Visualizing the Variation of Soil Respiratory Quotient at Various Depths in Harris County, Texas

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<div align="center">

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Problem

Respiratory quotient (RQ) is the measurement of carbon dioxide produced in soil divided by the oxygen consumed (dCO2/dO2), facilitated by microbial respiration and organic decomposition. It is a processes responsible for carbon fluxes between the atmosphere and soils as part of the global carbon cycle. RQ is not well documented worldwide, and with accelerating urbanization, microbial soil communities change and alter RQ. The goal of this project is intended to help characterize the global RQ and oxidative ration (OR, the inverse of RQ), which has been estimated to be about 0.9 (with OR = 1.1) globally with limited data sets. With more global RQ data from this project in Harris County, a more accurate global RQ can be calculated and a better prediction on soils carbon source/sink ability can be achieved. With the data available, the RQ values should be similar closer to each other, and resulting areas can be calculated to find the weighted average RQ of Harris County.

Data Collection:

Before analyzing RQ data spatially with calculated RQ values from lab, vector and raster data of the area was downloaded from the internet, and a .kml file was established with details on collection locations. These files can be found here:

Vector shapefile of Harris County (NAD83, UTM Zone 15N)
 - http://pdata.hcad.org/GIS/
Harris County Landsat 8 raster photography from USGS EarthExplorer (WGS84)
 - http://earthexplorer.usgs.gov/
Point data on sampling locations, plotted on Google Maps online application with recorded geographic coordinates from field data in February, 2016
 - https://www.google.com/maps/d/edit?mid=zx929lNhbKzo.k4RErg_RT5OA&usp=sharing
Table of sample RQ data and metadata, calculated in lab and available on Excel

Data Preprocessing:

Two images from EarthExplorer were downloaded to cover the entire span of Harris County. These images (from left to right) were from October 17, 2015 and October 10, 2015 (figure b). Despite the soil samples being taken in the summer, these dates were chosen because of the lack of cloud cover for these days for creating a quality basemap. The raster files were projected in WGS 1984, and were transformed to NAD83, UTM Zone 15N to match the Harris shapefile (figure c). These images were later clipped with the ArcToolbox Data Management > Raster > Raster Processing > Clip tool, with the output extent as the county shapefile serving as the input features for clipping geometry (figure d). While not absolutely necessary, the land cover underneath the eventual spatial analysis may play a part in different RQ values.
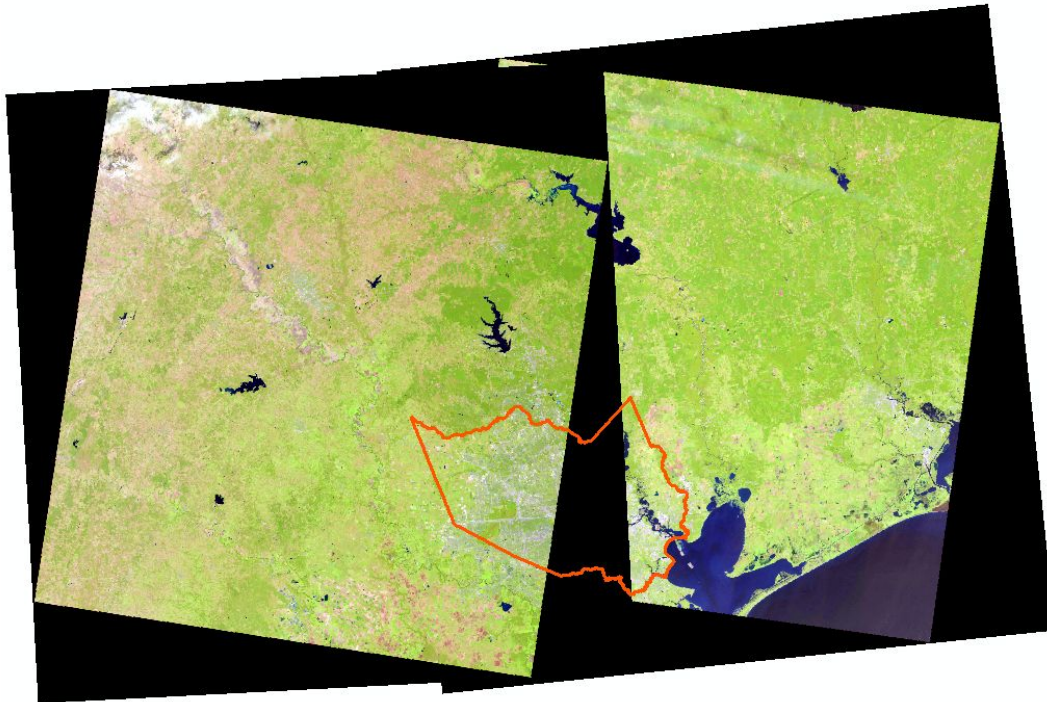
Figure b - Overlap of Landsat 8 raster images in need of clipping to Harris County shapefile.
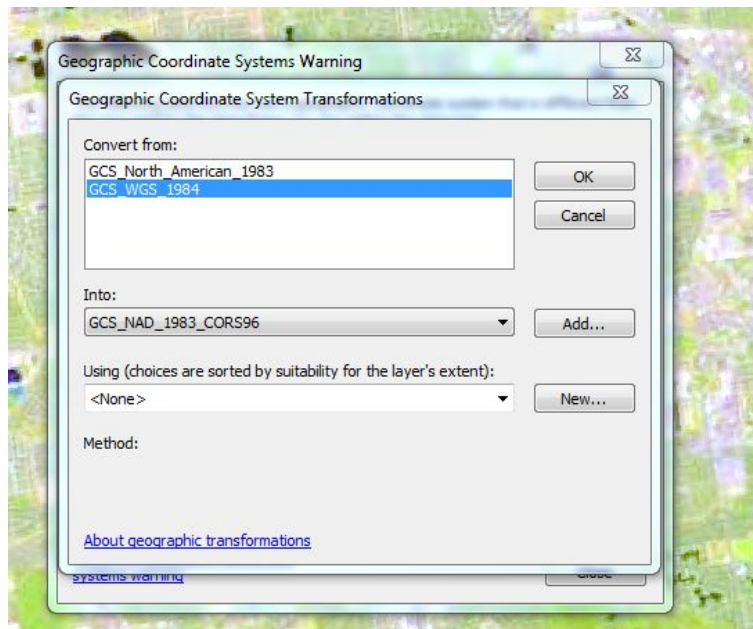

