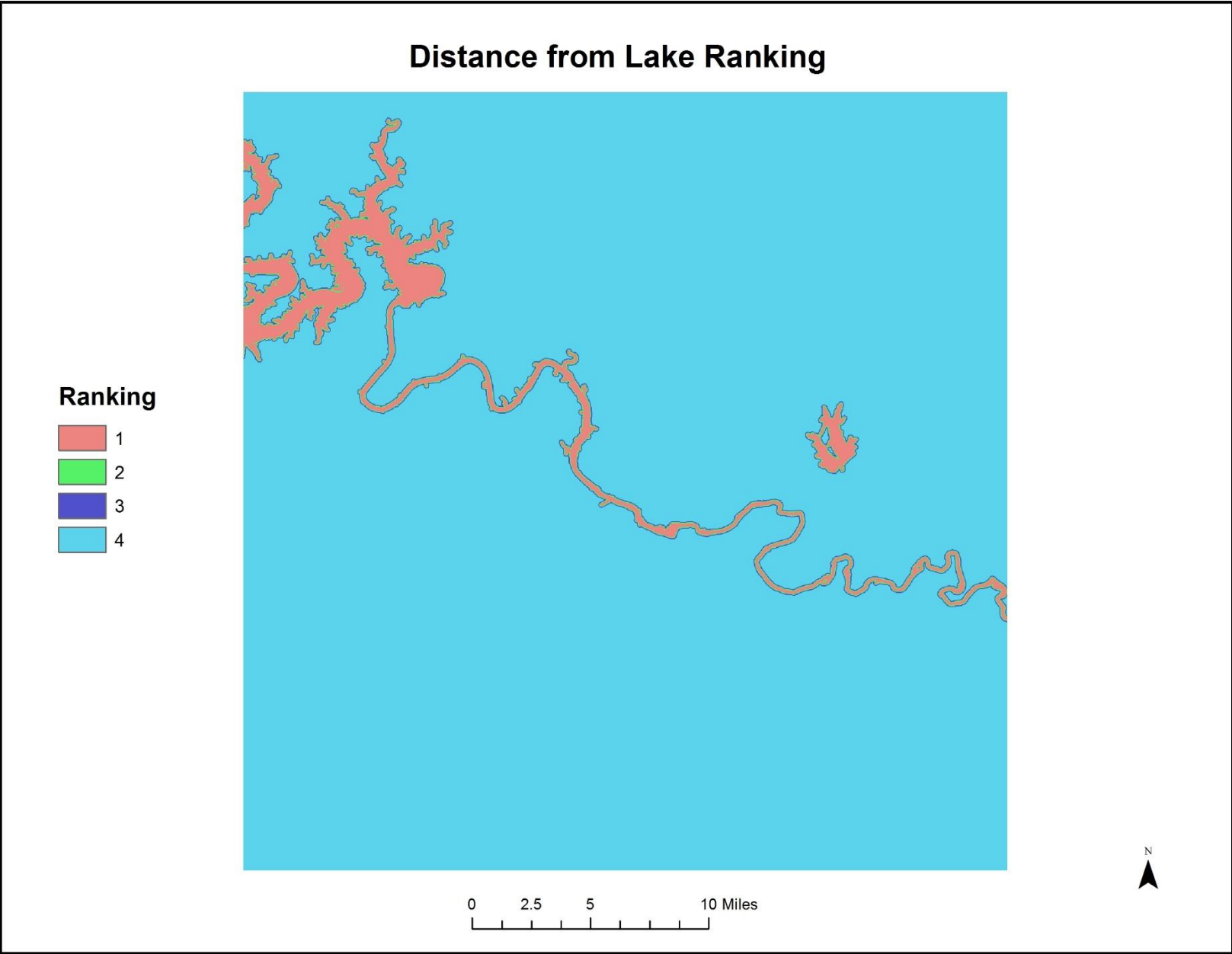
Figure 17: Reclassification of the distance from lake raster into intervals.

