





2018 National Tribal GIS Conference QGIS Training

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# Part A. Introduction to QGIS

## 1. QGIS

- QGIS is a free and open source cross-platform (Windows, Mac OS, Linux, BSD, and Android) Desktop Geographic Information System (GIS)
- QGIS can help users create, edit, visualize, analyze, and publish geospatial data
- QGIS integrates with other open source GIS software, including but not limited to PostGIS, GRASS GIS, and MapServer
- QGIS supports shapefiles, coverages, <u>file or personal geodatabases (only feature class)</u>, many raster formats (e.g., .tif, .img, etc.), and many other formats (e.g., PostGIS layers and SpatiaLite layers, GPX layers, etc.)

### 2. QGIS vs. ArcGIS

- QGIS free and open source software, more stable, less analysis tools, multi-platform
- o ArcGIS commercial software, less stable, more analysis tools, single-platform

### 3. Start to Learn QGIS

- o Graser, A. 2016. Learning QGIS, 3rd ed. Packt Publishing, Birmingham, UK.
- Mastering QGIS, Menke, K., Smith, R. Jr., Pirelli, L., and Van Hoesen, J. *Mastering QGIS*, 2nd ed. Packt Publishing, Birmingham, UK.
- Graser, A., Mearns, B., Mandel, A., Ferrero, V. O., and Bruy A. QGIS: Becoming a GIS Power User. Packt Publishing, Birmingham, UK.
- o Website
  - QGIS Workshop http://maps.cga.harvard.edu/qgis/
  - QGIS Tutorials and Tips <u>http://qgistutorials.com</u>
- Online Education
  - Udemy Introduction to GIS <u>https://www.udemy.com/gis-for-everyone/</u>
  - Udemy Learnt to use QGIS <u>https://www.udemy.com/draft/149366/</u>

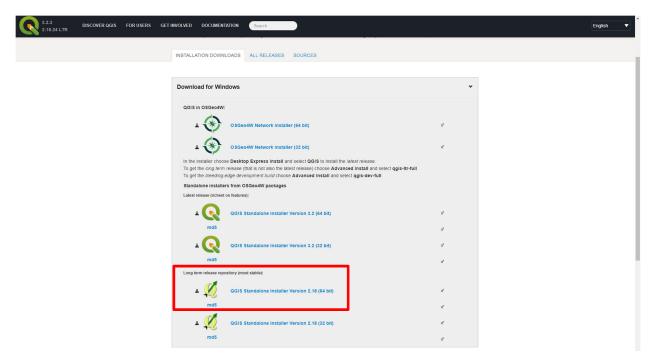
## 1. Download QGIS

(1) Go to <u>www.qgis.com</u>

(2) You will see a website looks like this; click on "Download Now" to go to the download page

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(3) Select the latest version that is compatible with your operating systems to download; preferably 64-bit; the long term release version is the most stable one for your choice

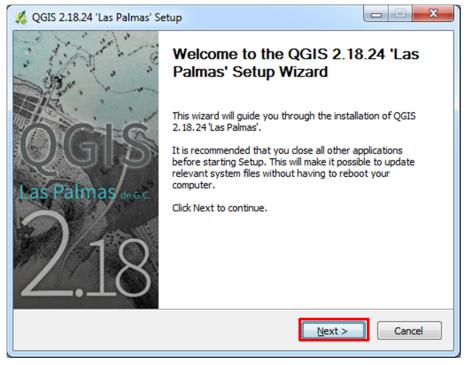


(4) Click on the QGIS Standalone Installer Version 2.18 (64 bit) and the web browser should be able to automatically download the installer

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3.2.3 DISCOVER QGIS FOR USERS 2.18.24 LTR	s get involved documentation Search	English 🔻
	Download QGIS for your platform	
	Binary packages (installers) are available from this page.	
	The current version is QGIS 3.2.3 'Bonn' and was released on 14.09.2018.	
	The long-term repositories currently offer QGIS 2.18.24 'Las Palmas'.	
	QGIS is available on Windows, MacOS X, Linux and Android.	
	We are currently in feature freeze preceeding the release of QGIS 3.4. Please consider testing the prevaleases. See road map.	
	INSTALLATION DOWNLOADS ALL RELEASES SOURCES	
	Download for Windows	
	QGIS in OSGeo4W:	
	OSGeo4W Network Installer (64 bit)	
	SGeo4W Network Installer (32 bit)	
	In the Installer choose Desktop Express Install and select QGIS to Install the latest release.	
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### 2. Install QGIS

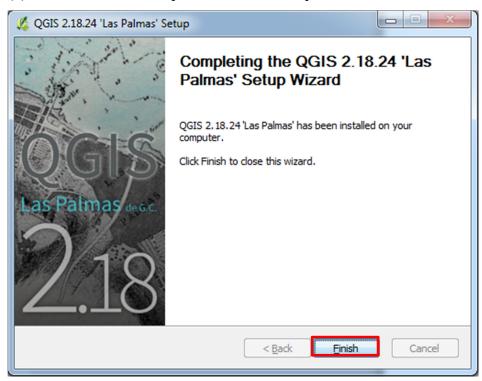
(1) Double click the installer; QGIS Setup Wizard will pop up; click Next to start the installation process; you will see a few dialogues including the License Agreement, Installation Location, and Components to Install, etc.



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(2) Click "Finish" to complete the installation process



Note: if you are using Mac OS X, click "Download for Mac OS X", and then select the version you want to download; the installation file (.dmg file) will be automatically downloading; you can install it directly. In the past, you have to the QGIS download page <u>http://www.kyngchaos.com/software/qgis</u> to do.

Note: for Linux please use the following command line for downloading and installation

sudo add-apt-repository http://qgis.org/debian

sudo apt-key adv --keyserver keyserver.ubuntu.com --recv-key CAEB3DC3BDF7FB45

sudo apt update

sudo apt install qgis

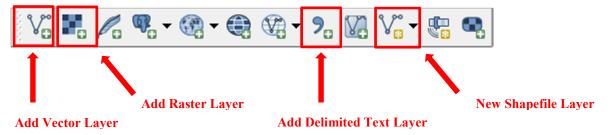
## 3. The QGIS Interface and Installing Plugins

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(2) You can move and dock any of the toolbars to a new location Status Bar

(3) You can add data by using the "Manage Layers Toolbar" or by dragging and dropping the correct file (.shp file, .tiff file, .img file, .bmp file, .csv file, etc.) to the Map Area. When using the "Manage Layers Toolbar", browse to the location of the input data folder for inserting. SpatiaLite layers, PostGIS layers, WMS/WFS/WCS layers, Virtual layers, Oracle GeoRaster layers can also be added by using the "Manage Layers Toolbar"



(4) Add vector layer; select Source type as File for shapefiles or desktop ESRI Personal Geodatabases; select Source type as Database for server hosted ESRI Personal Geodatabase or other types of databases

Note: File Geodatabase also works!

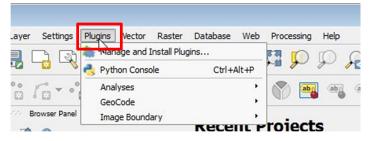
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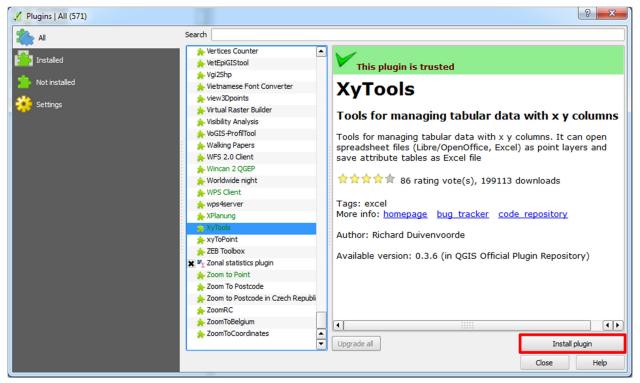
#### 4. Installing Plugins

Many default tools come with QGIS installation. QGIS also has "Plugins" available to help the users with geoprocessing tasks. One of the great benefits of QGIS is that it has an active development community which develops plugins to greatly extend QGIS's functionality.