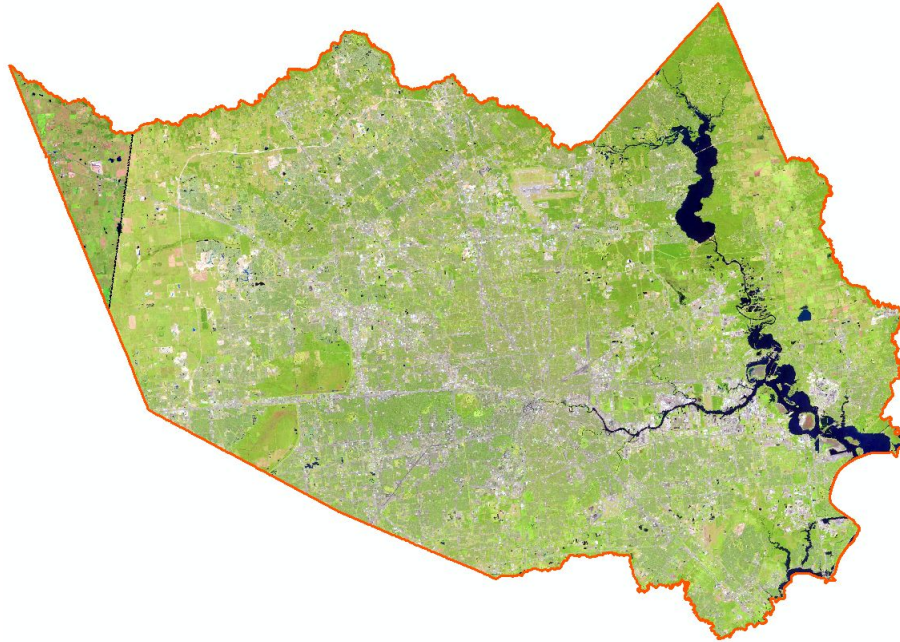Figure c - Geographic Coordinate System Transformation from WGS 1984 to NAD83.

Figure d - Clipped raster files, bound by county lines. Line delineating the two rasters in the west show edges of raster image taken by LandSat 8.

The point data was downloaded from Google and exported as a .KML file because this is the only format available from Google (figure e). Once it was downloaded, it needed to be converted into a layer file with the ArcToolbox tool Conversion Tools > From KML > KML to Layer. Its attribute table could then be inspected and altered if needed. Points were altered to be smaller and more discrete symbols to show off the later processing better (figure f).
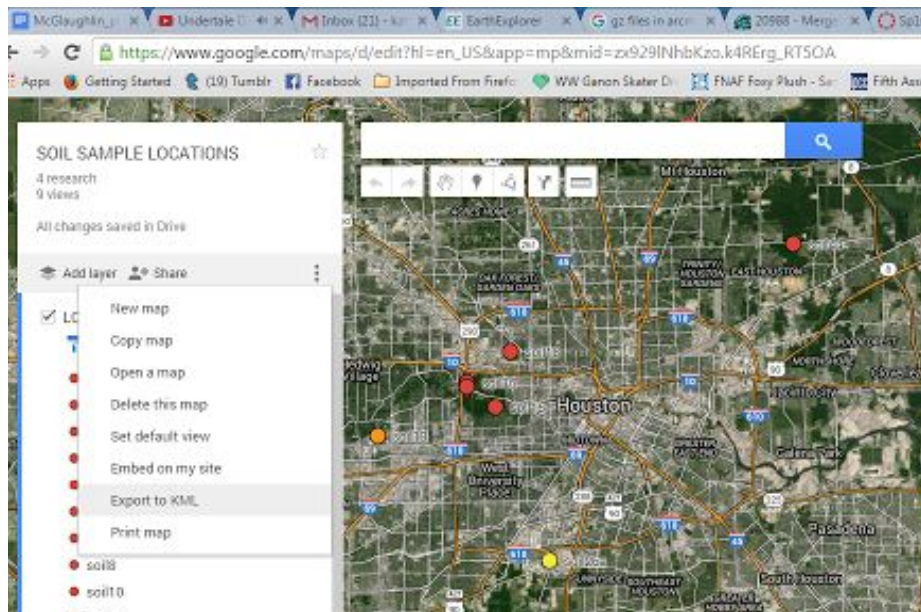