Distance from Hornsby Bend Ranking

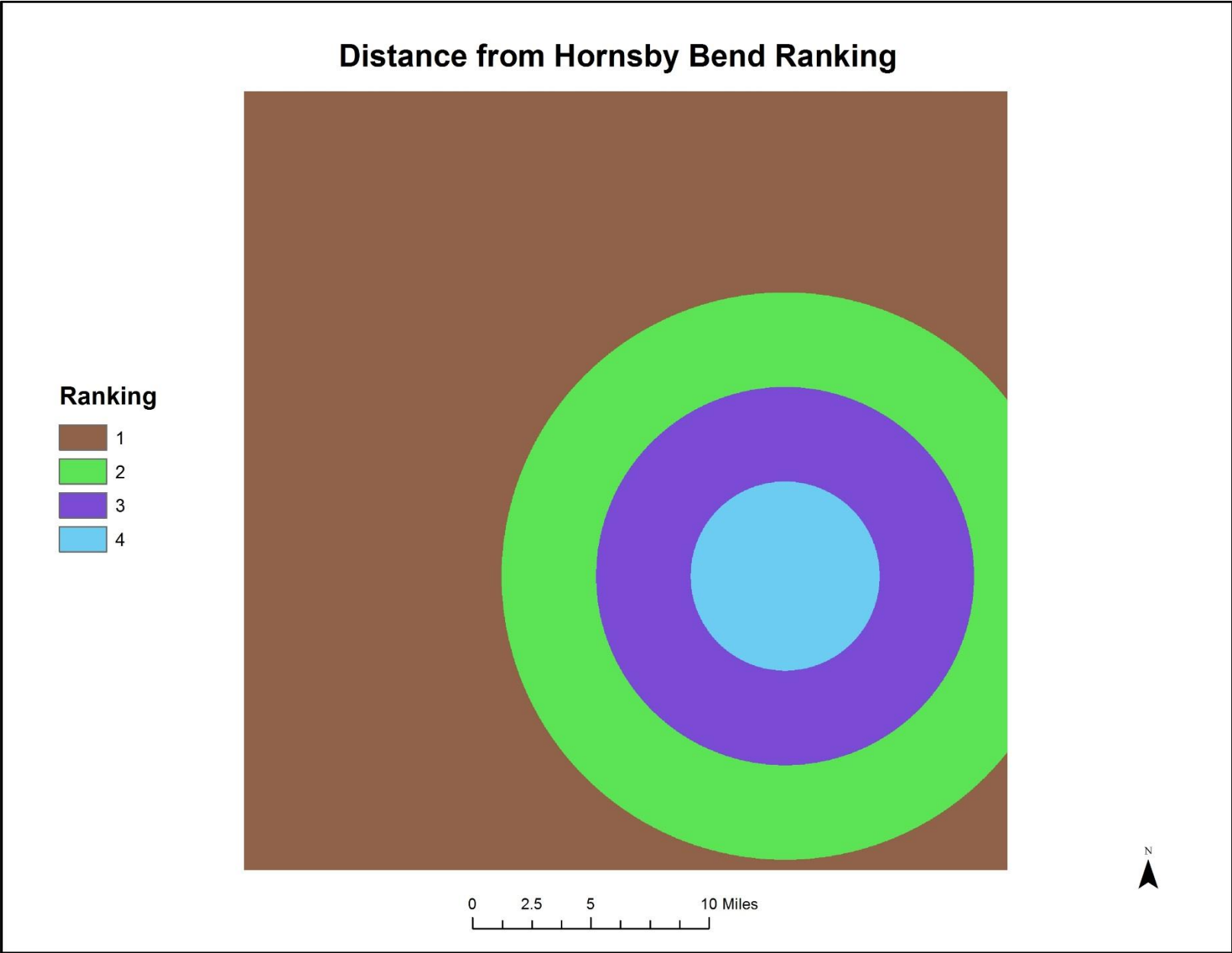Ranking
1
2
3
4

0   2.5   5   10 Miles

Figure 18: Reclassification of the distance from Hornsby Bend raster into intervals.

Finally, each raster was multiplied by its respective final weight and then added together using the Raster Calculator to determine the final ranking (Fig. 19). In order to be able to calculate the areas that were most suitable, the final ranking raster needed to be converted from a floating point raster to an integer raster in order to have an attribute table. To do this, I first multiplied the final ranking raster by 100 in order to preserve the first two decimal places. Then, I converted the floating point raster to an integer raster using the Ind function on the Raster Calculator (Fig. 20). Then, I chose to display the data using 5 natural breaks so as to maximize the differences between classes. I then assigned each of these classes a name based on the relative suitability, from very low to very high. From here, the number of cells in each interval could be determined. Finally, the number of cells in each interval was multiplied by the area of one cell in order to get the total area in each suitability interval as can be seen in Table 6. The final map displaying the results of the suitability analysis can be seen in Figure 21.