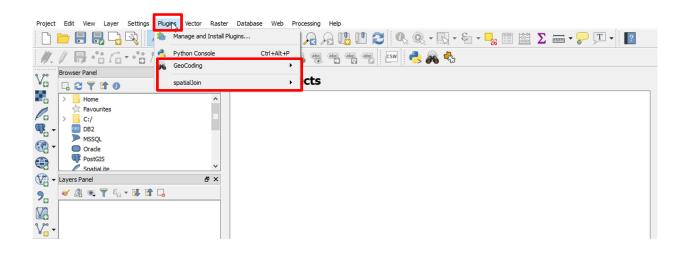
(1) Click the "Plugins" in the Menu Bar and then go to Manage and Install Plugins



(2) One example is provided here to demonstrate how to install plugins. In the Plugins dialogue, under the All Plugins, search for XyTools Plugin; when you find it, click on it and the explanation of this tool will be displayed on the right-hand side; click on "Install Plugin" to install it

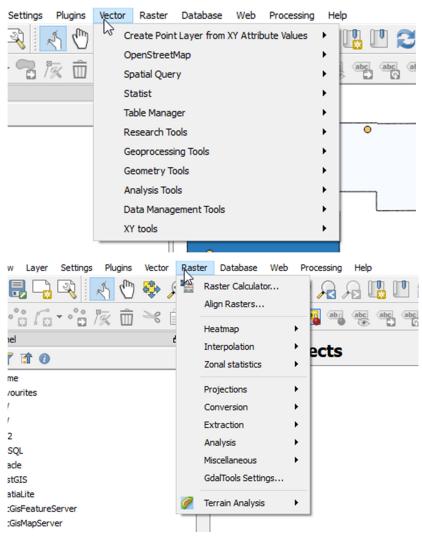


(3) Installed plugins could be located in different places. For example, the installed XyTools Plugin is located under Vector menu in the Menu Bar. Most of the installed plugins will be located under Plugins menu in the Menu Bar



(4) Some great plugins that you should consider

OpenLayer Plugins, Zonal Statistics, Heatmap, Table Manager, GeoCoding, and SpatialJoin, etc. There are many other available plugins provided by QGIS and you can explore them on your own time. For ESRI ArcMap users, you will discover that many of the QGIS tools have the same logic and functionality as ArcMap



### Part C. Working with Vector Data

### 1. Adding Vector Data

(1) Open QGIS Desktop application

(2) Navigate to the folder of QGIS\_Training >>> Part\_C >>> County\_Boundary

(3) Click on the County\_Boundary.shp and drag and drop it into your map area; you can also use the Add Vector Layer tool to add the layer; another option is using the Browser Panel to add data. Note: To quickly locate .shp files, use the file type filter.

QGIS does not have one Add Data button, but rather many different buttons depending on your data type. This is a notable difference between ArcMap and QGIS.

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### 2. Attribute Table

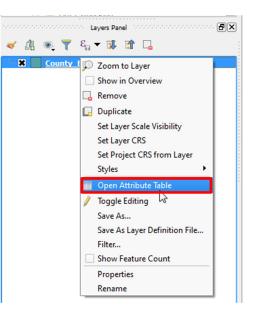
(1) Right-click on the County\_Boundary layer in the Layers Panel

(2) Left-click on the Open Attribute Table option

(3) The design of the attribute table is very similar to ArcMap

(4) Unlike ArcMap, there are not FID and Shape fields

(5) In the attribute table, users can <u>edit attributes</u>, <u>add</u> <u>features or delete features</u>, <u>select features</u>, <u>invert selection</u>, <u>deselect features</u>, <u>zoom map to the select row</u>, <u>move selection</u> <u>to the top</u>, <u>copy and paste selected features</u>, <u>create new fields</u>, <u>delete fields</u>, and <u>use field calculator</u> (see below).



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3	Lea	-9999	H1	01702365	8468799.000000	11372460346.00	+32.7956865	06				
4	Guadalupe	-9999	H1	00929111	2887727.000000	7848912419.000	+34.8697822	06				
5	Torrance	-9999	H1	00929112	2301144.000000	8663108604.000	+34.6346444	06				
6	Grant	-9999	H1	00915980	15349532.00000	10260561604.00	+32.7320870	06				
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Note: In order to edit attributes, add or delete features, and create or delete fields, users need to click the  $\checkmark$  button to toggle editing mode; to exit editing mode, left-click on the same button. Users can also right-click on the layer and then left-click on toggling editing to exit.

(6) Unlike ArcMap, users can open the same attribute table as many times as they want.

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3	Lea	-9999	H1	01702365			3	Lea	-9999	Н1	01702
4	Guadalupe	-9999	H1	00929111			4	Guadalupe	-9999	Н1	00929
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(7) Users can also sort a field by right-click on the field name and then select "Sort"; another simple way is left-click on the field name then it will automatically sort descending or ascending
(8) To see the summary statistics of a field, use the "<u>Basic statistics for numerical (or text) fields</u>" tools in Vector >>> Analysis Tools, users can also use the Statist plugin for the same function
(9) To rearrange the order of the fields, users need to install the <u>Table Manager</u> Plugin; users need to save the vector file (shapefiles or geodatabases) with rearranged fields as a new file to permanently keep the arrangements

## 3. Styling Vector Data

(1) Double-click on the County Boundary layer within the Layers Panel to bring up the layer's property dialogue; the default tab is Labels; click on the "Style" tab

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(2) Many symbology options are available, including

- Single symbol
- o Categorized
- o Graduated
- o Rule-based
- Inverted polygons
- o 2.5D

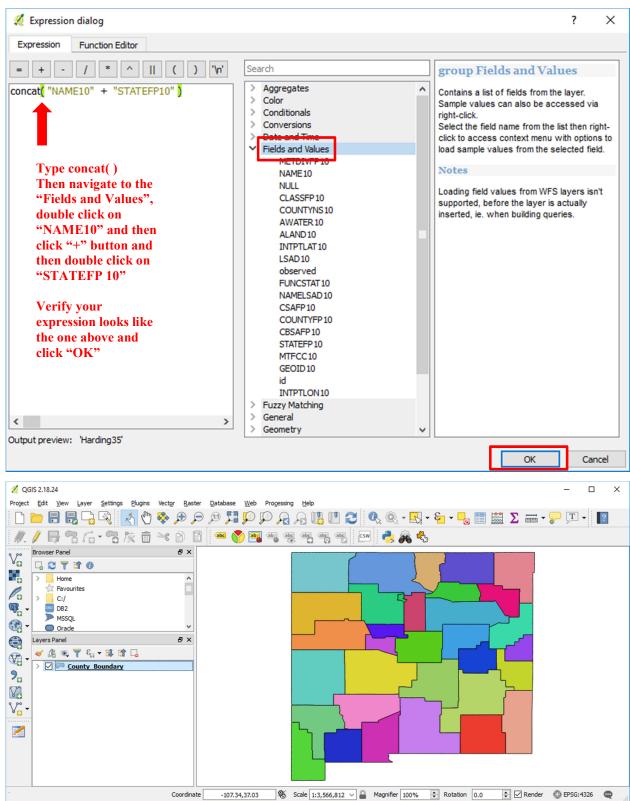
For this exercise, we will use Categorized. Change the Style from Single Symbol to Categorized

(3) Select NAME10 for Column

(4) Left-click on Classify; the symbols for different categories will display; and the color ramp will automatically change to "Random colors"

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(5) QGIS can also concatenate two fields (strings) for symbolization. Click the button at the end of the Column row to start the "Expression dialog"; repeat previous steps for symbolization.



## 4. Labeling Vector Data

(1) Double-click on the County\_Boundary layer within the Layers Panel to bring up the layer's property dialogue; click on the "Labels" tab

(2) Select "Show labels for this layer"

(3) Label with "NAME10"; choose an appropriate font size and color for display; click on OK

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8	Chaves	
V: -	Grant Lea	
	Dona Ana Otero Eddy	
	Hidalgo	
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## 5. Creating New Vector Layers

(1) Click the New Shapefile Layer button; make sure the current selection is New Shapefile Layer because this tool can also be used to create New SpatiaLite Layer, New GeoPackage Layer, and New Temporary Scratch Layer; the New Shapefile Layer dialogue will pop up after click on "New Shapefile Layer"; fill in the Name for the New Field, Type, and other information. Click Add to fields list. Click OK

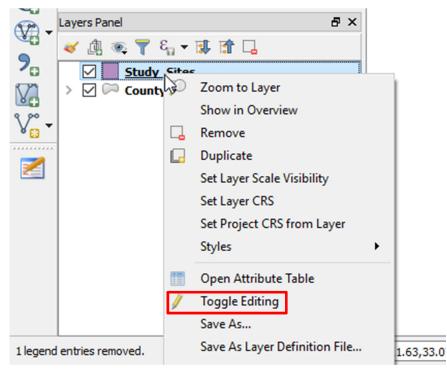
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			OK	Canaal			to remove fields.
			OK	Cancel	He	ip (	

(6) Once clicking on OK, the "Save layer as dialogue will display"; type in Study\_Sites as the layer name; make sure the layer will be saved in QGIS\_Training >>> Part\_C >>> Study\_Sites folder

→ ~ ↑	his PC > Desktop > QGIS_Training	> Part_C > Study_Sites		✓ Ö Sea	rch Study_Sites	,
rganize 👻 New fol	der				:== ·	- (
Lab_Instruction ^	Name	Date modified	Туре	Size		
🛆 OneDrive	Study_Sites.shp	10/25/2018 8:03 PM	SHP File	1 KB		
This PC						
File <u>n</u> ame: Stud	ly_Sites.shp					
Save as type: ESRI	Shapefile [OGR] (*.shp *.SHP)					

(7) The Study\_Sites layer will be automatically added to your Layers Panel

(8) Right-click on the Study\_Sites layer and then click on Toggle Editing



(9) Click on Add Feature button in the Digitizing Toolbar.



