This document takes you through the calculation of the landscape variables step-by-step. If you're working through the document, we're assuming you've already done the "getting started with qGIS" protocol and that you have the project open for route 270408. You should have buffers already drawn for 300 m, 600 m, 1 km, 5 km, and 10 km from the NAAMP stop.

First, here's a preview of the variables you will calculate.

VARIABLES TO BE CALCULATED FOR EACH STOP:

1) WET_AREA. This is the area of wetlands within a given distance from each stop, as calculated from the nwi wetlands layer.

2) T_ROAD_LEN. This is the total road length (in meters) within a given distance from each stop calculated from the TIGER roads layer. You will also calculate the length of primary roads (P_ROAD_LEN), secondary roads (S_ROAD_LEN), and other roads (O_ROAD_LEN).

3) PROP_FOR. This is the proportion of forest land within a given distance from each stop calculated from the NLCD raster layer.

4) PROP_DEV. This is the proportion of developed land (classes 22, 23, 24) within a given distance from each stop calculated from the NLCD raster layer. See: http://www.mrlc.gov/nlcd06_leg.php for color codes for this layer.

5) PROP_AGR. This is the proportion of agricultural land (i.e. row crops) within a given distance from each stop calculated from the NLCD raster layer.

6) WET_CONNECT. This is a measure of the connectivity of a stop, where connectivity is considered to be a function of the number and size of the wetlands in the landscape.

7) TOTAL_CONNECT. This is the measure of the connectivity of a stop, where connectivity is considered to be a function of the number and size of wetlands and the upland habitats that are adjacent to them.

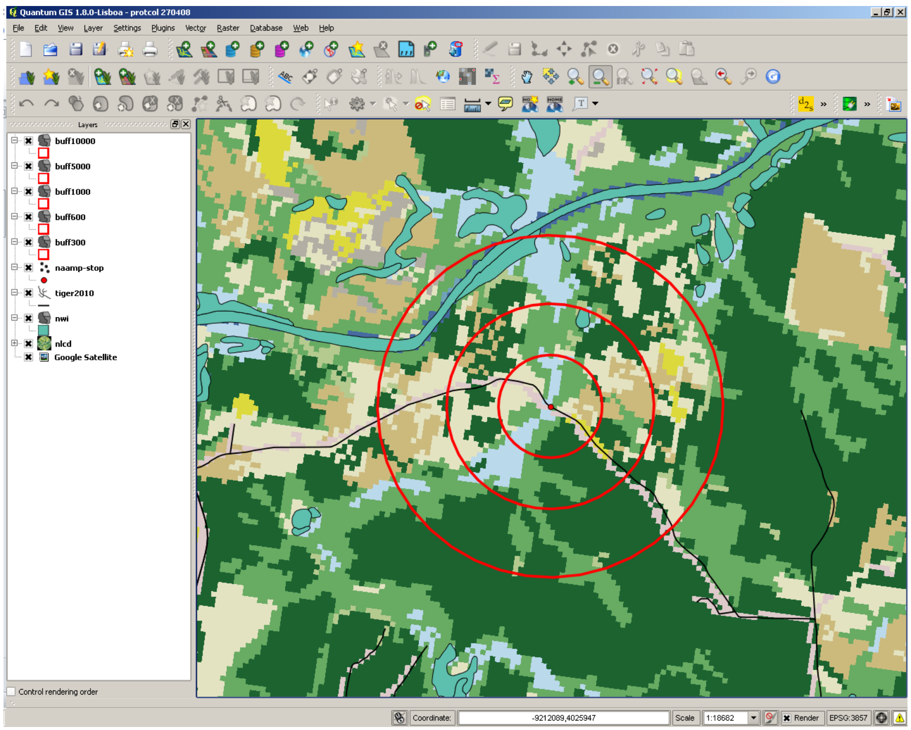
Not too bad. Now onto the methods…

1. Calculating wetland area within a given distance from each stop.

We'll start with calculating wetland area within a given distance of the NAAMP stop because this is the easiest of the calculations. We'll start arbitrarily with the 1000 m buffer, though it should be straightforward to adapt this for any distance.

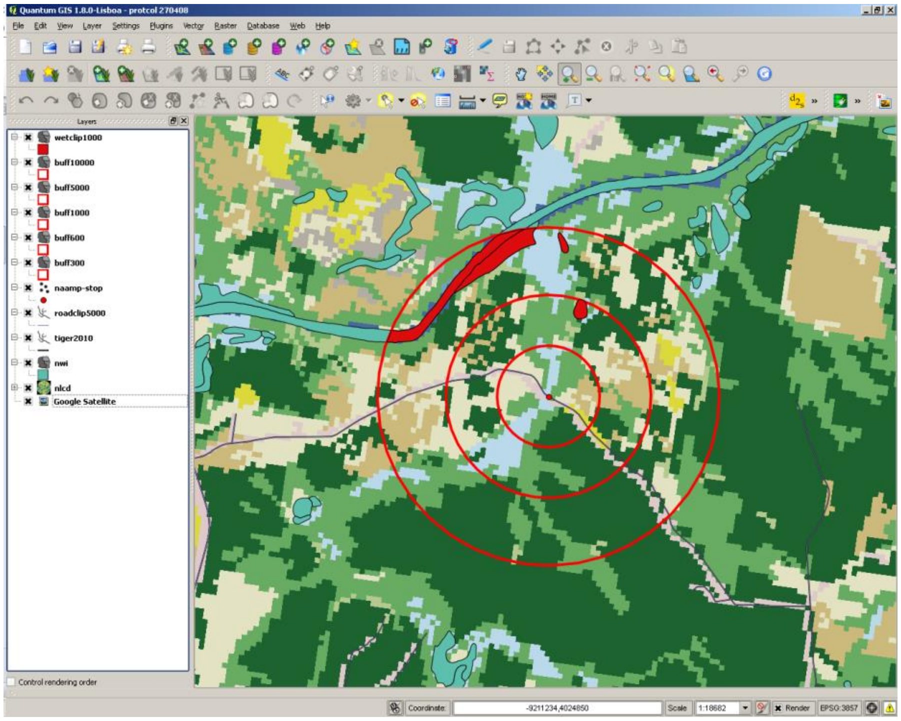
Calculating wetland area requires three steps. The first step is to create a new layer that includes only wetlands (and parts of wetlands) within the buffer (this is called a "clip"). The second step is to calculate the area of all the wetlands within the clip layer. And the third step is to sum up the areas.

