



# GIS for Property Tax Professionals: Using ArcGIS Pro and the R-ArcGIS Bridge for Modeling Fair & Equitable Valuations

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ESRI USER CONFERENCE



## Valuations, Valuation models, and GIS working together

- **Visualize data variables spatially, graphically, and within tables at the same time.**
- **Provides the necessary functionality to run analysis**
  - **Look at relationships , patterns, and correlations.**
  - **Analyze model and ratio diagnostics.**
  - **Also provides a way for a professional who knows how to use GIS to build models in the valuation profession.**
- **This presentation will provide a demonstration of a workflow for using ArcGIS Pro to build a valuation model.**

## Steps for modeling property sales data in ArcGIS Pro

- Import sale data from CAMA using SQL or .csv file.
- Add XY data to display sales as points.
- Data exploration (Can do with the R bridge in R, or in ArcPro with python)
  - Analyze patterns and relationships, look at overlays etc.
  - Variable transformations if necessary using python or R.
  - Preliminary ratio study (Using a tool created from R bridge)
- Build an OLS or GWR model from spatial statistic tools
- Analyze model diagnostics and recalibrate if necessary.
- Analyze spatial distribution of coefficients and point estimates.
- Analyze ratio study diagnostics.
- Repeat as necessary!

# Import Data from CAMA or other data source

Connect to a database and define the query.

Connection: remsodax51-scan.sde

List of Tables:

Name
GIS_REMS.PARCOPY
<b>GIS_REMS.PARDAT</b>
GIS_REMS.PARDATL
GIS_REMS.PARDATLMAX
GIS_REMS.PARDAT_ALL
GIS_REMS.PARDAT_HIST
GIS_REMS.PARDAT_IASW
GIS_REMS.PARDAT_SALE
GIS_REMS.PARDAT_SALE_IASW
GIS_REMS.PARDIST
GIS_REMS.PARDIST_ALL

Columns:

Name	Type	Nullable
JUR	Text	False
PARID	Text	False
TAXYR	Short	False
SEQ	Short	False
CUR	Text	True
WHO	Text	True
WEN	Date	True
WHOCALC	Text	True
WENCALC	Date	True
STATUS	Text	True
ALT_ID	Text	True

Name: SALES\_EXTRACT

Query:

```
SELECT
SUBSTR(P.PARID,1,2) DISTRICT,
P.PARID,
COUNT(D.PARID) OVER(PARTITION BY D.PARID) XCARD,
P.USER10 QUINTILE,
D.ADJFACT,
P.NBHD,
LP.NGROUP,
RM.CLUST,
MC.DEFMOD,
NVL(P.USER6,0) ACRES,
NVL(P.USER14,0) LNSQFT,
P.USER1 WATER,
P.USERS WATERTYPE,
SUM(CASE WHEN CODE IN ('FD0','000') THEN ADJACENT ELSE 0 END) DETGARVAL,
NVL(SUM(USER3),0) DETGARSTALLS
FROM GIS_REMS.OBY WHERE CUR = 'Y' AND TAXYR = 2018
GROUP BY PARID
)
```

Let ArcGIS Pro discover spatial properties for the layer  
 Define spatial properties for the layer

Validate

Back Next Cancel

Can connect directly to a data source and consume CAMA or sales data in SQL or Oracle.

Can write any SQL statement along with aliases and call PL/SQL functions.

Does not recognize commented lines.

Once table is built then can join on common attribute such as PARID in parcel polygon layer for CAMA attribution.

Sales can be built as points if XY coordinates are part of the query.