(10) Click on the Mapping Area to create a polygon, when done, right-click

(11) The Feature Attributes dialogue will display

(12) Type in the attributes value; for the Area field, just type in a random number for now; click on OK to finish the first feature

Study_S	ites - Feature Attributes		x
id	1	63	
Name	Su_Demo	6	
Area	100	6	
	[	OK Cancel	

(13) To calculate the real area for the feature your just create, you need to update the existing area field; to do this, you need to set your current project's coordinate system to a projected coordinate system unless your layer is already in a projected coordinate system like we did when we created the Study Sites layer; otherwise it will give you a "arcsec" value for area

(14) To change the current project's coordinate system, go to Project >>> Project Properties >>>
 CRS >>> select an appropriate coordinate system such as NAD 83 UTM Zone 13 N or WGS84
 UTM Zone 13 N

(15) Open the attribute table of the feature, and then click "Open field calculator" button

(16) Select "Update existing field", and then select \$area; click on OK

🕺 Field calculator		? ×
<ul> <li>Only update 0 selected features</li> <li>Create a new field</li> <li>Create virtual field</li> <li>Output field name</li> <li>Output field type</li> <li>Whole number (integer)</li> <li>Output field length 10          <ul> <li>Precision 3</li> </ul> </li> </ul>	✓ Update existing field ✓ Area	<b>•</b>
Expression         Function Editor           =         +         -         /         *         ^                    (         )         \n'	Search	function \$area ^
\$area /1000000 < > Output preview: 2349.84042472595	<ul> <li>Fuzzy Matching</li> <li>General</li> <li>Geometry</li> <li>angle at vertex</li> <li>\$area</li> <li>area</li> <li>azimuth</li> <li>boundary</li> <li>bounds</li> <li>bounds_height</li> </ul>	Returns the area of the current feature. The area calculated by this function respects both the current project's ellipsoid setting and area unit settings. Eg, if an ellipsoid has been set for the project then the calculated area will be ellipsoidal, and if no ellipsoid is set then the calculated area will be planimetric.

(17) Your attribute table should look like this; notice that the area's unit is  $\text{km}^2$ 

4	Study_Sites :: Fe	eatures total: 1, filter	red: 1, selected: 0		_		×
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12	3id ▼ = E			~ Up	date All	Update 9	Selected
	id	Name	Area				
1	1	Su_Demo	2349.840424725				
7	Show All Features	i.					3

(18) When done, click the "Save Layer Edits" button in the Digitizing Toolbar; and then click on

the "Toggle Editing" to turn off the editing mode

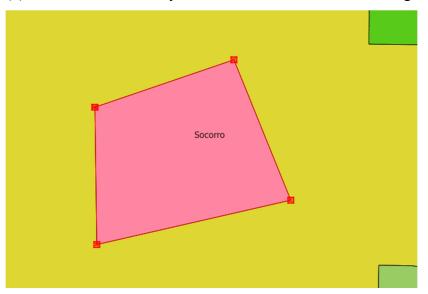


## 6. Editing Features

(1) In editing mode, click on the "Node Tool" button in the Digitizing Toolbar



(2) Click on the nodes of your feature of interest to start editing



(3) When done, click the "Node Tool" button again to stopping editing

(4) Click the "Save Layer Edits" button to save your edits; and then click on the "Toggle Editing" to turn off the editing mode

(5) Like ArcMap, your area geometry value will not be updated automatically; you need to recalculate it after you made changes to your features

### 7. Data Query Based on Attributes

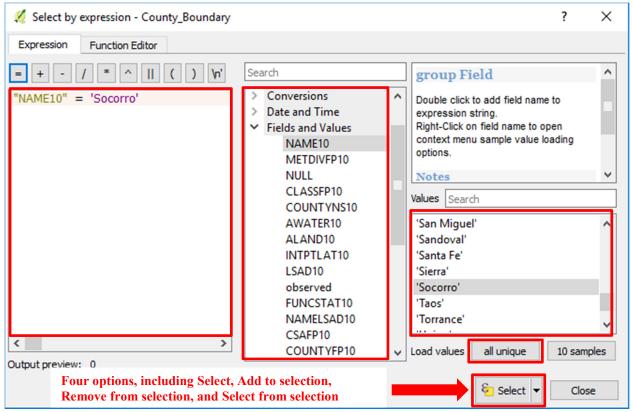
(1) Open the attribute table of the County\_Boundary layer

(2) Click on the "Select features using an expression"; you can also activate this function by clicking on the "Select features using an expression" button in the "Attribute Toolbar"

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	NAME10	METDIVFP 10	CLASSFP 10	COUNTYNS10	AWATER 10	ALAND 10	INTPTLAT 10		LSAD 10	^
1	Harding	-9999	Н1	00933055	1154341.000000	5504869120.000	+35.8631519	06		
2	Sierra	-9999	H1	01702370	148324021.0000	10823447042.00	+33.1194790	06		
3	Lea	-9999	H1	01702365	8468799.000000	11372460346.00	+32.7956865	06		
4	Guadalupe	-9999	H1	00929111	2887727.000000	7848912419.000	+34.8697822	06		
5	Torrance	-9999	H1	00929112	2301144.000000	8663108604.000	+34.6346444	06		
6	Grant	-9999	Н1	00915980	15349532.00000	10260561604.00	+32.7320870	06		
7	Otero	-9999	H1	00929104	37018891.00000	17128132345.00	+32.5887764	06		
8	San Juan	-9999	Н1	00936844	65673845.00000	14278776372.00	+36.5116245	06		
9	Roosevelt	-9999	Н1	01702369	18703928.00000	6338816708.000	+34.0214569	06		
10	Curry	-9999	Н1	00933053	8174297.000000	3638407189.000	+34.5729841	06		
11	Taos	-0000-	н1	00033056	3385868 000000	5706029510 000	136 5765387	06		>

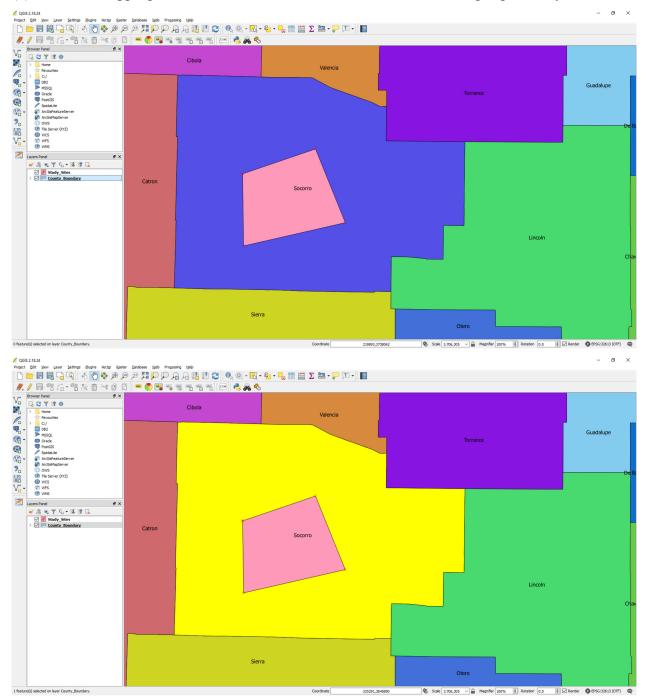


(3) In the Select by expression dialogue, building the query expression.



- (4) Browse the Fields and Values to select the NAME10, double-click on it
- (5) Click the "=" sign under "Expression"
- (6) Click "all unique" next to "Load Values"
- (8) Click on Select

(9) Go to the mapping area and users can see selected features will be highlighted in yellow color.



### 8. Data Query Based on Location

- (1) Load the Airport shapefile in the Part\_C folder
- (2) Go to Vector (in the Menu Bar) >>> Spatial Query

Note: two vector layers are required for this tool.