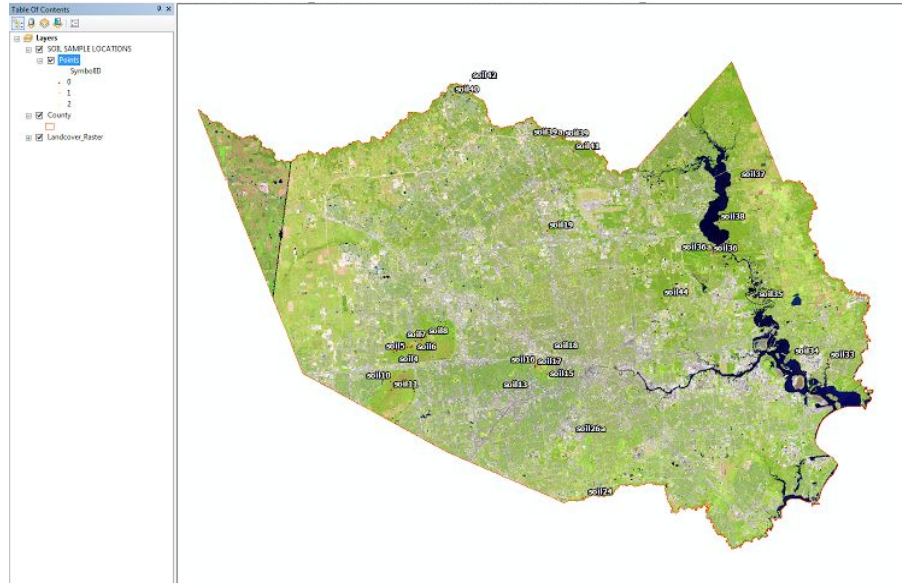Figure e - Exporting the online Google map to .KML file for later use.

Figure f - Layer file of point data, recently converted from .KML file format.

Because point files are also in WGS84, they are listed in geographic coordinates and are difficult to manipulate with other data in NAD83, UTM Zone 15N. The tool used to project this data into NAD83, UTM Zone 15N was in Data Management > Projections and Transformations > Project (figure g). This allowed for consistency across all data sets to permit more accurate data manipulation later when spatial analysis needed to be performed.
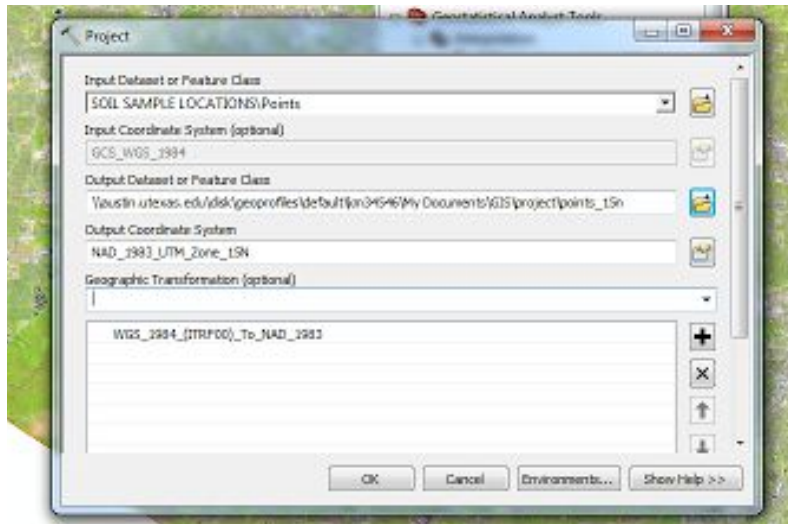

Figure g - Projecting the point data in UTM Zone 15N.

After this, several attributes describing the data can be seen in the .KML file, including symbol ID, FolderPath (where the file is located), and Name (from the Google My Maps program). What information isn't present is the RQ data, as calculated separately on an Excel file. These RQ values were entered the RQ information for each depth manually after adding 3 new Fields for each depth (figure h). These were float fields because RQ is a very precise decimal number, and not an integer.