# Exploratory Data Analysis

The screenshot displays the ArcGIS Pro interface with the following components:

- Map View:** A map of Fargo, ND, showing a grid of streets and numerous red and cyan circular markers representing data points.
- Contents Panel:** Shows the 'Fargo' workspace with layers including 'saledata', 'FargoData', 'Sale', 'Assessment Neighborhoods', 'Story Height', 'Total Value/SqFt', 'Topographic', and 'Standalone Tables'.
- Chart Properties Panel:** Displays the 'Relationship between CURVAL and ADJPRICE' chart. It includes the following statistics:
  - Variables: X-axis Number (CURVAL), Y-axis Number (ADJPRICE)
  - Statistics:  Show linear trend,  $y = 17753.12613 + 0.93200x$ ,  $R^2 = 0.8659159967$
  - Axes: X-axis, Y-axis
  - Number format: Standard
- Table View:** Shows a table of selected features from the 'saledata' layer:

OBJECTID	Shape	ParcelNo	ADJPRICE	CURVAL	SLRATIO	SLDATE	PROPTY	ASA
1717	Point Z	01-0100-00460-000	125900	838000	665.6	8/15/2014	2	
2859	Point Z	01-0100-00610-000	107600	717000	666.35	10/1/2014	1	
2865	Point Z	01-0100-00620-000	113300	717000	632.83	10/1/2014	1	
3656	Point Z	01-0100-00190-000	200000	1498000	749	7/30/2014	1	

# Exploratory Data Analysis

The screenshot displays the ArcGIS Pro interface for an exploratory data analysis. The main map shows a distribution of red points representing ADJPRICE by GRADE. A box plot chart is overlaid on the map, showing the distribution of ADJPRICE for grades 2 through 7. The chart shows a clear upward trend in price as the grade increases. The interface includes various toolbars, a Contents pane, and a Chart Properties pane.

**Chart Properties**

saledata - Distribution of ADJPRICE by GRA...

Data | General

- Create multiple series from a split field
- Create multiple series from multiple fields

**Variables**

Number

Fields

- ADJPRICE

Category (optional)

GRADE

Split by (optional)

Series

Fields | Label

- <Series> | ADJPRICE

Show outliers

> Axes

> Number format

**Table**

OBJECTID	Shape	ParcelNo	ADJPRICE	CURVAL	SLRATIO	SLDATE	PROPTY	ASA
1717	Point Z	01-0100-00460-000	125900	838000	665.6	8/15/2014	2	
2859	Point Z	01-0100-00610-000	107600	717000	666.35	10/1/2014	1	
2865	Point Z	01-0100-00620-000	113300	717000	632.83	10/1/2014	1	
3656	Point Z	01-0100-00190-000	200000	1498000	749	7/30/2014	1	