- (3) The Spatial Query dialogue will display
- (4) Select County\_Boundary for "Select source features from"
- (5) Select Contains for "Where the feature"
- (6) Select Airports for "Reference features of"

Select Create new selection for "And use the result to"

(7) Click on Apply

(8) In the result dialogue, select "Zoom to item" to see the selected feature

(9) Users can also click on "Create layer with selected" or

"Create layer with listed items" to create a feature layer

💋 Spatial Query 🛛 ? 🛛 🗙
Select source features from
County_Boundary
Selected geometries
Where the feature
Contains 🔻
Reference features of
° Airports 🔻
Selected geometries
And use the result to
Create new selection 🔹
Close Apply

🕺 Spatial Query		?	$\times$
Select source features from	Result feature ID's		
County_Boundary 👻	Result query		•
☑ 30 selected geometries	1 2		^
Where the feature	3		
Contains 👻	4 5		
Reference features of	6 7		
° Airports ▼	8		
Selected geometries	9 10		
And use the result to	11 12		~
Create new selection 👻	30 of 33 identified		Ъľ
Selected features			12
30 of 33 selected by "Create new selection"	Zoom to item     Create layer with listed items     Log messages		
Create layer with selected	Close	Арр	yly

(9) Another tool to do spatial query based on location is Vector >>> Research Tools >>> Select by Location

Select by location				?
Parameters Log		Run as batch process	Select by location	
ayer to select from			This algorithm creates a selection in a	vector laye
County_Boundary [EPSG:4326]		<b>▼</b> Ø	The criteria for selecting features is ba spatial relationship between each feat	ure and th
Additional layer (intersection layer)			features in an additional layer.	
Airports [EPSG:4326]		▼ 🔊		
Geometric predicate				
intersects	touches			
✓ contains	overlaps			
disjoint	within			
equals	crosses			
recision				
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lodify current selection by				
creating new selection		•		
				0
			Run	Close

## Note: when using this tool, make sure the two layers have the same coordinate system.

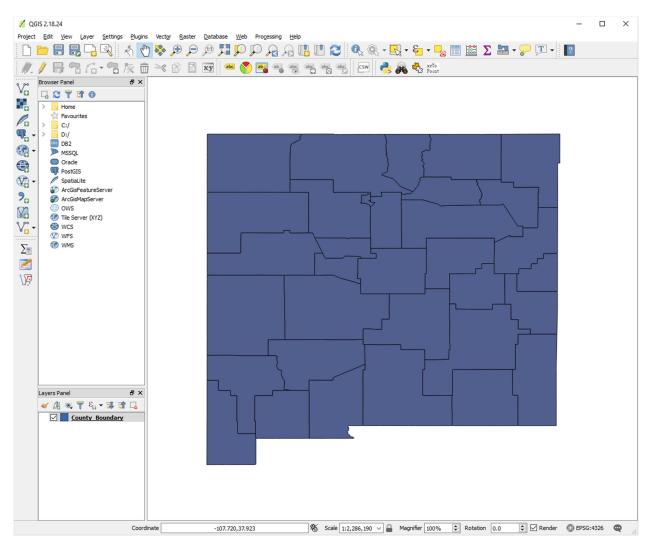
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## 9. Table Join

Sometimes a single shapefile does not include all the information you want, which makes "Table Join" to be necessary and useful; <u>Table Join</u> is typically used to append the fields of one table to another through an attribute or field common to both feature layers/tables.

(1) Start a new QGIS project

(2) Add the County\_Boundary shapefile located in QGIS\_Training >>> Part\_C >>> County\_Boundary folder



(3) Click on the "Add Delimited Text Layer" button; in the "Create a Layer from a Delimited Text File" dialogue, browse to the location of the County\_Population.csv file; provide a layer name, select CSV for file format, select 7 for Number of header lines to discard, check on First record has field names, and then select "No geometry"; click on OK



					Franking UTT (	Browse
	er name County_			-	Encoding UTF-	
ile	format	CSV (comma sep	arated values)	<ul> <li>Custom delimiters</li> </ul>	Regular expression del	imiter
	_					
eo	ord options	umber of header lin	es to discard	7 🗧 🗹 First record has field names		
ielo	d options	] Trim fields 🗌 🛛	iscard empty f	ields 🗌 Decimal separator is comma		
Geo	metry definition 🤇	) Point coordinates	s	<ul> <li>Well known text (WKT)</li> </ul>	No geometry (attribute	only table)
aye	er settings	Use spatial index		Use subset index	Uwatch file	
aye	er settings	Use spatial index	POP_2010	Use subset index	UWatch file	,
aye				Use subset index	U Watch file	í
	COUNTY_CODE	COUNTY_NAME	POP_2010	Use subset index	UWatch file	Í
1	COUNTY_CODE 35001	COUNTY_NAME Bernalillo	POP_2010 662564	Use subset index	UWatch file	Í
1 2 3	COUNTY_CODE 35001 35003	COUNTY_NAME Bernalillo Catron	POP_2010 662564 3725	Use subset index	UWatch file	
1 2	COUNTY_CODE 35001 35003 35005	COUNTY_NAME Bernalillo Catron Chaves	POP_2010 662564 3725 65645	Use subset index	U Watch file	
1 2 3 4	COUNTY_CODE 35001 35003 35005 35006	COUNTY_NAME Bernalillo Catron Chaves Cibola	POP_2010 662564 3725 65645 27213	Use subset index	U Watch file	,

(4) Right-click on the County\_Boundary layer and then left-click on Open Attribute Table; browse the table and find the unique IDs for each county (GEOID10)

Ø	County_Boundar	y :: Features total: 3	3, filtered: 33, selec	ted: 0		- 0	$\times$
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	CBSAFP 10	STATEFP10	MTFCC10	GEOID 10	id	INTPTLON10	^
1	-9999	35	G4020	35021	18611109	-103.8299311	
2	-9999	35	G4020	35051	18611110	-107.1881607	
3	26020	35	G4020	35025	18611111	-103.4132707	
4	-9999	35	G4020	35019	18611112	-104.7849677	
5	10740	35	G4020	35057	18611113	-105.8468361	
6	43500	35	G4020	35017	18611114	-108.3815043	
7	10460	35	G4020	35035	18611115	-105.7810785	
8	22140	35	G4020	35045	18611116	-108.3245778	~
<							>
7	Show All Features					E	3

(5) Close the attribute table

(6) Right-click on the County\_Boundary layer and then left-click on Properties; click on Joins on the Layer Properties dialogue; then click on the Green Plus (+) sign

Zayer Properties - County_Boundary   Joins								
🔀 General	Join layer	Join field	Target field	Memory cache	Prefix	Joined fields		
Style								
(abc) Labels								
Fields								
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octions								
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Diagrams								
🥡 Metadata								
8 Variables								
Legend	f = /							
	Style 🔻				ОК	Cancel Apply	Hel	p

(7) In the "Add vector join" dialogue, select County\_Population for "Join layer", select COUNTY\_CODE for "Join field", and select GEOID10 for Target field

💋 Add vector join		?	×
Join layer	County_Population		•
Join field	123 COUNTY_CODE		•
Target field	abc GEOID 10		~
Cache join layer in virtual memory			
Create attribute index on join field			
Choose which fields are joined			
Custom field name prefix			
	ОК	Can	cel

(8) Click on OK

(9) In the Layer Properties dialogue, it should show that the layer is appropriately joined; click on Ok to close the dialogue

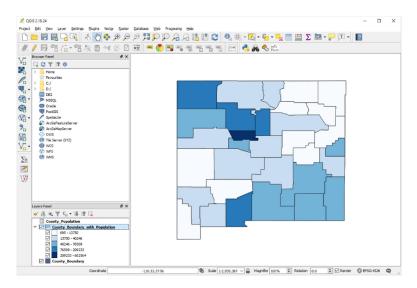
🕺 Layer Properties - 0	County_Boundary   Joins								?	×
🔀 General	Join layer County_Population	Join field	Target field	Memory cache	Prefix	Joined fields all				
ኛ Style	County_Population	COUNTY_CODE	GEOID IO	V		dii				
(abc) Labels										
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octions										
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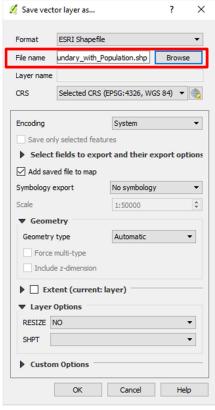
(10) Open the attribute table of the County\_Boundary layer again

(11) You can see that the two fields in the County\_Population layer are joined with the County\_Boundary layer

(12) The table joined result is temporary; right-click on the boundary layer and click on "Save As" to <u>permanently</u> save the joined layer (same as ArcMap)

(13) Visualize the new layer with Graduated symbol (for the field of County\_P\_1)





### 10. Spatial Join

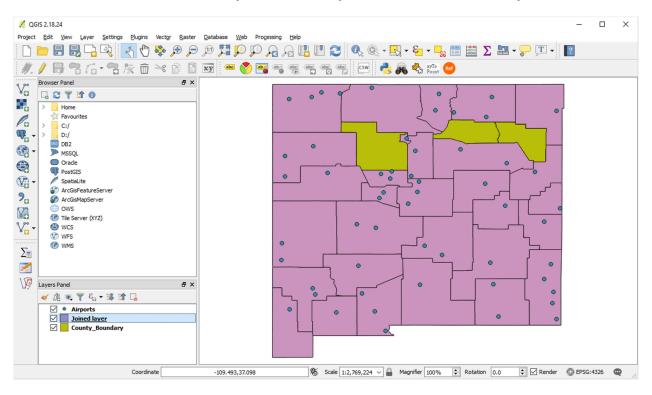
Another common operation is joining attributes from one feature to another based on their spatial relationships, known as <u>Spatial Join</u>. The target features and the joined attributes from the join features are written to the output feature class. Two tools can conduct <u>spatial join</u> operation, including the "spatialjoin" plugin and the "Join attributes by location" tool. For this exercise we only focus on the use of the "Join attribute by location" tool.