Name	OID *	FolderPath	SymbolID	RQ_2	RQ_10	RQ_30
soil1	1	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	1.561793	0.961256	0.664303
soil2	2	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	0.701632	0.591516	0.89769
soil3	3	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	0.711184	0.732638	0.293496
soil4	4	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	0.82492	0.684903	0.38413
soil5	5	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	0.569446	0.535402	0.388263
soil6	6	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	0.258215	0.300414	0.268751
soil7	7	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	0.850347	0.422501	0.295612
soil8	8	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	0.8235	0.664784	0.655946
soil10	9	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	0.721874	0.454818	0.329077
soil11	10	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	0.685413	0.686651	0.429399
soil13	11	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	1	<Null>	<Null>	<Null>
soil15	12	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	<Null>	<Null>	<Null>
soil16	13	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	<Null>	<Null>	<Null>
soil17	14	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	<Null>	<Null>	<Null>
soil18	15	SOIL SAMPLE LOCATIONS/LOCATIONS LAYER	0	<Null>	<Null>	<Null>

Figure h - Attribute table of point data, with RQ values in the process of being filled in.

ArcGIS Processing

To determine distribution of RQ values across the area, the Natural Neighbor Tool is used to determine the projected RQ across Harris County. This was chosen over kriging, cokriging, and other geospatial techniques because of a lack of data in certain parts of the County (north west, south east, etc) which would create inaccurate predictions in those areas. Natural neighbor was chosen over IDW and similar deterministic method To perform a Natural Neighbor analysis, the rasters for 2 cm, 10 cm and 30 cm depths were saved into the database for point data, "SOIL SAMPLE LOCATIONS".
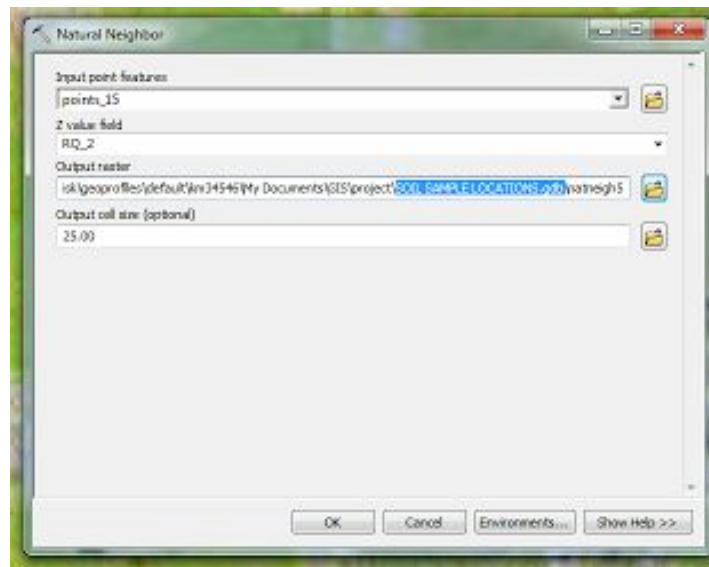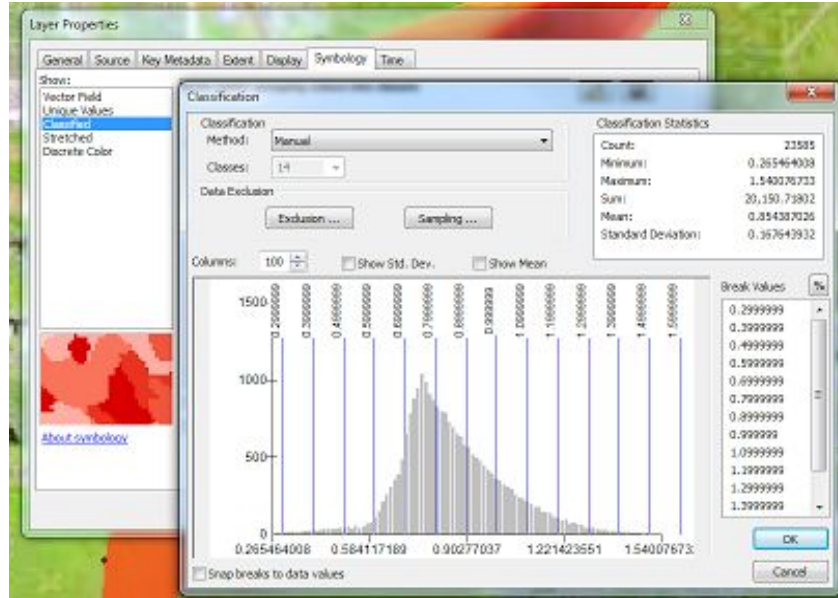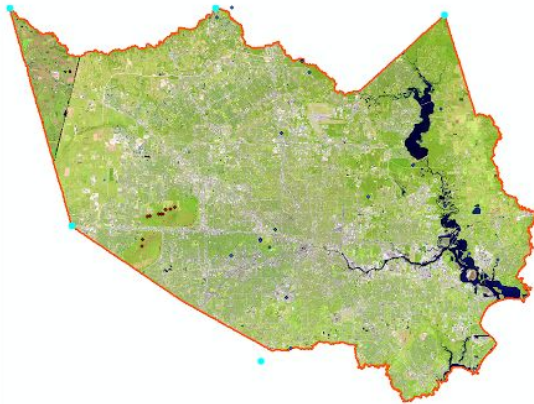

Figure i - Establishment of Natural Neighbor raster for data at 2 cm of depth. 25 foot cell size is used to emphasize detail.