Value	Class	Number of cells	Area of 1 cell (ft^2)	Area (ft^2)	Area (mi^2)
114-204	Very Low Suitability	230191	10000	2301910000	82.57
204-234	Low Suitability	455517	10000	4555170000	163.39
234-270	Moderate Suitability	302900	10000	3029000000	108.65
270-309	High Suitability	241609	10000	2416090000	86.67
309-378	Very High Suitability	299975	10000	2999750000	107.60

Table 6: Calculation of the total area in each suitability interval.
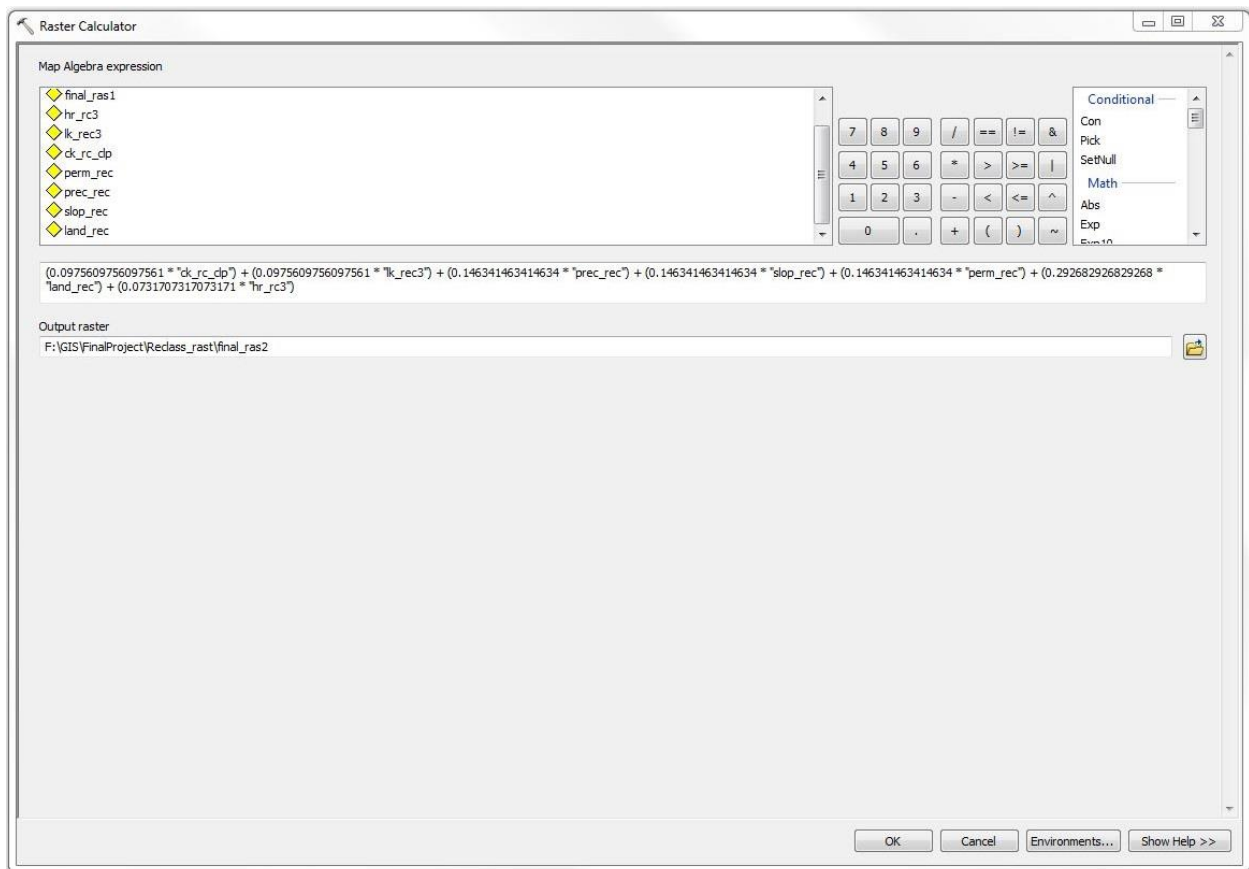