- (1) Create a new project
- (2) Insert the County\_Boundary layer and the Airport layer
- (3) Go to Vector >>> Data Management Tools >>> Join attributes by location

(4) Target vector layer uses the County\_Boundary layer; Join vector layer uses the Airports layer; Geometric predicate uses contains; Attribute summary uses Take summary of intersecting features; Statistics for summary (comma separated) uses sum; have all the input parameters setup as the following screen capture; and then click on Run

💋 Join attributes by location		? ×
Parameters Log	Run as batch process	Join attributes by location
Target vector layer		This algorithm takes an input vector layer and creates a new vector layer that is an extended
County_Boundary [EPSG:4326]	▼ … ②	version of the input one, with additional attributes in its attribute table.
Join vector layer		
Airports [EPSG:4326]	✓ ②	The additional attributes and their values are taken from a second vector layer. A spatial critera is
Geometric predicate		applied to select the values from the second layer that are added to each feature from the first layer
intersects	touches	in the resulting one.
✓ contains	overlaps	
disjoint	within	
equals	Crosses	
Precision		
0.000000	÷	
Attribute summary		
Take summary of intersecting features	<b>•</b>	
Statistics for summary (comma separated) [optional]		
sum		
Joined table		
Only keep matching records	-	
Joined layer		
/Users/suzhang/Desktop/QGIS_Training/Part_C/Count	y_Boundary/County_Boundary_with_Airports.shp	
☑ Open output file after running algorithm		
		0%
		Run Close

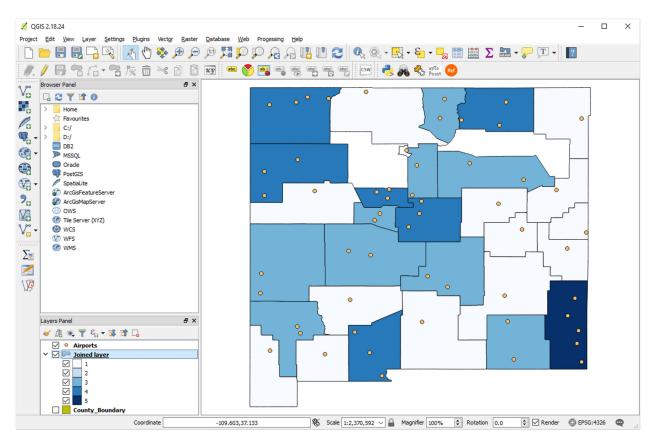
(5) A new layer with the name of "County\_Boundary\_with\_Airports" will be created in the selected folder; however, in the Layer Panel this layer is named with "Joinedlayer"



(6) Open the attribute table of the "Joinedlayer" you will see a field with the name of "count" to indicate how many airport in a specific county

X	Joined layer ::		>	×						
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	sumLATITUD	sumLONGITU	SUMELEVATN	sumTRA00_1	sumid	count	^			
1	23619800000	-107.270897000	4850.00000000	55.0000000000	6335414.000000	1.0000000000				
2	3 <b>.4</b> 905970000	-516.298089000	18307.0000000	104.000000000	31117689.00000	5.0000000000				
3	939498999999	-104.639397000	4782.00000000	47.0000000000	6310465.000000	1.0000000000				
4	<b>1.2733000000</b>	-318.278602000	18793.0000000	66.000000000	18132473.00000	3.0000000000				
5	39850200000	-216.364800000	11569.0000000	60.000000000	12503633.00000	2.0000000000				
6	839900999999	-105.990600999	4197.00000000	10.0000000000	6186031.000000	1.0000000000				
7	7 08 280 30000	-432 61000000	23125 00000000	70 000000000000000000000000000000000000	24868505 00000	4 0000000000000000000000000000000000000	~			
5	Show All Featur	es,				2	Ħ			

(7) Visualize the new layer with Categorized symbol (for the field of count)



## 11. Vector Data Analysis

QGIS provide many tools to conduct vector analysis, and many more tools can be found by using the Plugins; go to Vector or Plugins in the Menu Bar to find these tools; all of these tools have the similar function as ArcMap's tools and the uses of them are very straightforward

(1) Research Tools	Vector Raster Database Web Processing Heli	Processing Toolbox x
<ul><li>(2) Geoprocessing Tools</li><li>(3) Geometry Tools</li><li>(4) Analysis Tools</li></ul>	Create Point Layer from XY Attribute Values         OpenStreetMap         Spatial Query         Statist         Table Manager	Recently used algorithms         GDAL/OGR [48 geoalgorithms]         GRASS GIS 7 commands [314 ge         Models [0 geoalgorithms]
(5) Data Management Tools	Research Tools  Geoprocessing Tools Geometry Tools Analysis Tools -	<ul> <li> <sup>1</sup> QGIS geoalgorithms [111 geoalg</li> <li> <sup>1</sup> SAGA (2.3.2) [353 geoalgorithms]         <sup>1</sup> Scripts [0 geoalgorithms]         </li> </ul>
(6) Processing Toolbox	Data Management Tools	You can add more algorithms to the toolbox, <u>enable additional</u> providers. [close]

### Part D. Working with Raster Data

#### 1. Adding Raster Data

(1) Click on "Add Raster Layer" button in the "Manage Layers Toolbar"



(2) In the "Open a GDAL Supported Raster Data Source" dialogue, navigate to QGIS\_Training >>> Part\_D folder to locate the NM\_DEM (.img) file; similar to Add Vector Layer tool, users can use the file type filter to quickly locate the .img file

💋 Open a GDAL Supported	Raster Data Source				×
← → ~ ↑ 📙 > Th	is PC > Desktop > QGIS_Training > Part_D	ٽ ~	Search Part_D		Q
Organize 🔻 New fold	er				?
A Quick access	Name	Date modified	Туре	Size	
🗄 Documents 🖈	J NM_DEM	2/23/2018 5:04 PM	Disc Image File	47,774 KB	
👆 Downloads 🖈					
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			<u>O</u> pen	Cancel	

(3) Click on "Open" to open the New Mexico DEM file

Control Edit yew Layer Settings Plugins Vector Baster Database Web Processing Help     Image: Control     Image: Control <th></th> <th></th> <th></th> <th></th> <th></th>					
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## 2. Styling Raster Data

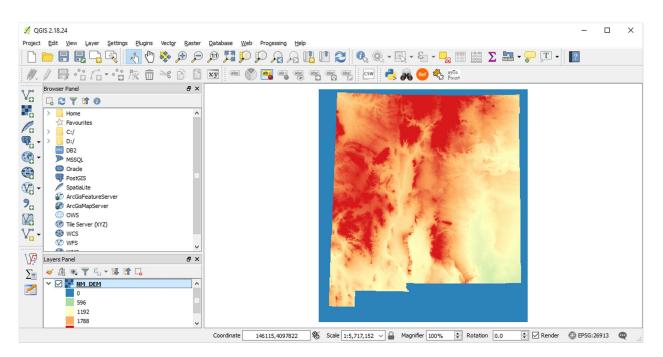
(1) Right-click on the NM\_DEM layer in the Layers Panel

(2) In the Layers Properties dialogue, click on the Style tab; change the "Render type" to Singleband pseudocolor; select Spectral for "Color", and check on Invert; click on Classify; and then click on OK

💋 La	ayer Properties - NM_D	EM   Style		?	$\times$
$\geq$	General	▼ Band re	ndering		^
~	Style	Render typ	e Singleband pseudocolor 💌		
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		Classify		5 🕈	
			frange values		J
		Style 🔻	OK Cancel Apply	Help	

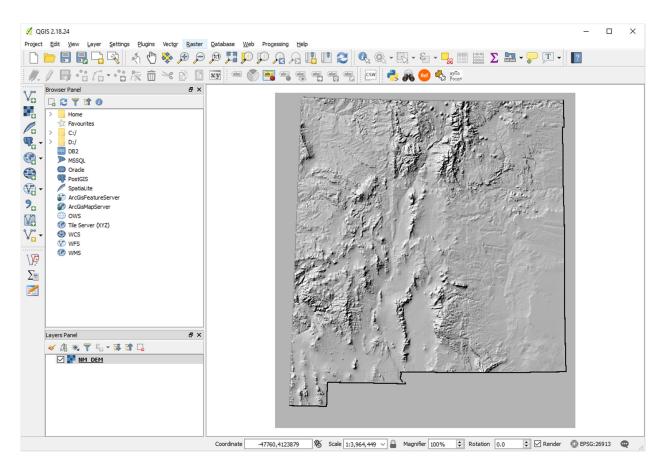
(4) Many other render types can be selected, including the followings

Band rend	ering					
Render type	Singleband pseudocolor	-	G			
Band	Multiband color Paletted Singleband gray					•
	Singleband pseudocolor Hillshade		0	Max	2384	_



(5) Users can also create a hillshade from the DEM by selecting Hillshade for "Render type." Change the Z factor to 5 or 8 or even larger to exaggerate the elevation difference.