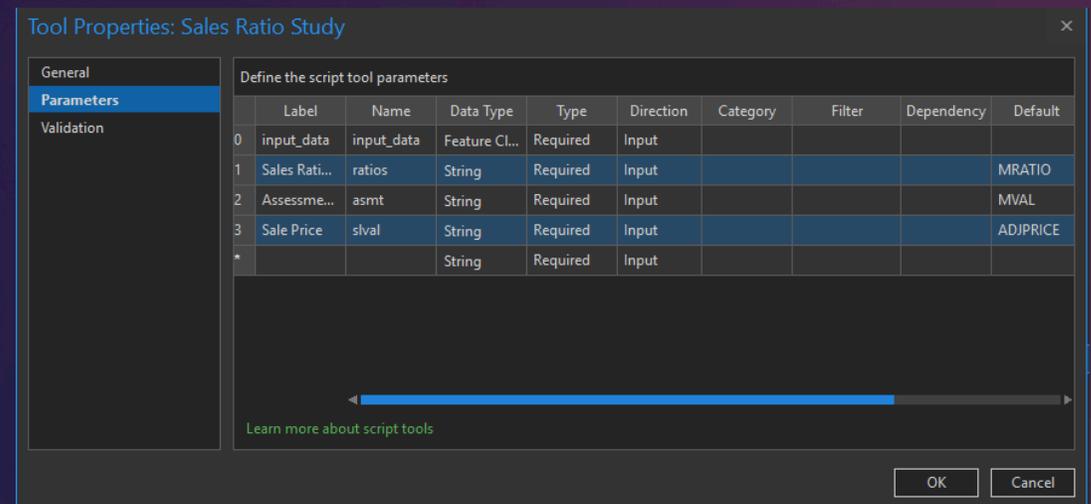
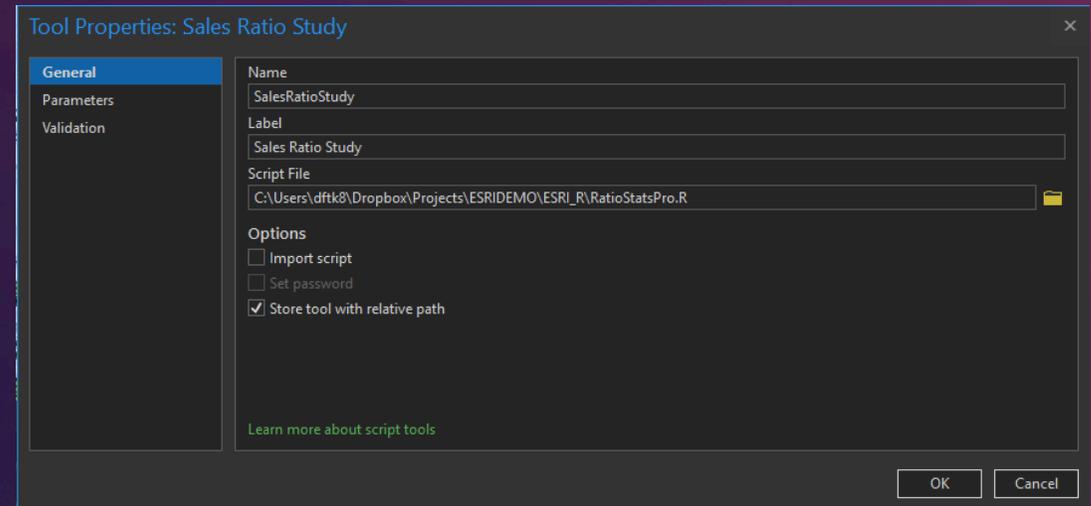
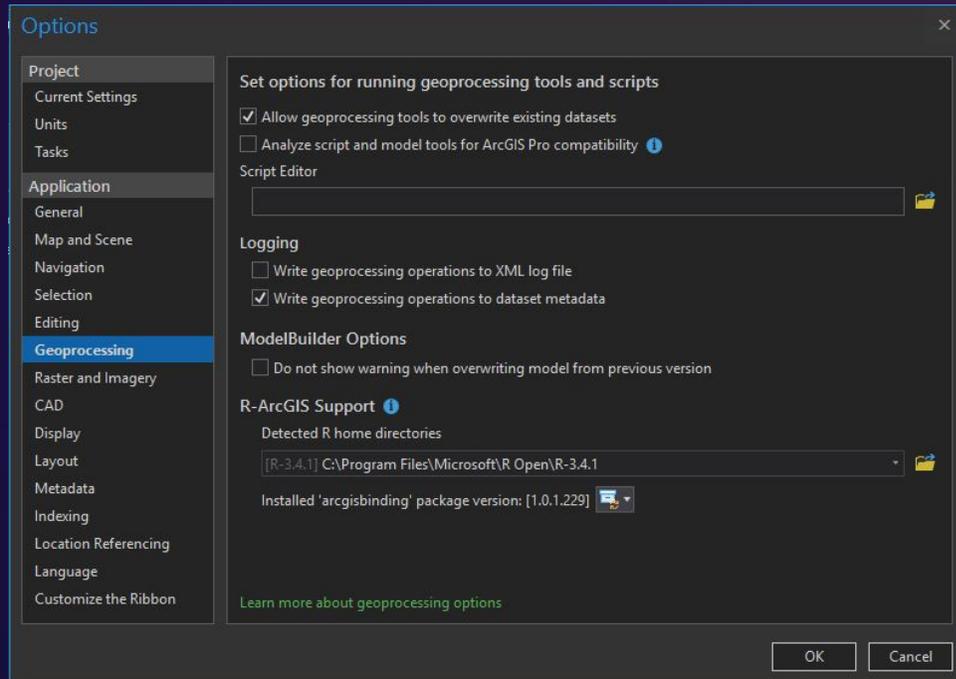
# Exploratory Data Analysis

The screenshot displays the ArcGIS Pro interface with the 'Data' tab active. The main map shows a geographic area with red circular markers representing data points. A 'Comparison of ADJPRICE and Normal Distributions' plot is overlaid on the map, showing a positive linear correlation between ADJPRICE and Standard Normal Value. A 'Reference' line is also shown for comparison.