Start by zooming in on the 1000 m buffer.

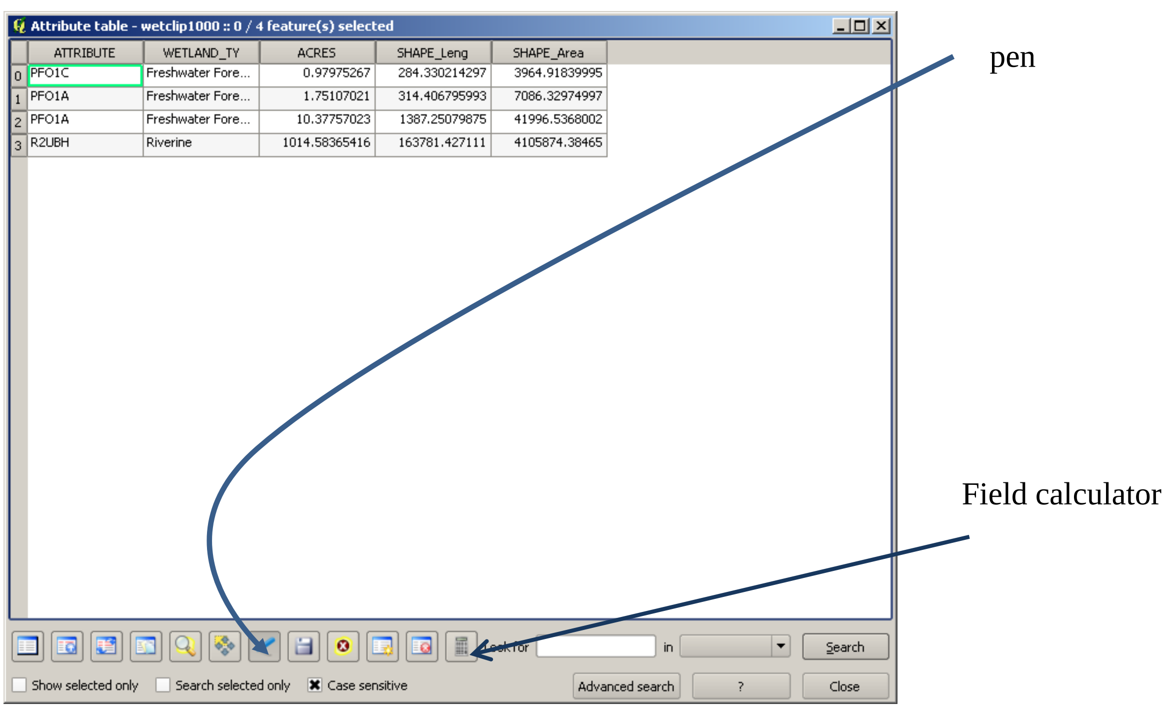


A few things you should note: 1) there are definitely a few wetlands on the NWI layer within 1000 m of the stop, 2) the river at the top is only partially within the buffer, and 3) NLCD believes there are some wetlands (light blue color) that are not recognized in the NWI layer (remember, we're going with NWI layer for consistency).

To create the clipped layer, go to the top menu and click on Vector then Geoprocessing Tools then Clip. For *Input vector layer*, select the nwi wetlands layer. For *Clip layer*, select the 1000m buffer for the stop (e.g.buff1000). Use Browse to set the name and location for the output file (something like wetclip1000, in the same folder with the data for the route). Then click OK to generate the output and add it to the table of contents. Note that any wetlands within the 1000m buffer have now changed color, as your new layer is now showing on the map.