×	Layer Properties - NM_D	EM   Style		?	$\times$
X	General	Band rendering			^
~	Style	Render type Hillsh	ade 👻		
	Transparency	Band	Band 1	•	
ŵ	Pyramids	Altitude (degrees)	45.00	-	
	Histogram	Azimuth (degrees)			
Í	Metadata	[	315.00	-	
÷	Legend	Z Factor Multidirectional	8.0000000	⊠ 📮	
		Color rendering Blending mode Norr Brightness Saturation Hue Resampling	nal   Contrast  Grayscale Off	Reset	P



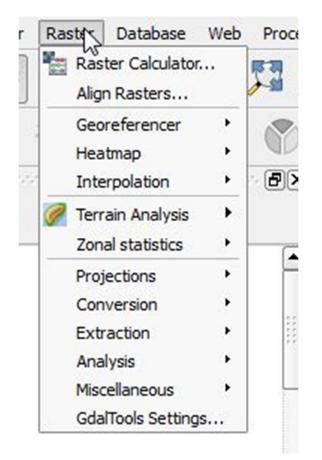
## 2. Raster Data Analysis

(1) QGIS provide many tools to conduct raster analysis, and many more tools can be found by using the Plugins; go to Raster or Plugins in the Menu Bar to find these tools; all of these tools have the similar function as ArcMap's tools and the uses of them are very straightforward

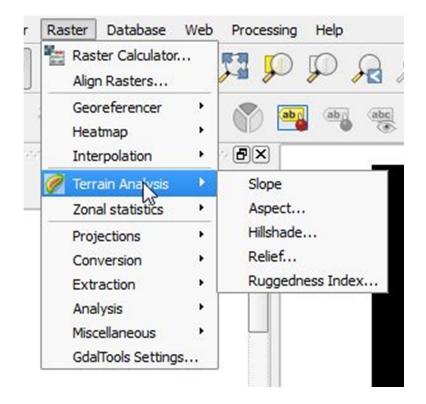
Note: Reclassifying rasters has to use the GRASS reclass tool, which can be found Processing >>> Toolbox >>> GRASS GIS >>> Raster

Processin	g Toolbox	×
Search		
	ightarrow r.quant - Produces the quantization file for a floating-point map.	^
	🗼 r.quantile - Compute quantiles using two passes.	
	$_{ m }$ r.random - Creates a raster layer and vector point map containing randomly located points.	
	ightarrow r.random.cells - Generates random cell values with spatial dependence.	
	🐳 r.random.raster - Create random raster	
	ightarrow r.random.surface - Generates random surface(s) with spatial dependence.	
	🗼 r.reclass - Creates a new map layer whose category values are based upon a reclassification of the categories in an existing raster map layer.	
	ightarrow r.redass.area.greater - Redassifies a raster layer, selecting areas larger than a user specified size	
	ightarrow r.reclass.area.lesser - Reclassifies a raster layer, selecting areas lower than a user specified size	
	🐳 r.recode - Recodes categorical raster maps.	
	r.regression.line - Calculates linear regression from two raster layers : y = a + b*x.	
	🗼 r.regression.multi - Calculates multiple linear regression from raster maps.	
	$_{\rm W}$ r.relief - Creates shaded relief from an elevation layer (DEM).	
	$_{ m }$ r.relief.scaling - Creates shaded relief from an elevation layer (DEM).	
	$_{\rm W}$ r.report - Reports statistics for raster layers.	
		_
fou can ad	I more algorithms to the toolbox, <u>enable additional providers.</u> [close]	

(2) Some of the common tools include the followings screen capture:

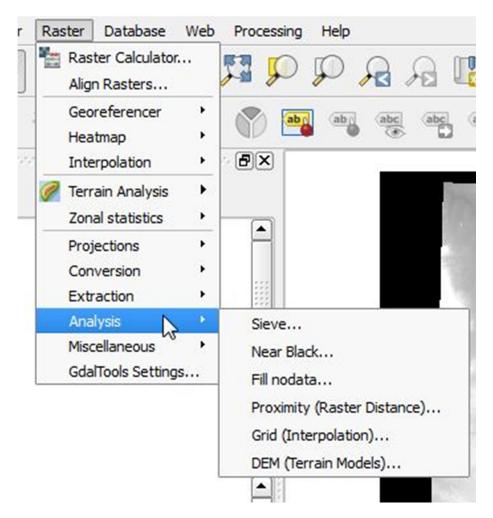


(3) Terrain Analysis is very useful, and it includes the following tools:

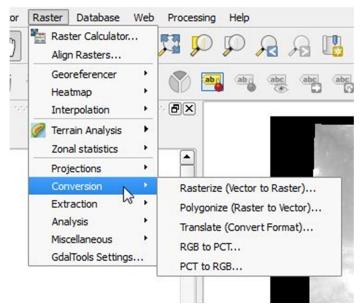


(4) The Georeferencer tool can be used to georeference images

(5) Analysis tools can be used to do the followings:

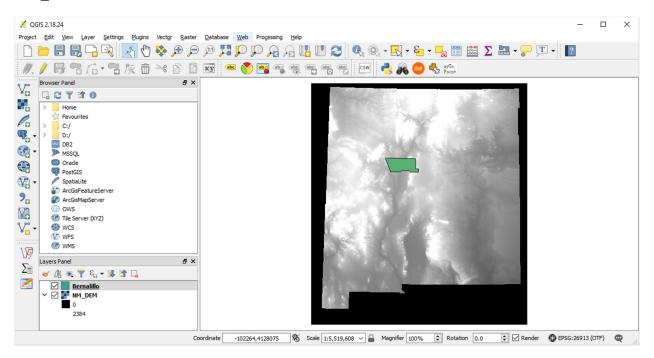


(6) Interpolation and Heatmap are plugins; raster calculator, Zonal statistics, Conversion, Extraction, and Projections are also very useful tools



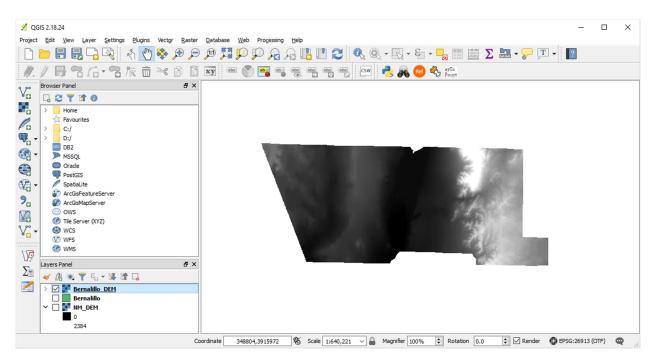
(7) As an example to use these tools, we are going to explore the Clipper tool

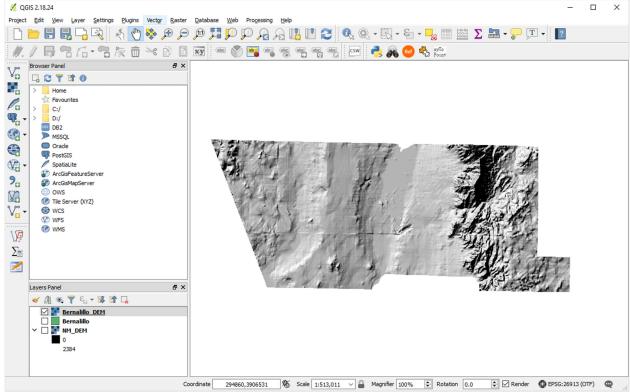
(8) Start a new project; add the Bernalillo layer and NM\_DEM layer in the QGIS\_Training >>> Part D folder.



