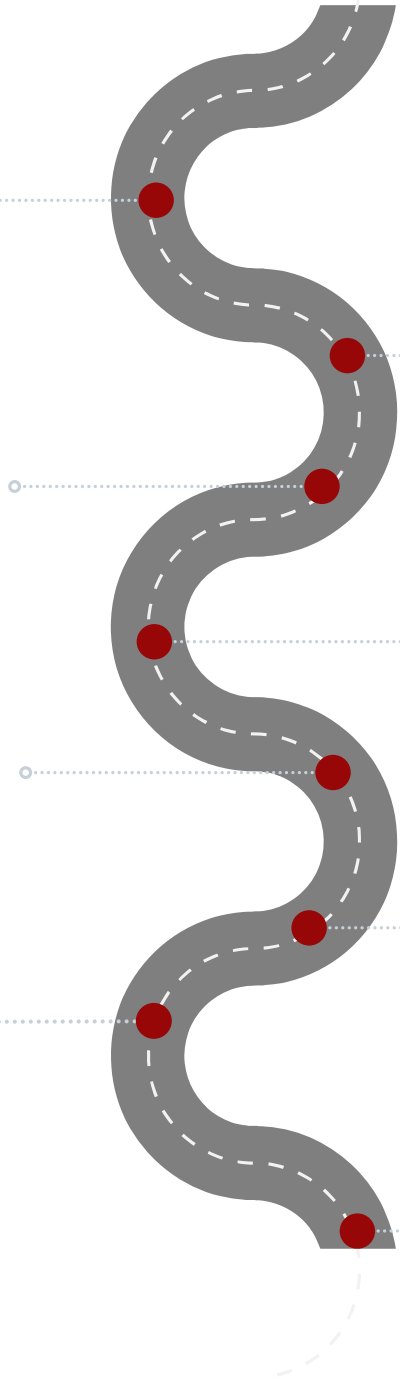
Emissions Calculations

Learning Objectives

- Discuss the difference between concentrations and emissions
- How to calculate emissions using a bottom-up approach
- How to use lookup tables for fuels, combustion completeness, and emissions factors of forestry/grasses/peatlands/croplands

Process



Step One

Visualize data in QGIS

Step Two

Link the Data

Step Three

Calculate statistics

Step Four

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Step Five

Open results

Step Six

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Step Seven

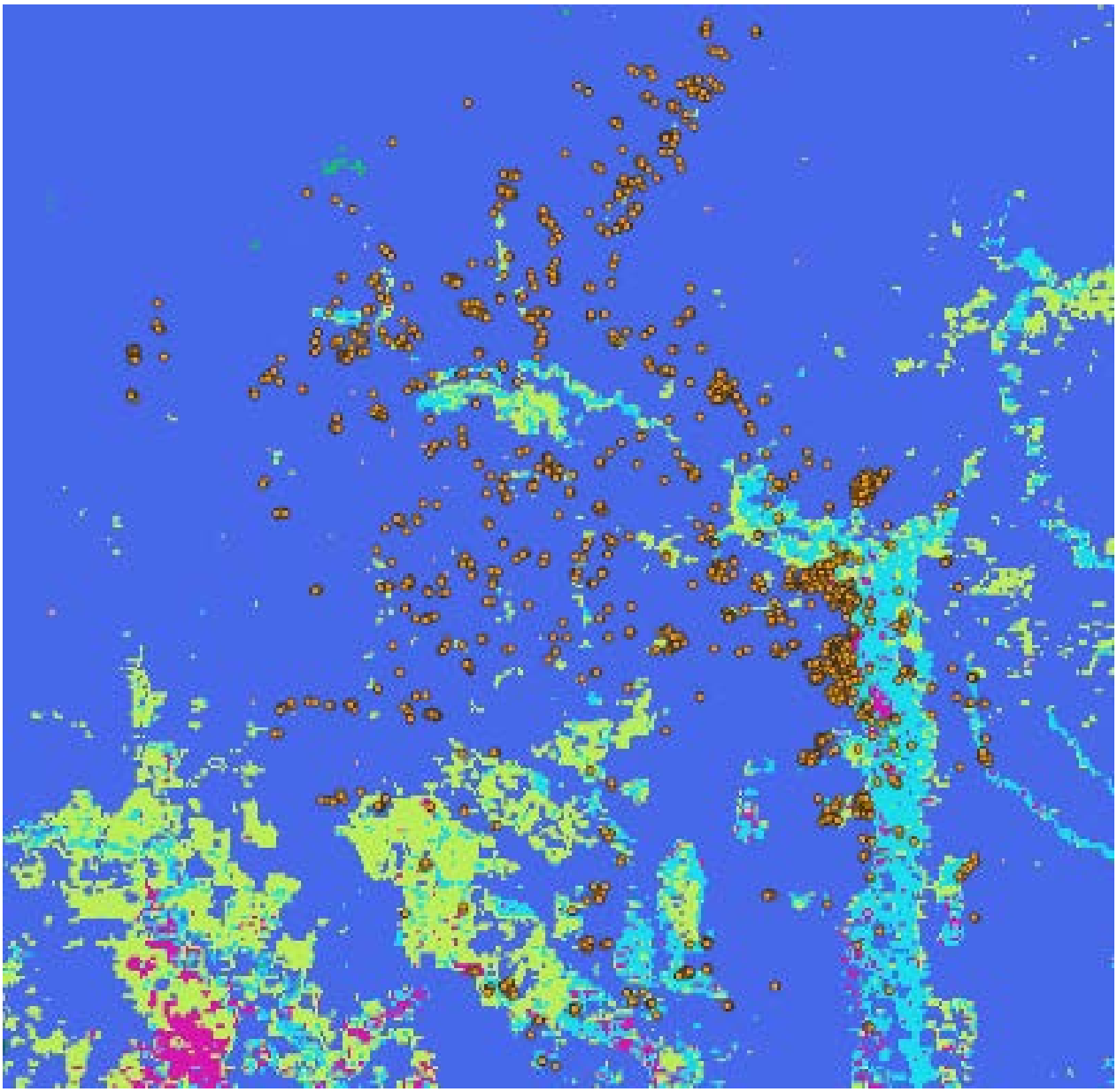
Join results and emission factors tables