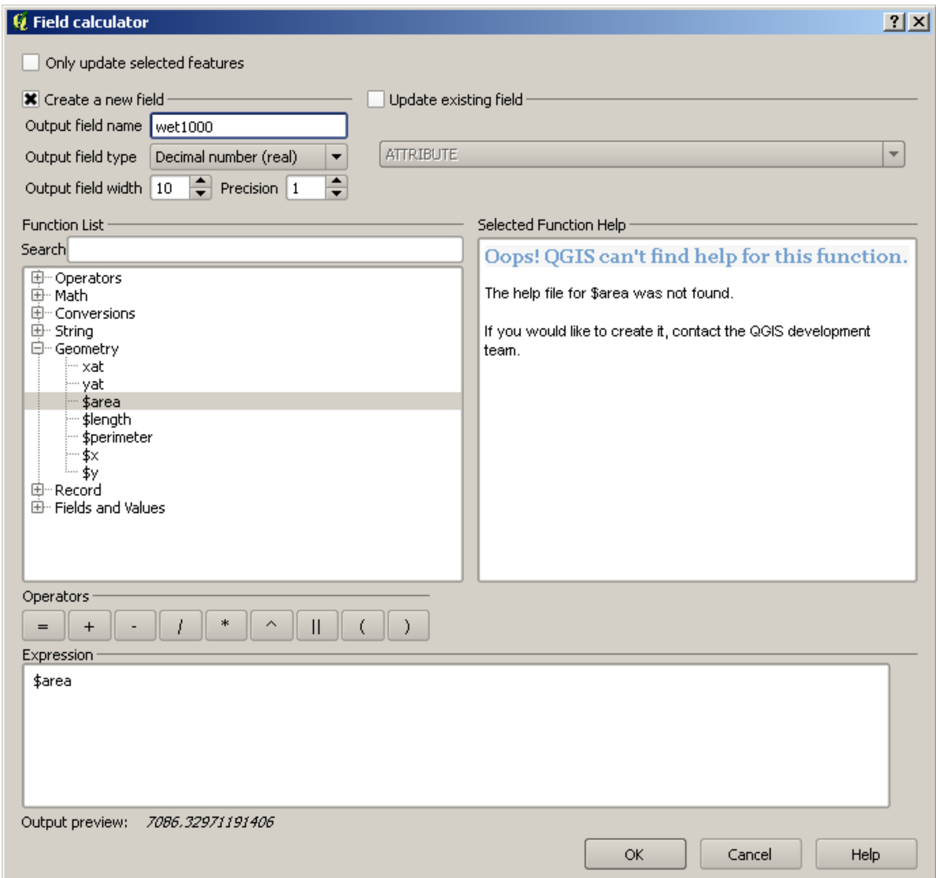


Looks good. For step two (calculating area of the wetlands within the clip), highlight the new layer (e.g.wetclip1000) in the layer window at the left. Open the attribute table for the clipped layer that you just created and turn on editing by clicking on the pen in the middle of the bottom row of icons in the attribute table window.

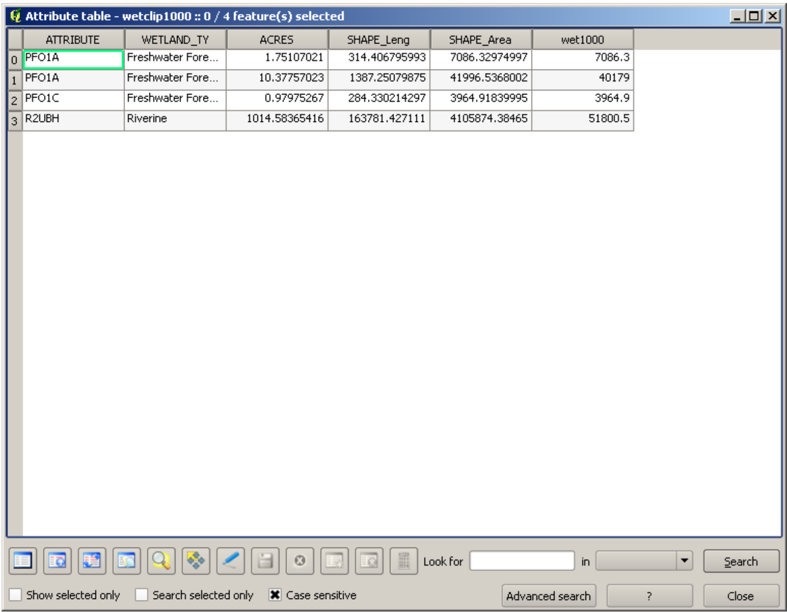


You'll see that the attribute table already includes a column for shape area (the last column). However, this is the area of the entire wetland, not just the part that's within the 1000m clip. To calculate the clipped area, open the Field Calculator, which is the last icon before the "Look for" space along the bottom row of icons in the attribute table.

Once the field calculator has open, click on Geometry, then double click on $area so that it appears in the Expression window at the lower left. Name the output field (this will not be a layer on the map but rather a column in the attribute table), something like "wet1000". Set Output field type to decimal number (real), and set precision (i.e. number of decimal places) to 1 (more than this is OK, but 1 is enough). Click OK, **then click on the editing pen again to turn off editing**. Save the changes to the attribute table. (*Note 1: if you forget to turn off editing, changes will not save properly*). (*Note 2: Don't worry about the "Oops!..." message in the Function Help window below – the function works fine, they just don't have a help file for it*)

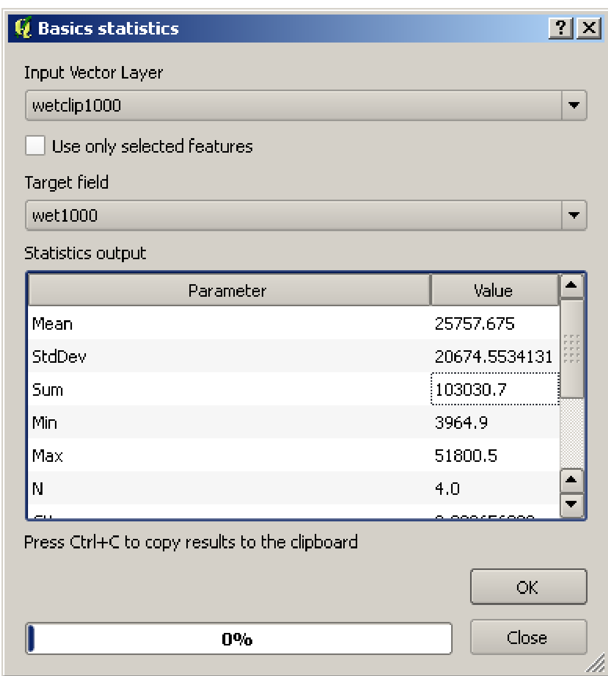


Once you've done this, your new attribute table should look like this:



Note that in the new column the wetlands are the same area as in the SHAPE_Area column if they are contained entirely within the buffer. If only part of the wetland is inside the buffer (as with the river flowing through the site, i.e. the last wetland on the list), the clipped area is much smaller. If you ever find the clipped wetlands in your new column to be larger than the whole wetlands in the default column (i.e. SHAPE_Area), then you've almost certainly done something wrong.

For the last step (summing up the areas), we could just type the new areas into a calculator, but qGIS will actually add them up for us. Go to Vector in the top menu, then Analysis Tools, then Basic Statistics. Choose the clipped layer (e.g.wetclip1000) for the Input Vector Layer and the new area column (e.g.wet1000) for the Target Field. Then click OK.



The third value down (**Sum = 103030.7**) gives you the total wetland area in square meters.