Figure 19: Using the Raster Calculator to determine the final ranking by multiplying each raster by its specific weight and then adding them all together.
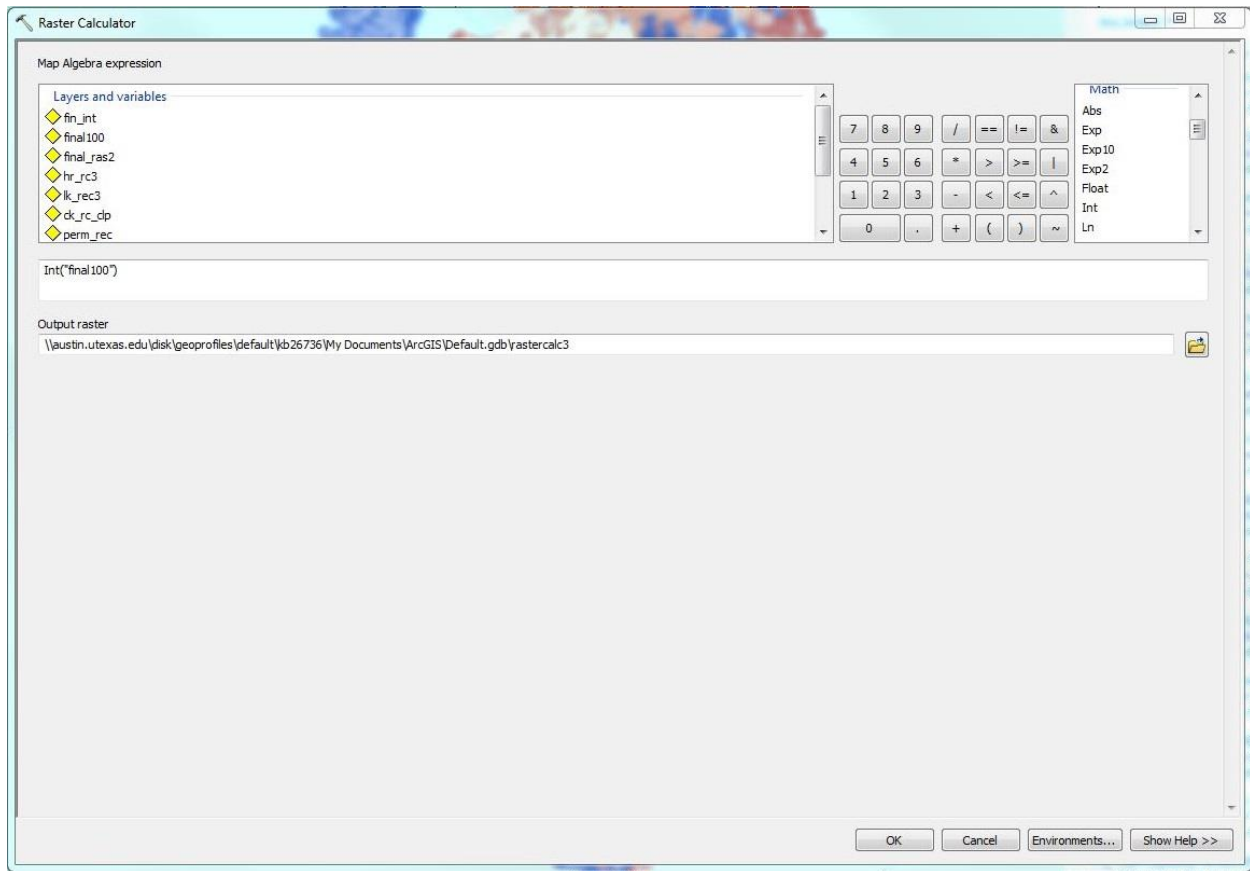
Figure 20: Using the Raster Calculator to convert the floating point final raster to an integer final raster.

Conclusion

My analysis indicated that approximately 65% of the areas had very low to moderate suitability for the application of Dillo Dirt and thus supports my initial hypothesis. The class with the largest area was the low suitability, while the class with the smallest area was the very low suitability. As far as spatial trends present, the suitability seems to be affected by the factors mostly in order of the importance I assigned to them. The land use has a visible influence on the final raster, while trends from the distance from Hornsby Bend are not visible. The distances from the creeks and lakes also had visible effects as there were large changes in ranking over relatively small distances. The slope and precipitation rankings seemed to cancel each other out, as areas of high slope had low values of precipitation. Soil permeability did not have much effect as it did not change very significantly over the study area. From a purely regulatory standpoint, Dillo Dirt can be applied anywhere the consumer desires without restriction. But my research has shown that fecal coliform bacteria can initially regrow when Dillo Dirt is watered and incubated at favorable temperatures. This analysis could thus be useful supplementary information to my research and be presented to the compost managers at the Hornsby Bend Biosolids Management Plant. However, further analysis based on criteria from verifiable scientific research is needed.