The data table on the right contains the following information:

OBJECTID	Shape	ParcelNo	ADJPRICE	CURVAL	SLRATIO	SLDATE	PROPTY
5040	Point Z	01-7230-00030-120	735600	697200	94.77	2/10/2016	1
5628	Point Z	01-6520-00090-000	703200	563900	80.19	7/15/2015	1
5647	Point Z	01-8489-00390-000	768200	796800	103.72	12/23/2014	1
5685	Point Z	01-7500-01200-000	958000	835100	87.17	12/9/2016	1
5707	Point Z	01-8489-00410-000	790100	820500	103.84	8/7/2015	1
5768	Point Z	01-7020-02320-000	902400	759900	84.2	4/18/2016	1
5788	Point Z	01-2489-00200-000	750000	608500	81.13	8/8/2016	1
5806	Point Z	01-8470-00060-000	1000800	1004900	100.4	9/29/2017	1
5871	Point Z	01-8510-01000-000	844800	887900	105.1	7/3/2017	1
5878	Point Z	01-3210-00540-000	700200	725900	103.67	8/26/2014	1
5907	Point Z	01-8536-01020-000	729500	721200	98.86	2/12/2016	1
5928	Point Z	01-3210-00480-000	735300	750800	102.1	1/12/2015	1
5955	Point Z	01-3210-00410-000	855800	1020600	119.25	12/14/2015	1

# R – ArcGIS bridge script tool



```
install.packages("arcgisbinding")
```

```
library(arcgisbinding)  
arc.check_product()
```

```
> library(arcgisbinding)  
> arc.check_product()  
product: ArcGIS Pro ( 12.1.3.10257 )  
license: Advanced  
version: 1.0.1.229  
> |
```

# R – ArcGIS Bridge and the sales ratio study script

```
1 #####
2 ## Daniel J. Fasteen, Ph.D.
3 ## Ratio Study Statistics for Models in ESRI
4 ## Calculates Counts, Median, Mean, COD, PRD, PRB, PRB Lower CI, PRB Upper CI,
5 ## Date: 10/10/2017
6 #####
7
8 #Tool Wrappings
9 tool_exec<- function(in_params, out_params){
10 #####
11 ### Check/Load Required Packages
12 #####
13 if (!requireNamespace("sp", quietly = TRUE))
14   install.packages("sp")
15   require(sp)
16 if (!requireNamespace("lawstat", quietly = TRUE))
17   install.packages("lawstat", quiet = TRUE)
18   require(lawstat)
19 if (!requireNamespace("arcgisbinding", quietly = TRUE))
20   install.packages("arcgisbinding", quiet = TRUE)
21   require(arcgisbinding)
22
23 #print(arc.check_product())
24 print('### IAAO SALES RATIO STUDY STATISTICS ###')
25
26 arc.progress_label("Loading packages...")
27 arc.progress_pos(20)
28
29 #####
30 ### Define input/output parameters
31 #####
32
33 input_data <- in_params[[1]]   ### SHAPEFILE OR FEATURE CLASS (FILE LOCATION)
34 ratios <- in_params[[2]]      ### COLUMN WITH SALES RATIOS
35 asmt <- in_params[[3]]        ### COLUMN WITH ASSESSMENT DATA OR MODEL OUTPUT
36 slval <- in_params[[4]]       ### COLUMN WITH SALE PRICES
37
38 #####
39 ### Load Data and Create Dataframe R Object
40 #####
41 arc.progress_label("Loading data...")
42 d <- arc.open(input_data)
43 |
44 #Create a data frame with the variables needed to run ratio analysis
45 fields <- append(c(ratios), c(asmt, slval))
46
47 ddf <- arc.select(d, fields = c(ratios, asmt, slval))
48 colnames(ddf) <- c("ratios", "asmt", "slval")
49
```