Always ask yourself if your answer seems reasonable. The total area of the buffer is $\pi * 1000^2 = 3,142,000$, so the wetland area is 103030.7/3142000 = 3.3% of the total area. Looking at the map, that looks about right. If the percentage were 33% (or 330%!), you would suspect that a mistake occurred along the way.

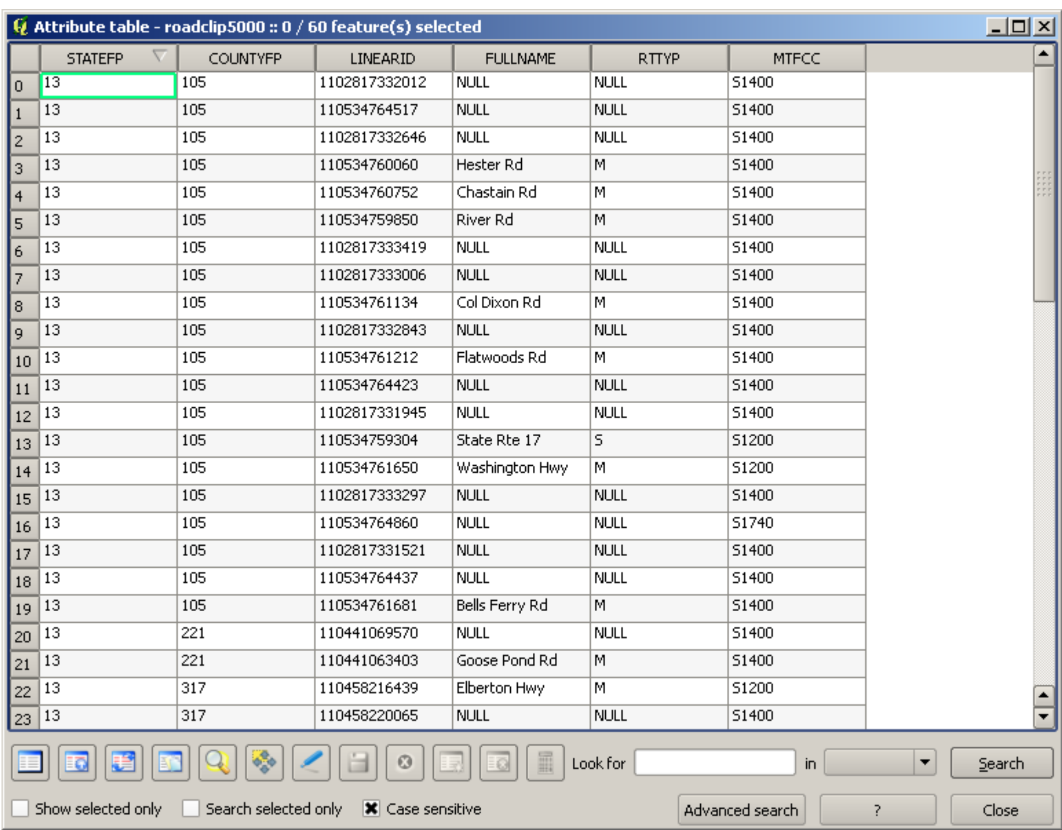
So, that's the wetland area with 1000 m. We'll also need the area within 300 m, 600m, 5000m, and 10,000m. For these just follow the same steps but use a clip that corresponds to the correct distance. *Note: you don't need to do this right now unless your instructor told you to!*

2. Calculating Road Length Within a given distance of a stop

Calculating road length is really similar to calculating wetland area. Since you're working with vector data, you need to carry out the same three steps: 1) create a clip of roads within your buffer, 2) calculate the length of each road within the clip,3) add up the road lengths.

Last year, we just did cumulative road length. However, from a frog's perspective, an interstate highway is probably very different from a gravel logging road. So, this year, we'll calculate total road length but we'll also separate this into primary roads (divided highways), secondary roads (state and county highways), and others (mainly, rural and neighborhood roads). We'll start with total length and then move on to the different sub-types. For road length, we'll stick with route 270408, but start with a 5000 m clip, because there's only one road within the 1000 m buffer. This is a good example of a site where road length/density varies with scale.

To make the clip, go to Vector, then Geoprocessing Tools, then Clip. This time, select the tiger2010 roads layer under *Input vector layer*. Then, enter the 5000m buffer (e.g. "buff5000") under *Clip layer*. Browse to your data folder and give the layer a name (e.g. roadclip5000). Go the attribute table for your new layer (right click on the layer name and click on attribute table).


Attribute table - roadclip5000 :: 0 / 60 feature(s) selected

	STATEFP	COUNTYFP	LINEARID	FULLNAME	RTTYP	MTFCC
0	13	105	1102817332012	NULL	NULL	S1400
1	13	105	110534764517	NULL	NULL	S1400
2	13	105	1102817332646	NULL	NULL	S1400
3	13	105	110534760060	Hester Rd	M	S1400
4	13	105	110534760752	Chastain Rd	M	S1400
5	13	105	110534759850	River Rd	M	S1400
6	13	105	1102817333419	NULL	NULL	S1400
7	13	105	1102817333006	NULL	NULL	S1400
8	13	105	110534761134	Col Dixon Rd	M	S1400
9	13	105	1102817332843	NULL	NULL	S1400
10	13	105	110534761212	Flatwoods Rd	M	S1400
11	13	105	110534764423	NULL	NULL	S1400
12	13	105	1102817331945	NULL	NULL	S1400
13	13	105	110534759304	State Rte 17	S	S1200
14	13	105	110534761650	Washington Hwy	M	S1200
15	13	105	1102817333297	NULL	NULL	S1400
16	13	105	110534764860	NULL	NULL	S1740
17	13	105	1102817331521	NULL	NULL	S1400
18	13	105	110534764437	NULL	NULL	S1400
19	13	105	110534761681	Bells Ferry Rd	M	S1400
20	13	221	110441069570	NULL	NULL	S1400
21	13	221	110441063403	Goose Pond Rd	M	S1400
22	13	317	110458216439	Elberton Hwy	M	S1200
23	13	317	110458220065	NULL	NULL	S1400