Potential Dillo Dirt Application Sites in Austin, Texas

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5/1/14

Explanation

- **Very Low Suitability** (red)
- **Low Suitability** (orange)
- **Moderate Suitability** (yellow)
- **High Suitability** (light green)
- **Very High Suitability** (dark green)
- **Texas Counties** (gray)

Factors Influencing Suitability

Land Use
Slope
Precipitation
Soil Permeability
Distance to Surface Water
Distance from Hornsby Bend

Williamson

Travis

Hays

Bastrop

Caldwell

N

0   2.5   5   10 Miles

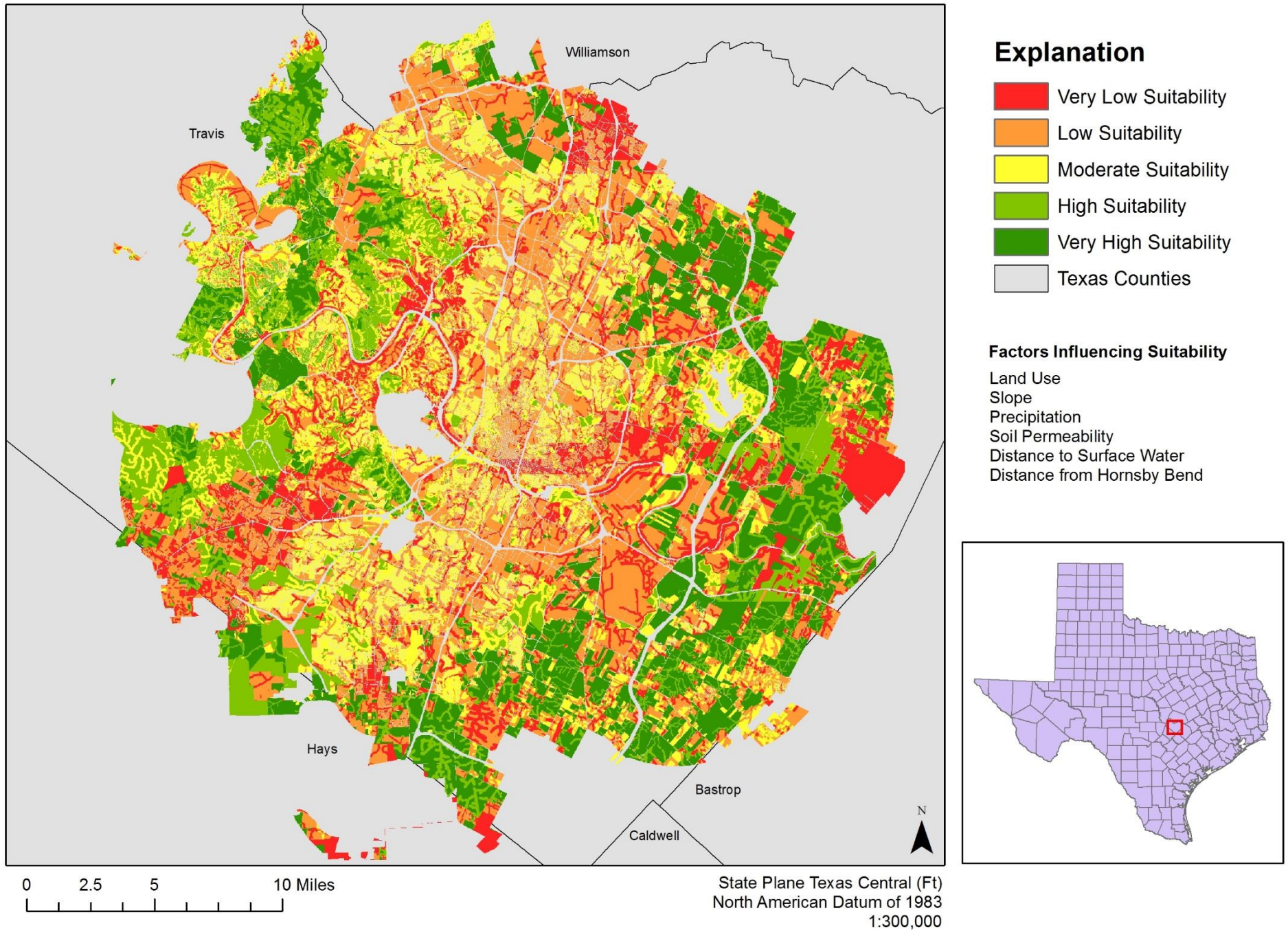State Plane Texas Central (Ft)
North American Datum of 1983
1:300,000

Figure 21: Final map displaying the results of the suitability analysis with regard to the potential application of Dillo Dirt in Austin, TX.