Figures J, K1, K2, K3 - Window with manual classification method, creating classes every 0.1 with "break values". Bottom set of figures (K1-3) is the same data under 16 class scheme, with 2 cm in the far left and 30 cm on the far right, with dark red indicating high RQ values (1.5-1.6) and pale yellow indicating low RQ values (0.0-0.1), with red indicating the estimated global average (0.9-1).

   To circumvent the issue of having spare sampling locations, placeholders with an RQ = 0.77 (2cm), 0.60 (10cm) and 0.46 (30cm) were placed out of Harris County boundaries. These numbers were they are the average RQs from previous runs of the data, and is an ideal RQ value with these methods in this location. To do this, the point data "points_15" was edited with the editor toolbar, and seven points outside of the county were added with 0.92 listed as their RQ values at 2, 10, and 30 cm, shown in figure L.

Figure L- Addition of points outside of Harris County to increase prediction area. These will be removed later because they are only important for the generation of the final raster product.

Finally, the Natural Neighbor analysis will be run on each of the depths with the data available (with unavailable date being labeled as "null"). Natural Neighbor is preferable here because the geology of the area creates similar soil types adjacent to each other, and thereby similar RQ calues closer to each other. Because of the "outie" points outside of the county lines, this will create a raster that stretches across the county and out of county lines, as seen in figure L. From here, clipping is necessary with the Data Management > Raster > Raster Processing > Clip tool. Harris County shapefile will be used as both output extend and as "input feature for clipping geometry", similar to that specified in figure D. This figure, shown in figure M, needs to be reclassified to match the varying RQ values listed.
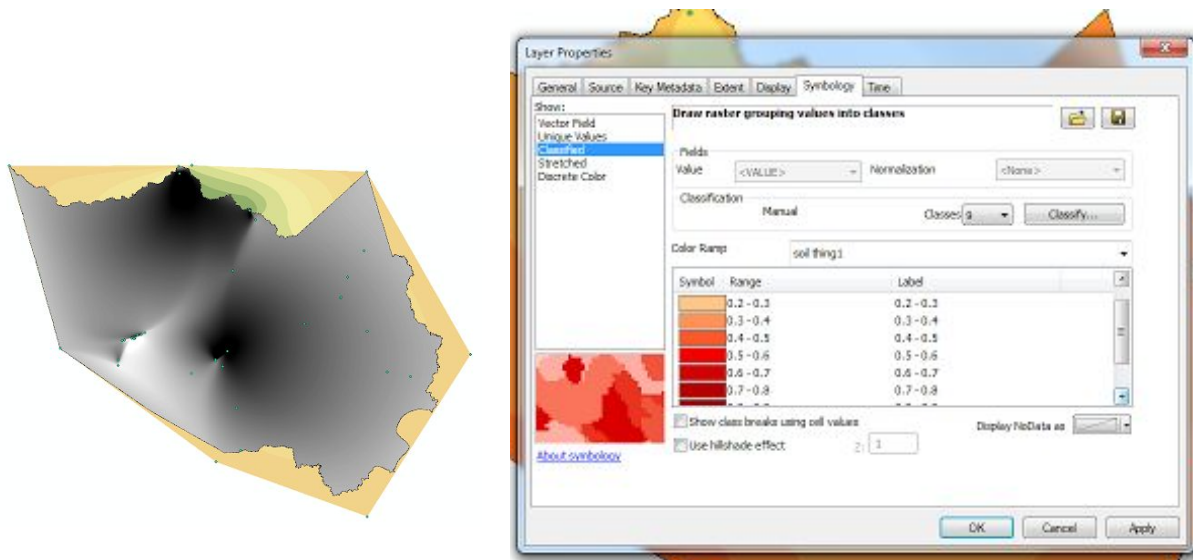

Figure M - Clipping and reclassifying the newly clipped raster for the 10 cm depth data. A different raster was generated for each depth, clipped, and classified.