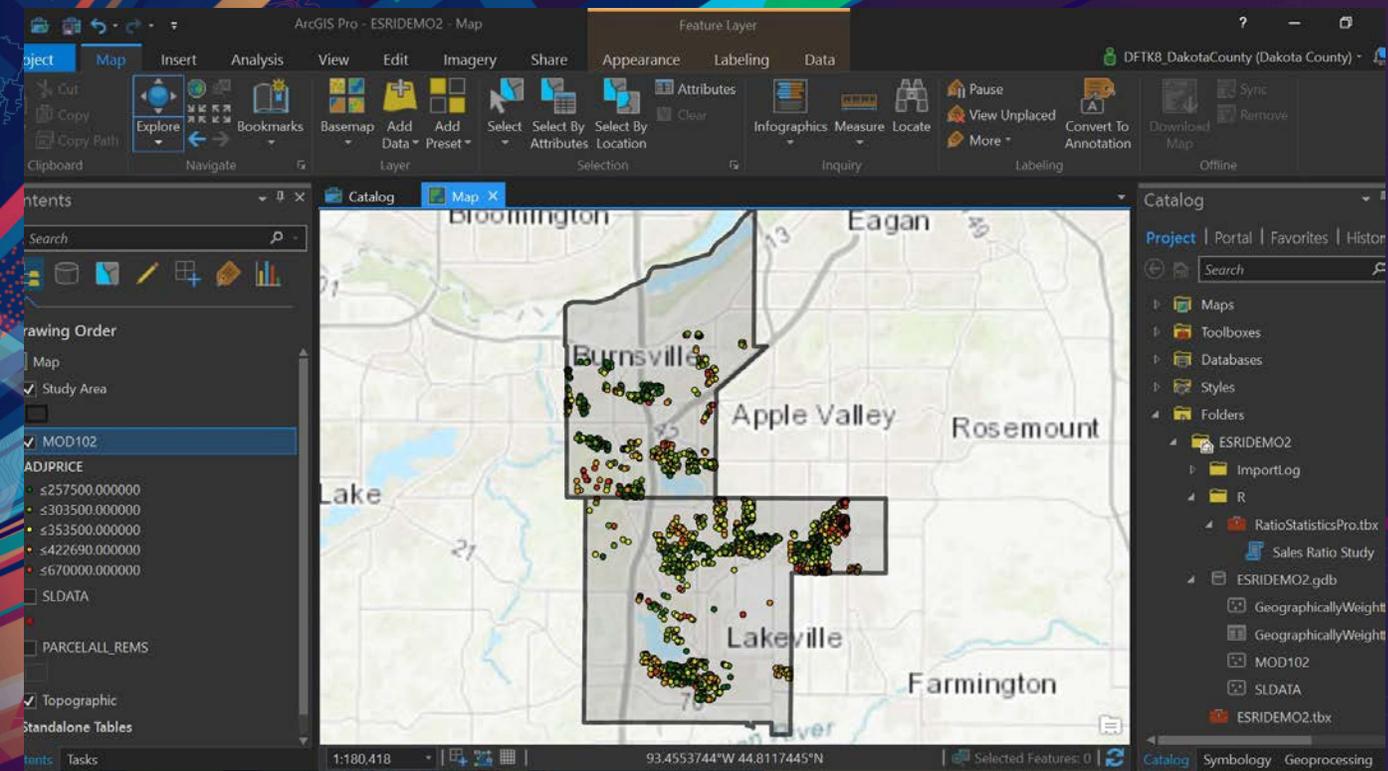
```
50 #####
51 ### CALCULATE SALES RATIO STATISTICS
52 #####
53
54 size <- length(ddf$ratios)
55 med_rat <- median(ddf$ratios)
56 mean_rat <- sum(ddf$ratios)/size
57 whtmean_rat <- sum(ddf$asmt)/sum(ddf$slval)
58
59 #find COD
60 cod_rat <- cd(ddf$ratios)$statistic * 100
61 names(cod_rat) <- NULL
62
63 #find prd
64 prd = mean_rat/whtmean_rat
65
66 #find prb
67 value <- (ddf$asmt/med_rat + ddf$slval)/2
68 l <- log(ddf$slval)/log(2)
69 per_diff <- (ddf$ratios - med_rat)/med_rat
70 reg <- lm(per_diff ~ l)
71 #summary(reg)
72
73 prb_rat <- reg$coefficient[2]
74 prb<-as.numeric(prb_rat)
75
76 #names(prb_rat) <- NULL
77
78 #PRB Confidence Interval
79 prb_confidence_interval <- c(prb - qt(p=0.95,df=size)*summary(reg)$coefficients[2,2],
80                             (prb + qt(p=0.95,df=size)*summary(reg)$coefficients[2,2]))
81
82 rm(d, ddf, asmt, fields, input_data, ratios,prb_rat, slval,l, value, per_diff, reg, whtmean_rat)
83
84 #VIEW RESULTS IN SEPERATE DATAFRAME
85 resultsRATIOS <- data.frame(
86   N = size,
87   MEDIAN = med_rat,
88   MEAN = mean_rat,
89   COD = cod_rat,
90   PRD = prd,
91   PRB = prb,
92   PRB_Low = prb_confidence_interval[1],
93   PRB_Up = prb_confidence_interval[2])
94
95 #REMOVES VALUES FROM MEMORY
96 rm(size,med_rat,mean_rat,cod_rat,prd,prb, prb_confidence_interval)
97
98 #####
99 ### SALES RATIO STATISTICS RESULTS
100 #####
101 print(resultsRATIOS)
102 rm(resultsRATIOS)
103 }
```