Just a brief explanation of what's in here. Each state and county has a code, and each road has a long LINEARID. Then they show the road name, RTTYP is a code for who maintains the road, and MTFCC is a code for road type. Since we'll be looking at road type, this is probably the most important column. Here's the full set of codes:

S1100 Primary Road
S1200 Secondary Road
S1400 Local Neighborhood Road, Rural Road, City Street
S1500 Vehicular Trail (4WD)
S1630 Ramp
S1640 Service Drive usually along a limited access highway
S1710 Walkway/Pedestrian Trail
S1720 Stairway
S1730 Alley
S1740 Private Road for service vehicles (logging, oil fields, ranches, etc.)
S1780 Parking Lot Road
S1820 Bike Path or Trail
S1830 Bridle Path
S2000 Road Median

Most of the roads will be S1400 (these are the "other roads" in the variable list), S1200 (secondary roads), or S1100 (primary roads). We'll include the others in the total length calculation but you won't find many alleys or stairways near NAAMP stops.

Now back to the calculation of total road length. Before we can do this directly, we'll need to take care of one additional problem. We recently discovered that the TIGER layer in some cases contains duplicates when a single road has two different names (e.g. rt 60 = Nelson St.) for part or most of their length. Without any adjustment, qGIS would double-count these roads in length calculations. Fortunately, an available plugin (mmqgis) can take care of this problem.

1) Go to Plugins, then Fetch python plugins, then search for MMQGIS and click Install plugin at the bottom of the screen.
2) Go to Plugins, then mmqgis, then modify, then Delete Duplicate Geometries
3) In the pop-up window, select roadclip5000 as the source layer
4) Click Browse and click to the folder where your map layers are stored.
5) Give the new layer a name, for example "roads2_5000" and click OK.

You now have a new layer called "roads2_5000" (or whatever you called it). If you check the attribute table for this layer, you'll notice it has 55 entries, as opposed to 59 in the original clip, so 4 duplicates were deleted.

Two more important things:

1. ***Make sure you use this layer in all subsequent calculations with road length (it only helps to make the layer if you actually use it)***

2. Sadly, you'll have to repeat the "Delete duplicate geometries for each clip". Roads might be duplicates within the 600m buffer (for example) but not be exact duplicates in the 5000 m buffer (and therefore not be eliminated by applying the function at this larger scale).

OK, using the new clip, we're now ready to calculate road length.

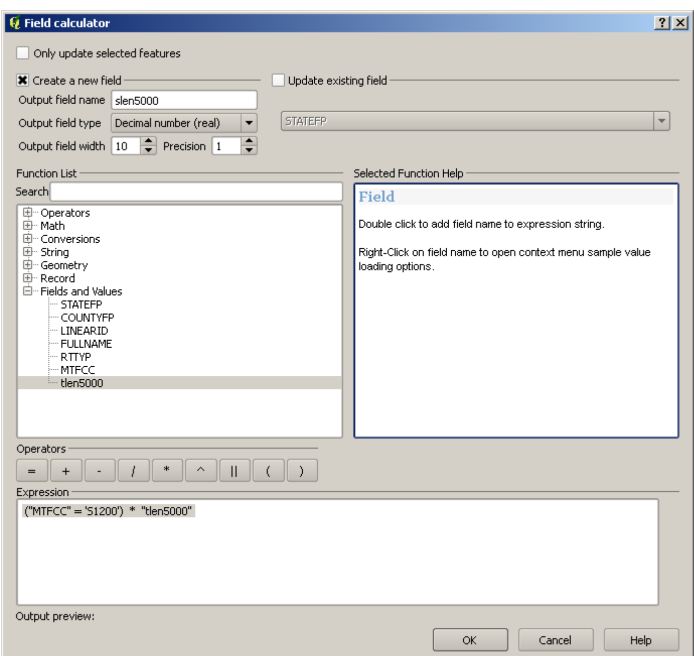
Open the attribute table for the new clip (e.g. "roads2_5000"). Then click on the pen icon to turn editing on, and then click on the Field Calculator. Once this opens, click on Geometry, then double-click on $length so that it appears in the Expression window. Type a name for the new column (e.g."tlen5000" – I write tlen for total length) in the output field, and set Output field type to decimal number(real) with Precision = 1. *Note: if your column name is too long, you may get a "NULL" result when you try to perform the calculations below.*

Next, turn editing off (click on the pen icon again) and save your changes. Now, if you scroll to the end of the of the attribute table, you should see your new column. As before, go to Vector then Analysis tools then Basic statistics. Use your edited clipped roads layer (e.g. roads2_5000) as your *Input Vector Layer* and the new length column (e.g.tlen5000) as the *Target field*. Once again, the sum (74144.7) gives you the total road length in meters.

Does this value seem reasonable? Given that the buffer is 10000 km wide (i.e the 5000 m radius times 2), this is equivalent to about 7 roads passing straight through the buffer. Looking at the map, that seems reasonable. If you had the equivalent of 1/10 of a road or 100 roads (e.g. 1000 m or 1000000 m), you might be suspicious.

OK, so what about the length of individual road types? Here, we can make use of the MTFCC codes to specify different roads to be included. First, go back to the attribute table for the roads2_5000 layer. Click on the pen and then the field calculator.