To generate the areas and percent covers of each RQ at each depth, the Reclassify tool under spatial analysit generates a new raster file. This new file has an attribute table, with the area of each class listed in the table. Both of these are shown in figure N. Repeated for all depths, results can be calculated as percent area or actual area.
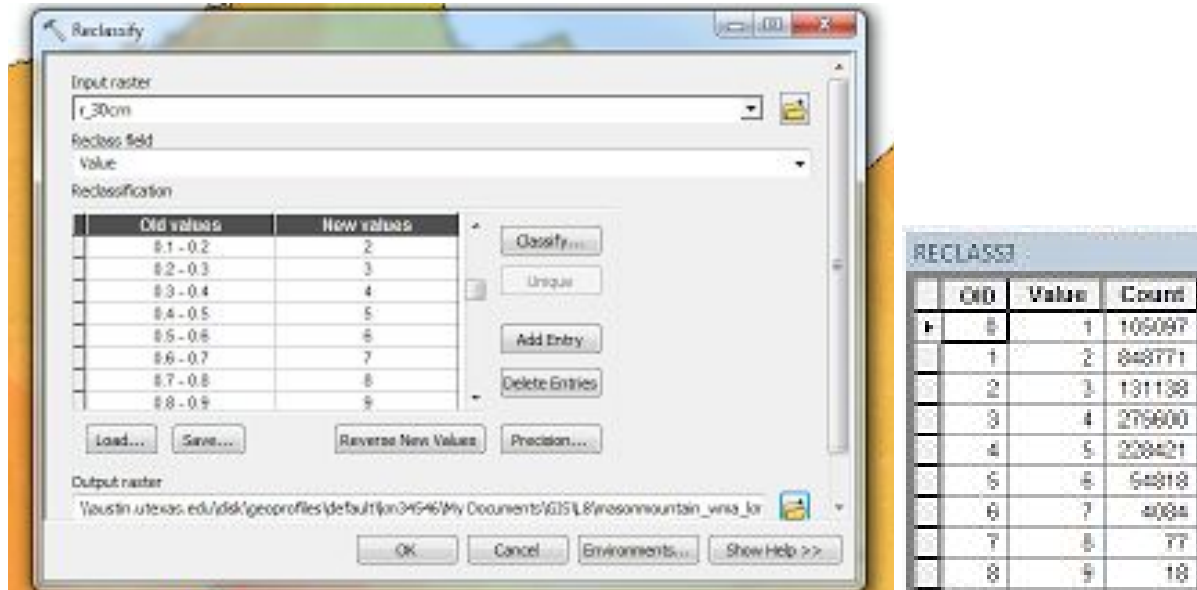

Figure N - Reclassification of 30 cm raster, with new attribute table shown on the left. "Count" indicates cells in each class, with 1 count = 625 ft^2 (25 x 25 ft cell size).

Results

This analysis showed that average RQ at each depth plunges in a downward trend, suggesting less CO2 is produced deeper in the soil.This may be due to the lack of exposure to oxygen - plants and microbes need oxygen to respire, and without atmospheric exposure, respiration is difficult. Unusually high RQ values, like those found clustered together in the West Harris County area, make sense because of all of the decomposing matter on the surface and in the subsurface. This is because those sample locations are in Barker and Addicks reservoir which frequently flood and bring in/destroy vegetation, leaving it to decompose, and raising RQ. Occurs at all depths because of the reservoirs are old and continuously bring in/bury new organic material. Lower RQ values are found near urban areas and towards the center of Harris County. These urban areas may have inefficient microbial CO2 production or may have little organic matter to decompose on the ground, thus lowering RQ values. This assessment unfortunately is only a ⅔ of the entire data set for this research project, and null values were included in the calculation, explaining the lack of curvature in the RQ classes in East and North West Harris County.

Average RQ @ depth across Harris County = SUM((AVGVALUE)*(%AREA@DEPTH))

depth	Average RQ	
2 cm	0.80	
10 cm	0.45	
30 cm	0.24	

% AREA@DEPTH = Count/SUM(COUNT)

RQ Value	% Area at 2 cm	% Area at 10 cm	% Area at 30 cm
0.0-0.1	0	0	6.4
0.1-0.2	0	<0.1	51.5
0.2-0.3	<0.1	6.3	8.0
0.3-0.4	0.4	44.8	16.7
0.4-0.5	4.1	11.6	13.8
0.5-0.6	19.6	15.9	3.3
0.6-0.7	13.0	20.6	0.2
0.7-0.8	27.0	0.5	<0.1
0.8-0.9	22.9	<0.1	<0.1
0.9-1.0	2.4	<0.1	0
1.0-1.1	0.9	0	0
1.1-1.2	0.4	0	0
1.2-1.3	0.2	0	0
1.3-1.4	0.1	0	0
1.4-1.5	<0.1	0	0
1.5-1.6	<0.1	0	0