# R – ArcGIS Bridge

The screenshot shows the ArcGIS Bridge interface with the following components:

- Map Window:** Displays a map of Burnsville, Apple Valley, and Lakeville. A study area is outlined, and numerous colored points (representing sales data) are scattered across the area.
- Geoprocessing Window:** Shows the 'Sales Ratio Study' tool. The parameters are:
  - input\_data: C:\Users\dftk8\Dropbox\Projects\ESRIDEMO\ESRIDEMO2\ESRIDEMO2.gdb\MOD102
  - Sales Ratio Field: SLRATIO
  - Assessments Value Field: CURTOT
  - Sale Price: ADJPRICEThe Messages pane shows the following output:

```
Start Time: Wednesday, July 11, 2018 9:10:44 AM
Running script SalesRatioStudy...
[1] "### IAAO SALES RATIO STUDY STATISTICS ###"
N  MEDIAN  MEAN  COD  PRD  PRB  PRB_Low  PRB_Up
1  1747  1.006207  1.015375  7.70569  1.006317  -0.1140718  -0.1284104  -0.09973334
Completed script Sales Ratio Study...
Succeeded at Wednesday, July 11, 2018 9:10:44 AM (Elapsed Time: 0.79 seconds)
```
- Geoprocessing List:** Shows the 'Sales Ratio Study' tool as 'Completed successfully' with a 'Run' button.
- Contents Panel:** Lists layers including 'Study Area', 'MOD102', 'ADJPRICE', 'SLDATA', and 'PARCELALL\_REMS'. The 'ADJPRICE' layer is expanded to show a legend with five price ranges.



# Geographically Weighted Regression (GWR)

Using ArcGIS Pro

[Click to watch video](#)

# Model results and diagnostics

The screenshot shows the ArcGIS Desktop interface with the Geoprocessing window open for the 'Sales Ratio Study'. The window displays the following parameters:

- input\_data: C:\Users\dftk8\Dropbox\Projects\ESRIDEMO\ESRIDEMO2\ESRIDEMO2.gdb\GeographicallyWeightedRegression7
- Sales Ratio Field: MRATIO
- Assessments Value Field: Predicted
- Sale Price: Observed

The Messages window shows the following output:

```

Start Time: Wednesday, July 11, 2018 9:43:20 AM
Running script SalesRatioStudy...
[1] "### IAAO SALES RATIO STUDY STATISTICS ###"
N  MEDIAN  MEAN  COD  PRD  PRB  PRB_Low  PRB_Up
1  1747  0.997727  1.007543  7.281507  1.00973  -0.1679212  -0.1797729  -0.1560695
Completed script Sales Ratio Study...
Succeeded at Wednesday, July 11, 2018 9:43:21 AM (Elapsed Time: 0:46 seconds)
    
```

The main map area shows a map of a lake area with a scale of 1:180,418. The Contents pane on the left shows the layer 'GeographicallyWeightedRegression7' selected, with a legend for 'StdResid' ranging from < -2.5 Std. Dev. to > 2.5 Std. Dev.