We'll start with the length of secondary roads, because there are not any primary roads within the buffer. Type in a name for the output field (I used "slen5000" for secondary road length within 5000 m). Then, in the Expression window, type in (or paste) the following formula: ("MTFCC" = 'S1200') * "tlen5000"



(Note: you can use the drop down for "Fields and Values" to click in the variable names "MTFCC" and "tlen5000" so that you won't risk mis-typing them. Note 2: The use of double quotes for variable names and single quotes for attribute types (e.g. 'S1200') is required syntax for qGIS)

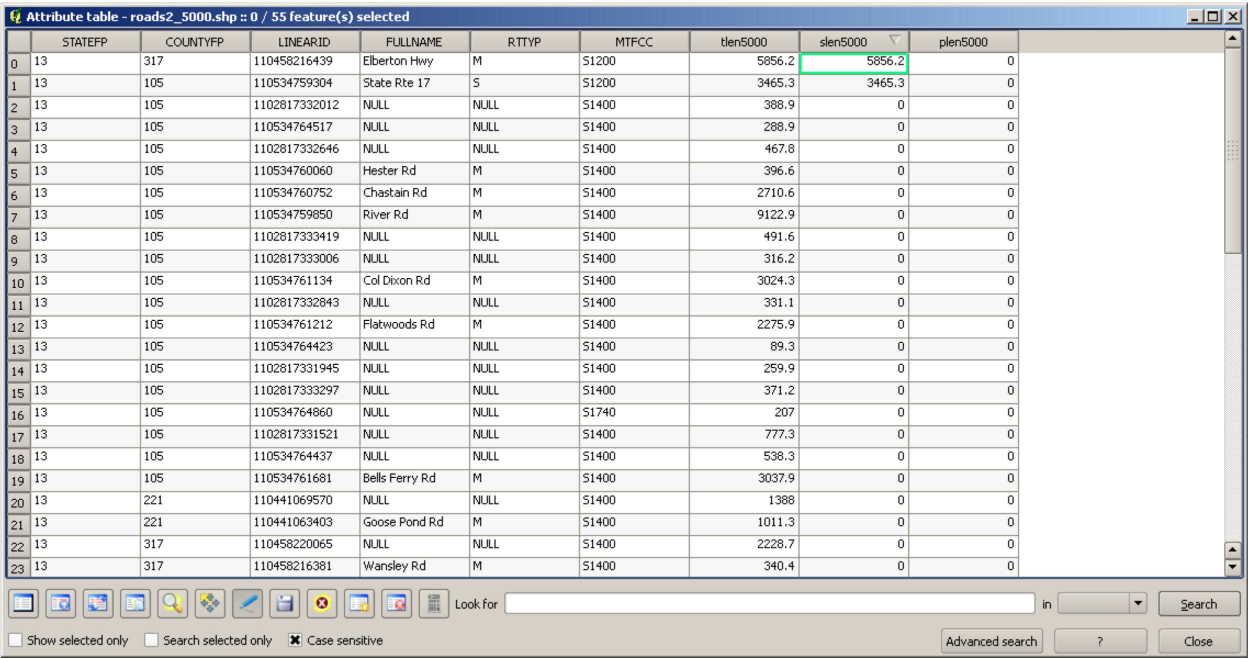
So what's this formula? The first term ("MTFCC"='S1200') creates a "1" where this condition is true (i.e. the road is a secondary road) and a 0 where this condition is false. The second term * "tlen5000" then multiplies these ones or zeros by the length of the road within the clip. So, if the road is a secondary road you get the length, otherwise you get a zero. If you have any experience with computer programming, you'll be used to these sorts of logical operators as they are not unique to qGIS.

Clicking OK should create a new column in the roads2_5000 attribute table called "slen5000". Make sure to click the pen to save this column. Now of course you can go to Vector then Analysis Tools, then Basic Statistics and see the sum for the column slen5000 (9321.5 m, about 12% of the total road length for the buffer).

For primary roads do the same thing, but call the column plen5000 (or something similar) and use the formula:

("MTFCC" = 'S1100') * "tlen5000"

Click OK and then click the pen to save the changes. Your attribute table should look something like this:



	STATEFP	COUNTYFP	LINEARID	FULLNAME	RTTYP	MTFCC	tlen5000	slen5000	plen5000
0	13	317	110458216439	Elberton Hwy	M	S1200	5856.2	5856.2	0
1	13	105	110534759304	State Rte 17	S	S1200	3465.3	3465.3	0
2	13	105	1102817332012	NULL	NULL	S1400	388.9	0	0
3	13	105	110534764517	NULL	NULL	S1400	288.9	0	0
4	13	105	1102817332646	NULL	NULL	S1400	467.8	0	0
5	13	105	110534760060	Hester Rd	M	S1400	396.6	0	0
6	13	105	110534760752	Chastain Rd	M	S1400	2710.6	0	0
7	13	105	110534759850	River Rd	M	S1400	9122.9	0	0
8	13	105	1102817333419	NULL	NULL	S1400	491.6	0	0
9	13	105	1102817333006	NULL	NULL	S1400	316.2	0	0
10	13	105	110534761134	Col Dixon Rd	M	S1400	3024.3	0	0
11	13	105	1102817332843	NULL	NULL	S1400	331.1	0	0
12	13	105	110534761212	Flatwoods Rd	M	S1400	2275.9	0	0
13	13	105	110534764423	NULL	NULL	S1400	89.3	0	0
14	13	105	1102817331945	NULL	NULL	S1400	259.9	0	0
15	13	105	1102817333297	NULL	NULL	S1400	371.2	0	0
16	13	105	110534764860	NULL	NULL	S1740	207	0	0
17	13	105	1102817331521	NULL	NULL	S1400	777.3	0	0
18	13	105	110534764437	NULL	NULL	S1400	538.3	0	0
19	13	105	110534761681	Bells Ferry Rd	M	S1400	3037.9	0	0
20	13	221	110441069570	NULL	NULL	S1400	1388	0	0
21	13	221	110441063403	Goose Pond Rd	M	S1400	1011.3	0	0
22	13	317	110458220065	NULL	NULL	S1400	2228.7	0	0
23	13	317	110458216381	Wansley Rd	M	S1400	340.4	0	0

I sorted by MTFCC code and you can see clearly that there are no primary roads within this buffer. However, I would definitely suggest doing the calculations (for roads and wetlands) rather than scanning the attribute table for zeros that you can skip over. Scanning by eye can get difficult when it's late at night and you've got very long lists of roads or wetlands to look at.