Projected Respiratory Quotient (RQ) Across Harris County, Texas
2 cm of Depth

Katherine McGlaughlin
May 5, 2016

Legend

RQ Values

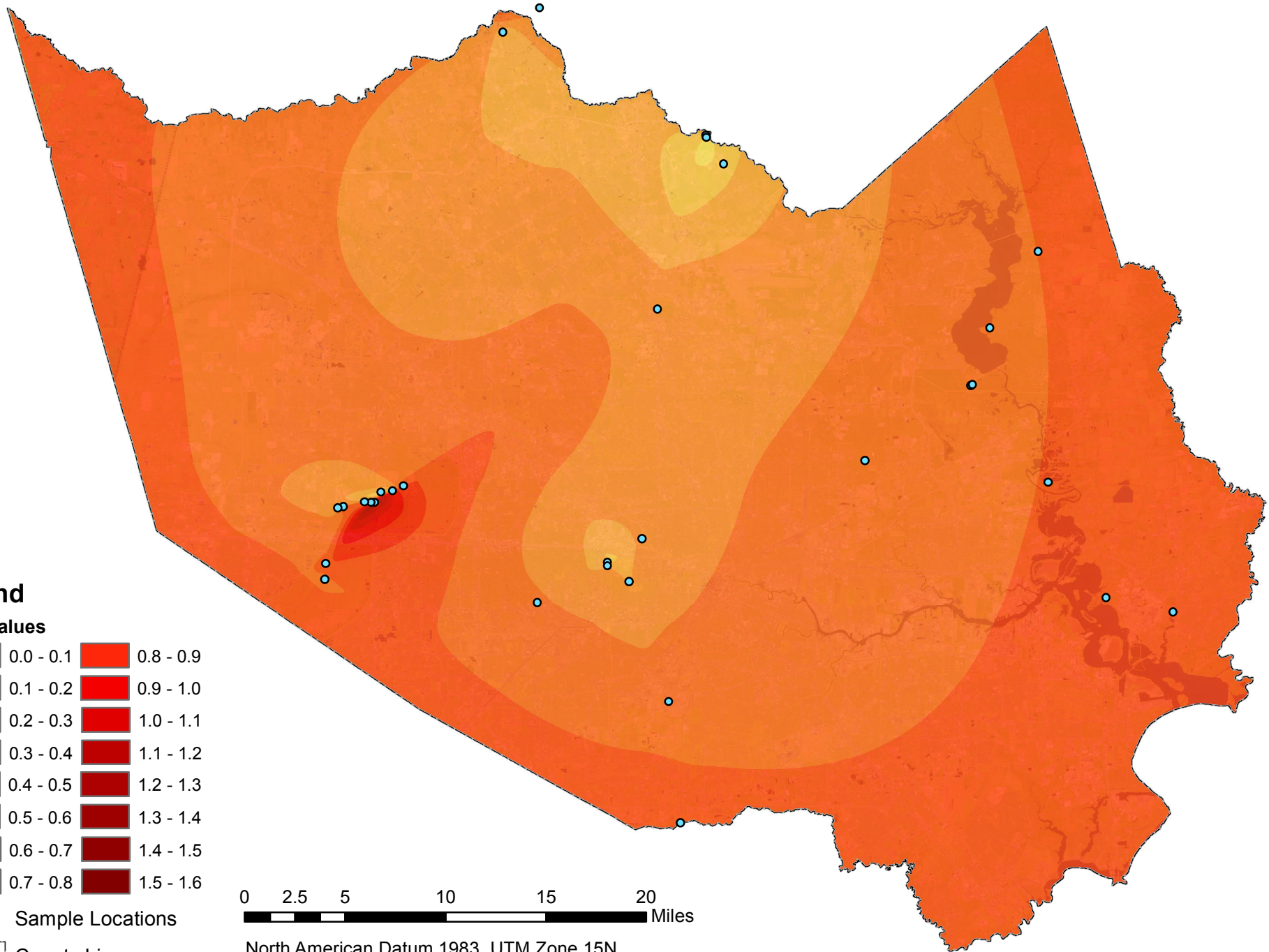|	
0.0 - 0.1	0.8 - 0.9
0.1 - 0.2	0.9 - 1.0
0.2 - 0.3	1.0 - 1.1
0.3 - 0.4	1.1 - 1.2
0.4 - 0.5	1.2 - 1.3
0.5 - 0.6	1.3 - 1.4
0.6 - 0.7	1.4 - 1.5
0.7 - 0.8	1.5 - 1.6

○ Sample Locations

☐ County Lines

0   2.5   5   10   15   20   Miles

North American Datum 1983, UTM Zone 15N

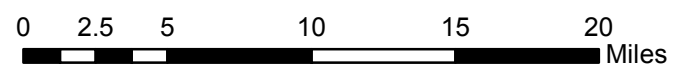# Projected Respiratory Quotient (RQ) Across Harris County, Texas
10 cm of Depth

Katherine McGlaughlin
May 5, 2016

N

Legend

RQ Values

0.0 - 0.1	0.8 - 0.9
0.1 - 0.2	0.9 - 1.0
0.2 - 0.3	1.0 - 1.1
0.3 - 0.4	1.1 - 1.2
0.4 - 0.5	1.2 - 1.3
0.5 - 0.6	1.3 - 1.4
0.6 - 0.7	1.4 - 1.5
0.7 - 0.8	1.5 - 1.6