### Geographically Weighted Regression (GWR) (Spatial Statistics Tools) X

Completed Today at 9:41:31 AM

Parameters	
Input features	MOD102
Dependent variable	ADJPRICE
Explanatory variable(s)	AGLA;GRADE;MODIFF;ACRES
Output feature class	C:\Users\dftk8\Dropbox\Projects\ESRIDEMO\ESRIDEMO2\ESRIDEMO2.gdb\GeographicallyWeightedRegression7
Kernel type	ADAPTIVE
Bandwidth method	AICc
Distance	
Number of neighbors	30
Weights	
Coefficient raster workspace	
Output cell size	49.804
Prediction locations	
Prediction explanatory variable(s)	
Output prediction feature class	
GWR_supp output table	C:\Users\dftk8\Dropbox\Projects\ESRIDEMO\ESRIDEMO2\ESRIDEMO2.gdb\GeographicallyWeightedRegression7_supp
Coefficient rasters	

**Messages**

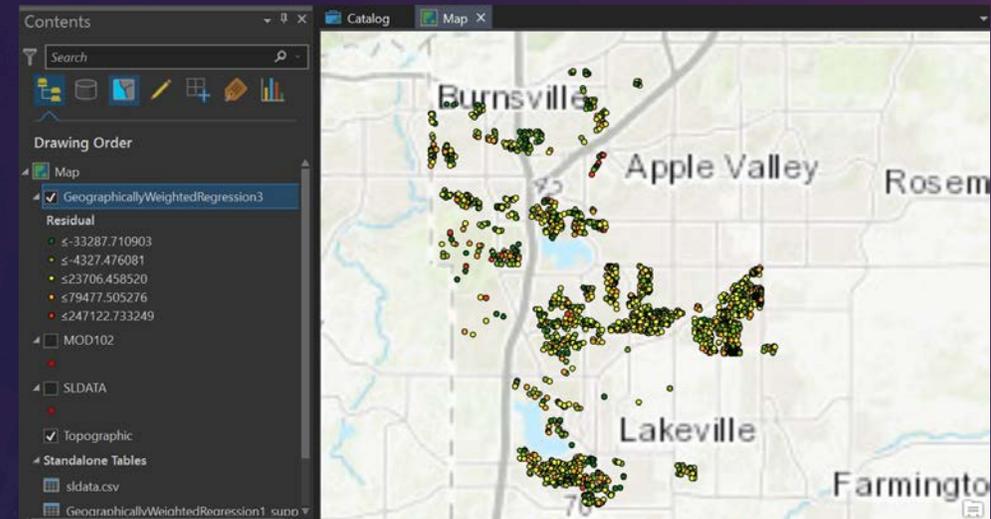
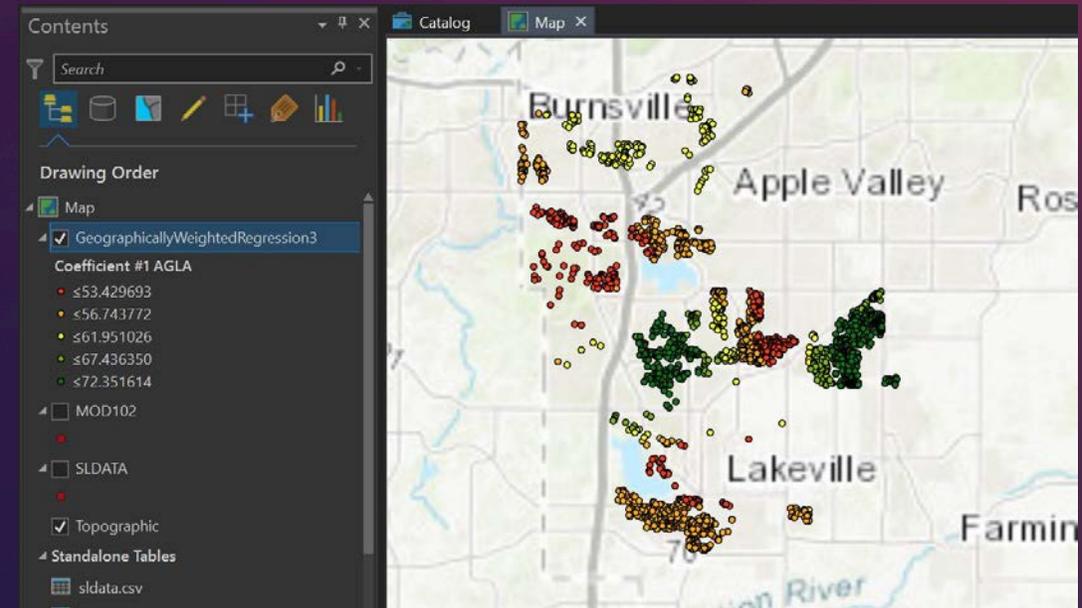
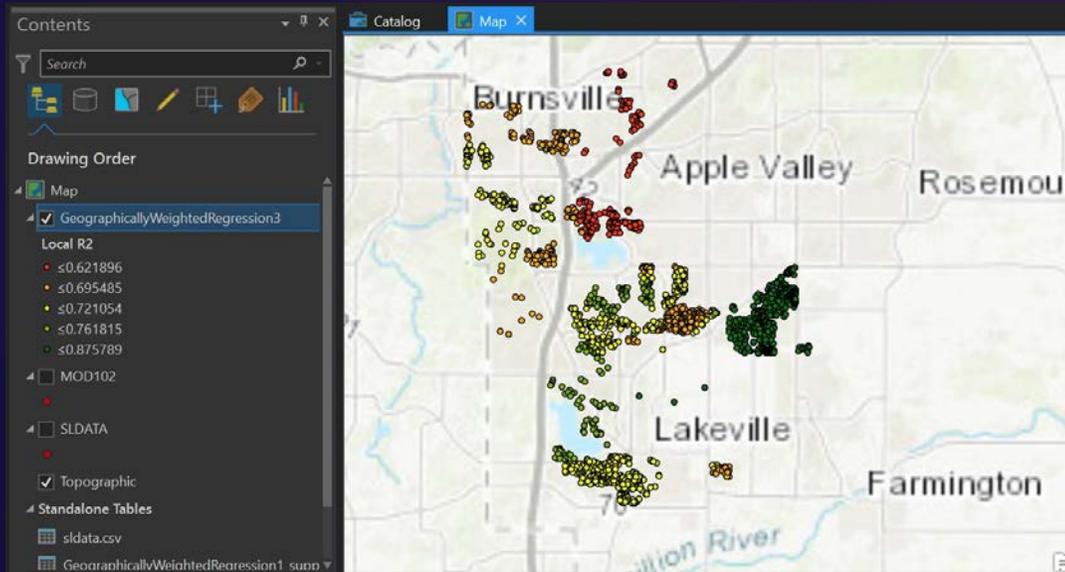
Start Time: Wednesday, July 11, 2018 9:41:22 AM

```

Neighbors : 437
ResidualSquares : 1681047032884.1052
EffectiveNumber : 56.735707499425047
Sigma : 31536.436910711745
AICc : 41185.822390378482
R2 : 0.77549654173307103
R2Adjusted : 0.7680936408150949
    
```

Succeeded at Wednesday, July 11, 2018 9:41:30 AM (Elapsed Time: 7.85 seconds)

# Analyzing the results



## Why perform this analysis in GIS?

- **Most local governments have ESRI licenses.**
- **R is free!**
- **Puts additional tools in the hands of assessors to view their sales data and analyze statistical relationships without needing a statistician on staff.**
- **Allows assessors to visualize what's happening and where!**

### Go Further

- **Use Cluster and grouping tools to segment out areas and understand what forces are shaping the market.**
- **Use interpolation to build statistical surfaces.**
- **Extrude into 3D**

**Thank You!!**

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