Once you have tlen (here, 74144.7), slen (9321.5) and plen (0.0), it is easy to subtract from tlen and get olen (i.e. the length of "other" roads, which would be 74144.7-9321.5-0 = 64823.2).

One final note – for each road type, I took you through the steps of adding a length column to the attribute table and then summing up that length column using Analysis Tools. *Once you've done this once or twice, you'll almost certainly find it faster to add all the length columns first, then use analysis tools to get the summed lengths for each.*

3-5. Calculating the proportion of surrounding land that is developed, forested, or agricultural

Since the land use (nlcd) layer is raster data (i.e. color-coded cells), this calculation is a bit different from the calculations above. Recall that the landcover classifications (http://www.mrlc.gov/nlcd06_leg.php) are more specific than just “forested” or “developed”.

Rather, there are 3 different codes for forest (Deciduous, Evergreen, and Mixed), and 4 different codes for Developed (from Developed, Open Space to Developed, High Intensity). So, to calculate proportion developed (or forested, or agricultural) you first have to create a new raster layer that classifies cells as to whether they fall into any of the developed codes or not (using 1 for developed and 0 for not developed).

Once you have this new layer, you then calculate the mean value of the cells within the buffer on interest, which will give us the proportion of cells that are developed. You may have to think about this for a minute to understand why it works. If say half the cells are developed then the mean of half 1s and half 0s will be 0.5. If ¼ of the cells developed then the mean of cells (¼ of which are scored as 1 and ¾ of which are scored as 0), will be 0.25.

One positive – unlike the wetland and road calculations where you had to make a new clip for each buffer, here you just need to create the derived rasters once and then you can use them for all your buffer distances sequentially.

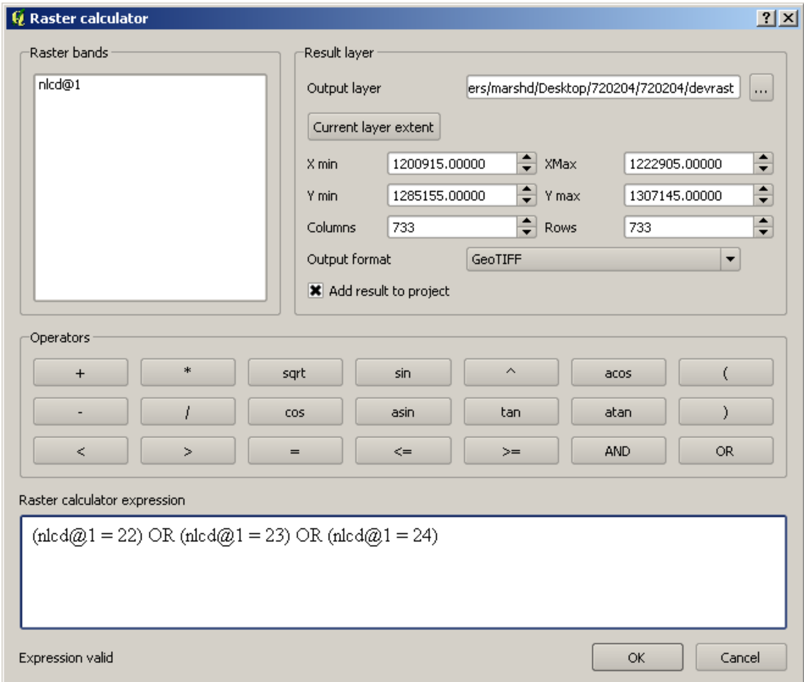
For these raster calculations, you’ll need to enable a Plug-In called “Zonal Statistics.” Go to Plugins, then Manage Plugins. Scroll down to the bottom from the list. Around third from the bottom is “Zonal Statistics.” You’ll need to click the box next to this item and click OK.

Now, go to Raster at the top menu, then Raster Calculator. The Calculator window should open. Click the “…” (i.e. browse) button and then type in a name for the output layer (I called mine devrast for developed raster). *Note: for some reason if you just type directly into the output layer window without first browsing to the desired folder (i.e. without hitting the "…" button), your raster layer will not be created*. Anyway, once you have the name entered, type (or copy and paste) the following expression into the Raster calculator expression window:
(nlcd@1 = 22) OR (nlcd@1 = 23) OR (nlcd@1 = 24)

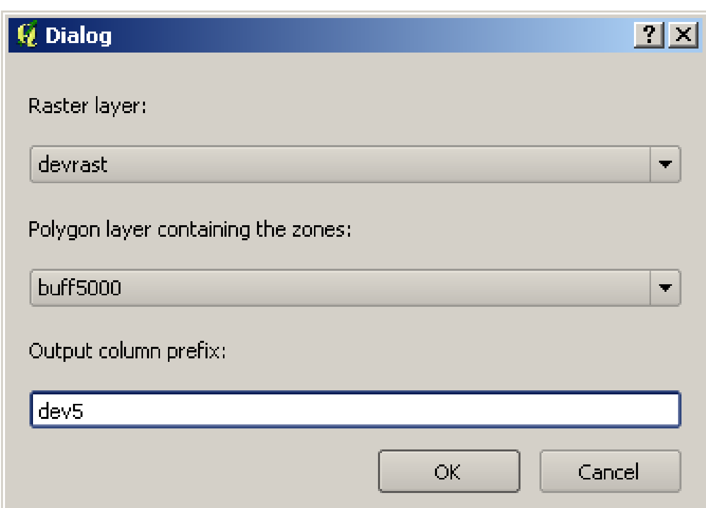
The @1 assigns a value of 1 to each relevant cell and the = 22, = 23, etc refer to the color codes for developed on the nlcd raster http://www.mrlc.gov/nlcd06_leg.php . So, this expression assigns a “1” to any cell that falls into any of these 3 developed classes. By default, other cells are assigned the value zero.