○ Sample Locations

County Lines

0   2.5   5   10   15   20   Miles

North American Datum 1983, UTM Zone 15N

Projected Respiratory Quotient (RQ) Across Harris County, Texas
30 cm of Depth

Katherine McGlaughlin
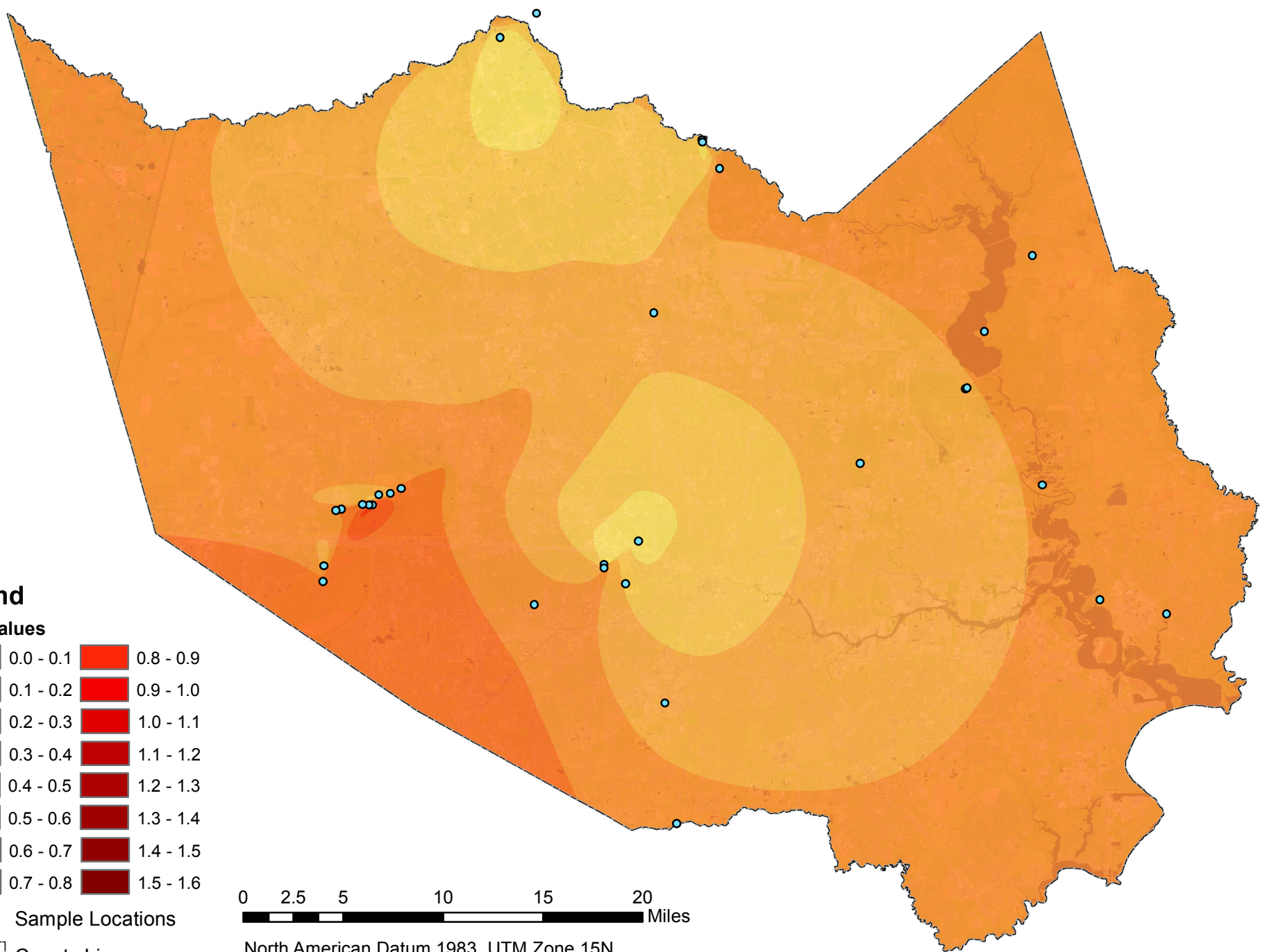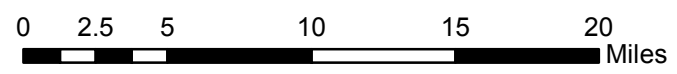May 5, 2016

N

Legend

RQ Values

	0.0 - 0.1		0.8 - 0.9
	0.1 - 0.2		0.9 - 1.0
	0.2 - 0.3		1.0 - 1.1
	0.3 - 0.4		1.1 - 1.2
	0.4 - 0.5		1.2 - 1.3
	0.5 - 0.6		1.3 - 1.4
	0.6 - 0.7		1.4 - 1.5
	0.7 - 0.8		1.5 - 1.6

Sample Locations

County Lines

0   2.5   5   10   15   20   Miles

North American Datum 1983, UTM Zone 15N