(9) Go to Raster >>> Extraction >>> Clipper

💋 Clipper		?	$\times$		
Input file (raster)	NM_DEM ~	Select			
Output file	S_Training/Part_D/Bernalillo_DEM.tif	Select			
✓ No data value	0		-		
Clipping mode					
O Extent	Mask layer				
Mask layer Bern	alillo ~	Select			
Create an out	tput alpha band				
Crop the exte	ent of the target dataset to the extent	of the cutline	2		
Keep resolution	on of input raste 🔘 Set output file r	esolution			
Load into canvas	when finished				
gdalwarp -dstnodata			1	💋 Finished	×
100.0 100.0 -of GTif \Users\suzhang\Des	ktop\QGIS_Training\Part_D\Bernalillo.sh ff C: ktop\QGIS_Training\Part_D\VM_DEM.in esktop/QGIS_Training/Part_D/Bernalillo	ng	¢	Processing of	ompleted.
	OK Close	Help			OK

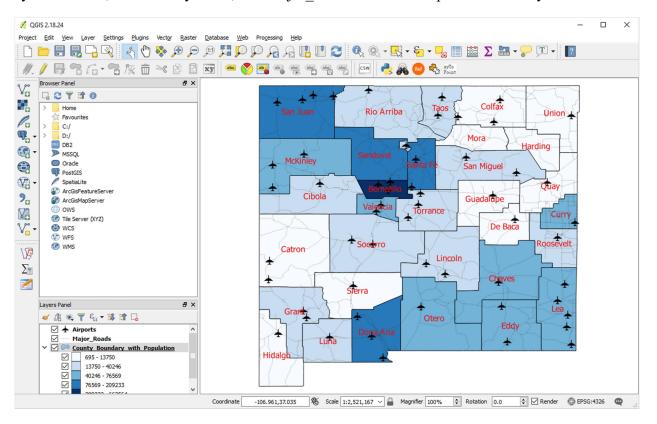




## Part E. Creating Maps

1. Add the layers in QGIS\_Training >>> Part\_E folder.

2. Table Join County\_Population data to County\_Boundary data; use Graduated for symbolization; label county name; add Major Roads data and Airports data and symbolize them



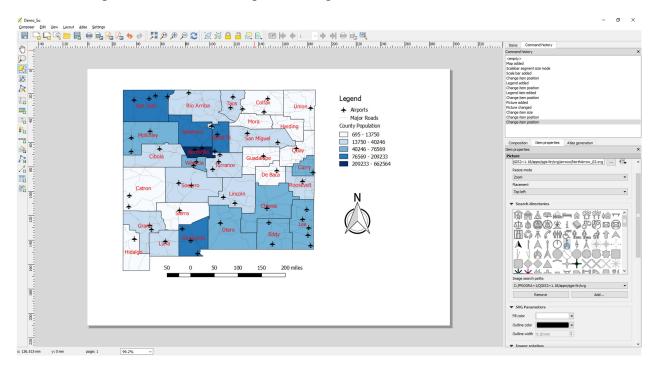
- 3. Click on Project
- 4. Click on New Print Composer
- 5. Type in a name for your composer

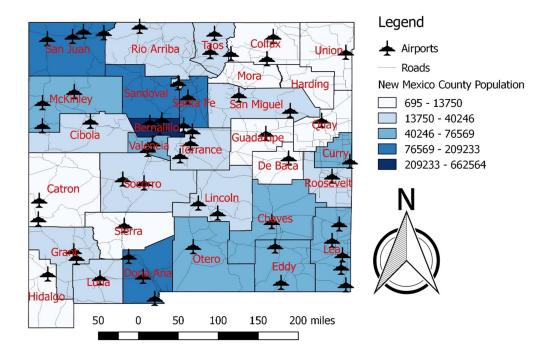
💋 Composer title	?	$\times$
Create unique print co (title generated if left o		title
Demo_Su		$\sim$
ОК	Can	icel

6. The composition panel should display, Click Layout and then click Add map

	Atlas Settings Add Map Add Label Add Scalebar Add Legend Add Image Add Shape Add Shape Add Nodes Item Add Arrow Add Attribute Table	, ,	180 P00		Items     Command history       Command history     X
	Add HTML Add HTML Move Item V Move Content C Edit Nodes Item				Composition     Item properties     Atlas generation       Atlas generation     ×       Generate an atlas       Configuration
		rl+G rl+Shift+G			Coverage layer 🗸 🗸
	Lower Ctr Bring to Front Ctr	rl+] rl+[ rl+Shift+] rl+Shift+[			Page name Filter with Sort by
	Lock Selected Items Ctr	rl+L rl+Shift+L		~	✓ Output     Output filename expression     'output_'  @atlas_featurenumber     Single file export when possible
x: 211.438 mm y: 103.719	mm page: 1	99.2%	> ~		single nie export when possible

- 7. Use mouse pointer to select the area on the canvas of the composer for adding the map
- 8. In Layout click on add Scale bar, Add Legend, and Add Image (for North Arrow)
- 10. In Layout click on Add Shape and then click Add Rectangular to add neatline (optional)
- 9. Click Composer and then click Export as Image

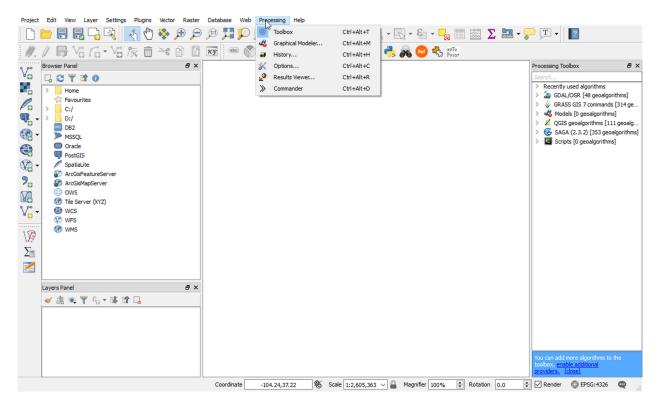




## Part F. Working with the Graphical Modeler

A typical spatial analysis involves a series of GIS operations, with the output of one operation as the input for the next one, until the final result is generated. Using the Graphical Modeler, users can combine these individual steps into a single process. Thee interface of Graphical Modeler allows users to visually draw inputs, GIS algorithms, and output. A major benefits of this approach is that the completed analytical workflow can be modified and rerun.

1. Click on Processing and then click on Graphical Modeler



2. The processing modeler opens as a new window; on the left-hand side of the window, there are two tabs: **Inputs** and **Algorithms**; these are used to add both types of element to the modeler canvas that takes up the remainder of the window

🚀 Processing modeler	- 0	×
🖿 🗟 🥫 📔 🗑 🗊		
✓ Parameters	[Enter model name here] [Enter group name here]	
🕂 Boolean		^
🕂 Extent		
🕂 File		
🕆 Number		
🕂 Raster layer		
🖶 String		
🕆 Table	Modeler Canvas	
🕆 Table field	Wodeler carras	
🕆 Table multiple field		
🕆 Vector layer		
🕂 Point		
Inputs and Algorithms		~
Inputs Algorithms	< >>	

3. Before creating a model, it is always a good practice to configure the modeler; models ae saved as JSON files with a .model extension; when users save a model, QGIS will prompt the users to save the model file to the **Models** folder; users can set the location of the **Models** folder by navigating to Processing >>> Options

🕺 Processing options	?	$\times$
Search		
Setting Value		
> 🏶 General		
> 🔚 Menus (requires restart) Reset to defaults		
🗸 🥰 Models		
🕰 Activate 🔽		
Kan Strate C:\Users\suzhang\.qgis2\processing\models		
> 🛞 Providers		
> 🔄 Scripts		
OK	Can	cel

4. Create a new model; type in Airport Buffer in "Enter model name here", and type in Proximity in "Enter group name here"; click on the save button 🗉 and the Save Model dialog will open

Param		[Enter model name here]	[Enter group name here]	
	Boolean			
	P Extent			
	P File			
-	P Number			
	<ul> <li>Raster layer</li> </ul>			
	P String			
	P Table			
-	<ul> <li>Table field</li> </ul>			
	Table multiple field			
	<ul> <li>Vector layer</li> </ul>			
4	P Point			
	Algorithms	<		
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5. In the **Save Model** dialog, type in a name for your model file; the following figure shows the **Save Model** dialog; if models are saved to the **Models** folder, they will appear as model tools in the **Processing Toolbox** panel; the model will appear with the name that was entered into the graphical modeler as opposed to the name of the \*.model file. Models can be saved outside the **Models** folder, but they will not appear in the **Processing Box** panel

💋 Save Model						×
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Organize 👻 New f	older					:== - ?
	^ Name	^		Date modified	Туре	Size
<ul> <li>Quick access</li> <li>Documents</li> <li>Downloads</li> </ul>			No item	s match your search		
Pictures *						
Deckton	×					
File <u>n</u> ame: Ci	reate_Buffer_for_Ai	ports				~
Save as <u>t</u> ype: Pr	ocessing models (*	model)				~
∧ Hide Folders					<u>S</u> ave	Cancel
	Settings Bugins Ve			A 🖪 🖱 🔁		×
Browser Panel         5           □         ○         ▼         10         5           □         ○         ▼         10         0           □         ○         ▼         10         0           □         ○         ▼         10         0           □         □         □         □         0         0           □         □         □         □         □         0         0           □         □         □         □         □         □         0					Prov See >	cessing Toolbox
✓     ✓     SpatiaLite       ✓     ✓     ArcGisFeatureSo       ✓     ✓     ✓       ✓     ✓     ✓       ✓     ✓     ✓       ✓     ✓     ✓       ✓     ✓     ✓       ✓     ✓     ✓       ✓     ✓     ✓       ✓     ✓     ✓       ✓     ✓     ✓       ✓     ✓     ✓	e n v					SAGA (2.3.2) [353 geoalg
↓     ↓     ↓     ↓     ↓     ↓     ↓     ↓       ↓     ↓     ↓     ↓     ↓     ↓     ↓	» »					
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6. To open a saved model, in the **Processing modeler** dialog, click on the **button** to open the **Open Model** dialog and then navigate to the location where you model has been saved