If you look at the NLCD classes, you’ll note that we have not included the NLCD class 21 “Developed, Open Space” here. This class is mostly lawns, parks, etc. and our judgment was that these don’t include what people normally think about when they think about “developed” land. It’s possible, of course, that some of these land uses do affect amphibians (either positively or negatively), but we can’t necessarily do everything the first time through.

Anyway, here's what the raster calculator window should look like:

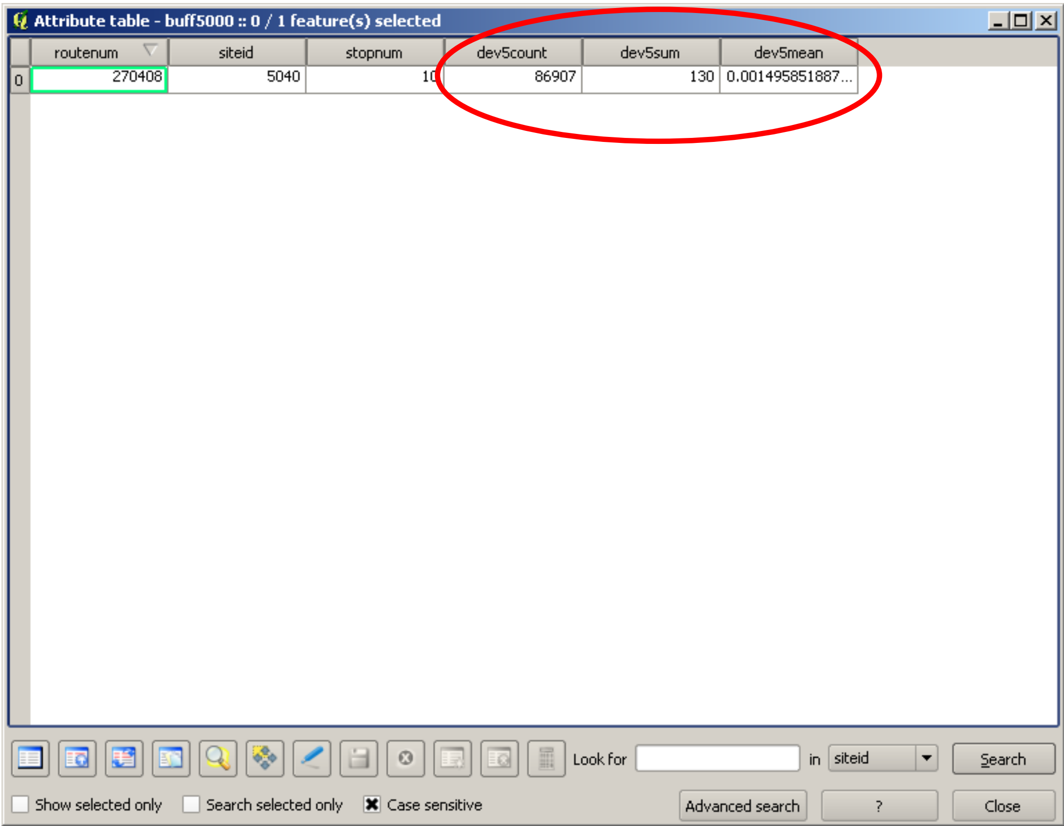


When you click OK, the new layer will eat your map by covering over it with a solid color. But, no worries, just move the new raster to the bottom of the layer list. You'll need it for calculations, but there's no reason to look at it.



Now go to Raster (at the top menu) and then Zonal Statistics. A Dialog box should open.
Use your newly created raster layer as the *Raster layer* (e.g. devrast) and to do the calculation at the 5000 m scale, specify the 5000 m buffer (buff5000) as the *Polygon layer containing the zones*. Also, give the Output column a short (5 characters or less!) prefix (I used dev5). Click OK. Note, output column names longer than 5 characters will just give you "NULL" for the output columns.

Almost done. The last step is to open the attribute table for the 5000 m buffer (i.e. highlight and right-click buff5000 in the layer window). Magically, three new columns have appeared:



"dev5mean" is the proportion of the buffer that falls into one of the three developed classes. That number is 0.00149. This seems very low but if you look back at the map, it indeed looks reasonable. There's a little swatch of development in the northeast section of the buffer and another one in the northwest, but most of the land here is agricultural or forest.

Speaking of which, you can follow the same set of steps to determine the proportion of land in forest or agricultural usage. First, create a new raster to represent whether the cells are forested (or agricultural) or not; then, use the Raster calculator to figure out the mean value of these cells within the buffer. In the raster calculator, make sure you're still using the Raster band (top-left) nlcd@1 to create your derived rasters for forest or agriculture.

The only other thing that's different for forested or agricultural land is the expression that goes into the Raster calculator, since of course the land use codes are different.

So, for proportion forest, instead of the expression for developed, you would use:

(nlcd@1 = 41) OR (nlcd@1 = 42) OR (nlcd@1 = 43)

Since 41, 42, and 43 are the codes for the 3 forest types. This should give you a forest landcover of 0.541.

Similarly, for proportion agriculture, you would use:

(nlcd@1 = 82), which will give you zero (none of this land is in row crops, although there is a fair amount of pasture and shrubland).

A few important points about these raster calculations:

- Always look back at the map to make sure your entry looks reasonable. You probably won't be able to tell 0.20 from 0.25, but you should be able to distinguish 0.20 from 0.02.

- Always make sure your 3 land use variables don't add up to more than 1!

- When you go to do the other buffer distances (e.g. 300 m, 600 m, etc.), you can use the rasters you already created for developed, forested, and agricultural cells (these apply to the whole NLCD layer). So, you will only have to carry to create the derived rasters one time -your next set of calculations in Zonal Statistics will use the same raster with a new buffer distance.