2 Processing modeler			– 🗆 X
😑 🗟 🗟 [ 🗟 🕅 [ 🗟 [	3e		
<ul> <li>▼ Parameters</li> <li>⊕ Boolean</li> <li>⊕ Extent</li> <li>⊕ File</li> <li>⊕ Number</li> <li>⊕ Raster layer</li> <li>⊕ Table</li> <li>⊕ Table</li> <li>⊕ Table field</li> <li>⊕ Table field</li> <li>⊕ Vector layer</li> <li>⊕ Point</li> </ul>		[Enter model name here]	[Enter group name here]
Inputs Algorithms		<	*
	> Su Zhang > .qgis2 > processing > models	<b>~ ট</b> S	earch models
Organize 🔻 New	/ folder		8== 🕶 🔟 🕐
✓ Quick access         ☑ Documents         ↓ Downloads         ☑ Pictures         ☑ 2018         ☑ Desktop         ☑ Document	Name     Create_Buffer_for_Airports.model	Date modified Typ 10/28/2018 3:23 PM MO	e Size DEL File 1 KB
	File <u>n</u> ame:	~	Processing models (*.model *.ħ ∨ <u>O</u> pen Cancel

7. To begin the creation of a model, users will need to define the inputs. The graphical modeler will accept the followings as input:

- o Boolean
- o Extent
- o File
- o Number
- o Raster layer
- o String
- o Table
- Table field
- Vector layer

8. To add an input, either double-click on the appropriate category from the Inputs tab or drag the input onto the modeler canvas; the Parameter definition dialog will open; give the parameter a name and fill in any other details, which change depending on the input that is selected; when an input parameter is defined and added to the model, it is essentially a conceptual parameter; it is not actually be connected to a data layer until you are ready to run the model

9. For this exercise, we will add a vector layer; we will specify the geometry of the vector data and select it as a required parameter:

💋 Parameter definitio	on	?	×
Parameter name Airp	orts		
Shape type	Point		•
Required	Yes		•
ОК		Cancel	

10. Once you click on OK, the input object will be added to the modeler canvas; all the objects in the modeler canvas can be selected with a mouse click and dragged to reposition; click on the pencil icon of an input will open the Parameter definition dialog to make changes



11. We will also add a number input, which allows us to expose the buffer distance value as an input that can be changed when the model is executed; it will be named "Buffer distance" and it will be given a Default value of 3000, since 3000 it the distance that we initially want to use Note: in the graphical modeler, distances are expressed in current project's coordinate system units

💋 Parameter definition		?	×
Parameter name Buffer distance			
Min/Max values			
Default value 3000			
Required	Yes		•
	OK	Cancel	

🔏 Processing modeler			-	×
🖿 🗟 📓 🛛 😹 🕅 🗍 🔛 🖉				
✓ Parameters	Airport Buffer	Proximity		
🕂 Boolean				^
🕂 Extent				^
🕂 Number		🕆 Buffer distance		
🕆 Raster layer		×.		
🕀 String				
🕆 Table				
🕆 Table field	🕆 Airports			
🕆 Table multiple field	Airports			
🕆 Vector layer				
🕆 Point				
Inputs Algorithms	<			> ~
Inputs regeneration	•			 -

12. The following screenshot shows the model with a vector layer input and a number input

13. Algorithms are added to the graphical modeler in the same way as inputs; click on the "Algorithms" tab; in the Algorithms tab, there is a special category named Modeler-only tools, and there are three tools, including Calculator, Raster layer bounds, and Vector layer bounds; they are tools that can only be used in the graphical modeler

💋 Processing modeler			-		$\times$
🖿 🗟 🛃 🗍 🛼 🔛 🛛 🕬 🖓					
Search	Airport Buffer	Proximity			
> 🍙 GDAL/OGR					^
> 🖗 GRASS GIS 7 commands					
🗸 🥰 Modeler-only tools					
<ul> <li>Modeler-only tools</li> </ul>	🕆 Airports	🕆 Buffer distance	×		
Calculator			<u>I</u>		
Raster layer bounds					
Vector layer bounds X QGIS geoalgorithms					
> SAGA (2.3.2)					
					~
Inputs Algorithms	<				>
🕺 Calculator			?		×
You can refer to model values in your formula	using single-letter variables, as follows:				
a->Buffer distance	a, daing aingle retter variables, as follows.				
		OK		Cance	el

14. In the search bar, type in buffer and many tools show up; click on the "Fixed distance buffer" tool in QGIS geoalgorithms >>> Vector geometry tools

💋 Processing modeler						-	×
🖿 🗟 🗟 🛯 🚔 🕼 🛛 🖾							
buffer		Airport Buffer		Proximity			
✓ ≦a GDAL/OGR	^						^
<ul> <li>[OGR] Geoprocessing</li> </ul>							
a Buffer vectors					*		
Single sided buffers (and offset lin			🕆 Buffer	distance	*		
🗸 🖗 GRASS GIS 7 commands							
✓ Raster (r.*)							
v r.buffer - Creates a raster map lay							
v r.buffer.lowmem - Creates a raste		🕂 Airports					
Vector (v.*)							
v.buffer.column - Creates a buffer							
v.buffer.distance - Creates a buffe							
💙 🔏 QGIS geoalgorithms							
<ul> <li>Vector geometry tools</li> </ul>							
Fixed distance buffer							
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✓ SAGA (2.3.2)							
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S Raster buffer	~						
Inputs Algorithms		<					>
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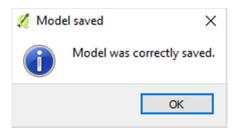
15. Click on the "Fixed distance buffer", and the Fixed distance buffer dialog open; set up the parameters as below; the **Segments** indicate how many segments that your buffer circle will consist of (the more segments the smoother the circle; default value is 5); output will be Airport Buffer

🙋 Fixed dist	ance buffer			?	$\times$
Parameters	Help				
					^
Description	Fixed distance	uffer			
Input layer					
Airports				-	
Distance					
Buffer dist	ance			$\sim$	
Segments					
20.0				$\sim$	10
Dissolve res	ult				
Yes				-	
Buffer < Out	putVector>				
Airport Buf	fer				
Parent algo					
0 elements	selected				
			 		•
			OK	Can	cel

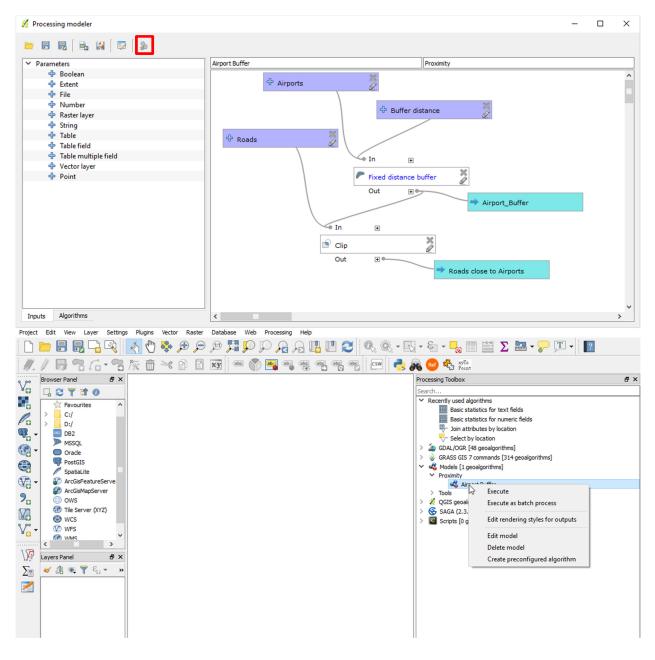
16. Next, add the Roads layer and the Clip tool to the model using the following parameters

🕺 Clip		?	×
Parameters Help			
Description Clip			
Input layer			
Roads			•
Clip layer			
'Buffer' from algorithm 'Fixed dista	ince buffer'		-
Clipped <outputvector></outputvector>			
Roads close to Airports			
Parent algorithms			
0 elements selected			
	ОК	C	Cancel
1 December and deler		_	
💋 Processing modeler		-	
<ul> <li>Parameters</li> </ul>	Airport Buffer Proximity		
<ul> <li>♦ Boolean</li> <li>♦ Boolean</li> <li>♦ Extent</li> <li>♦ File</li> <li>♦ Number</li> <li>♦ Raster layer</li> <li>♦ String</li> <li>♦ Table</li> <li>♦ Table field</li> <li>♦ Vector layer</li> <li>♦ Point</li> </ul>	Airports		
Inputs Algorithms			>

17. Click on the Save button to save your model and then close your model



18. The model can be run either from the **Processing modeler** window or from the **Processing Toolbox** panel; in the **Processing modeler** window, click on the **Run model** button ; to run from the **Processing Toolbox**, first save and close the model and then find the model by navigating to model and then right-click on it, and choose **Execute** from the context menu



19. The tool will open with a regular tool interface, fill in the parameters as below and then click on Run; the results will be placed in the folder that you selected