Step Eight

Emissions calculation

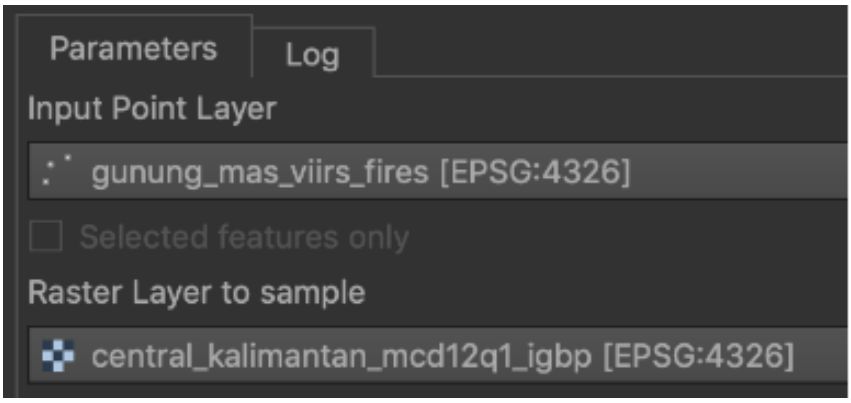
1- Visualize data in QGIS

Add the fire points and LULC raster by dragging and dropping them into QGIS. Then in the raster layer properties symbology tab, change the type to Unique Values and symbolize by IGBP class. The colors will differ for everyone, but the important part is that you can see the difference between land cover classes. This will help us assess the accuracy of the results from our next step.

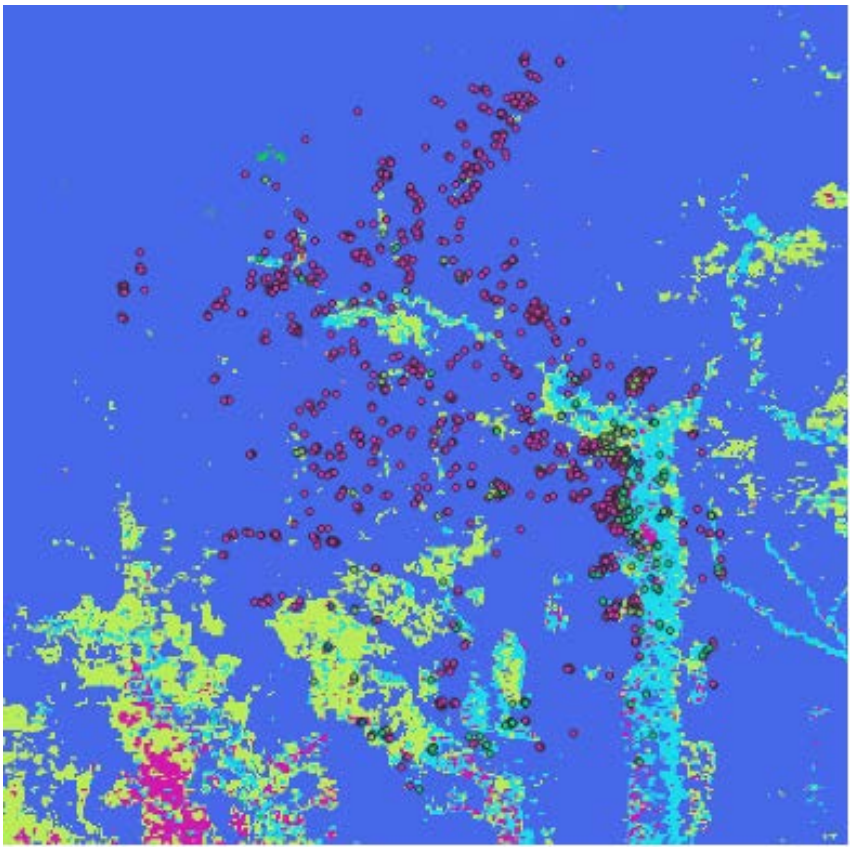


2- Link the Data

In the Processing Toolbox, under Raster Analysis, select the Sample Raster Values tool. You may have more than one option for each of the two inputs so set them as seen below.



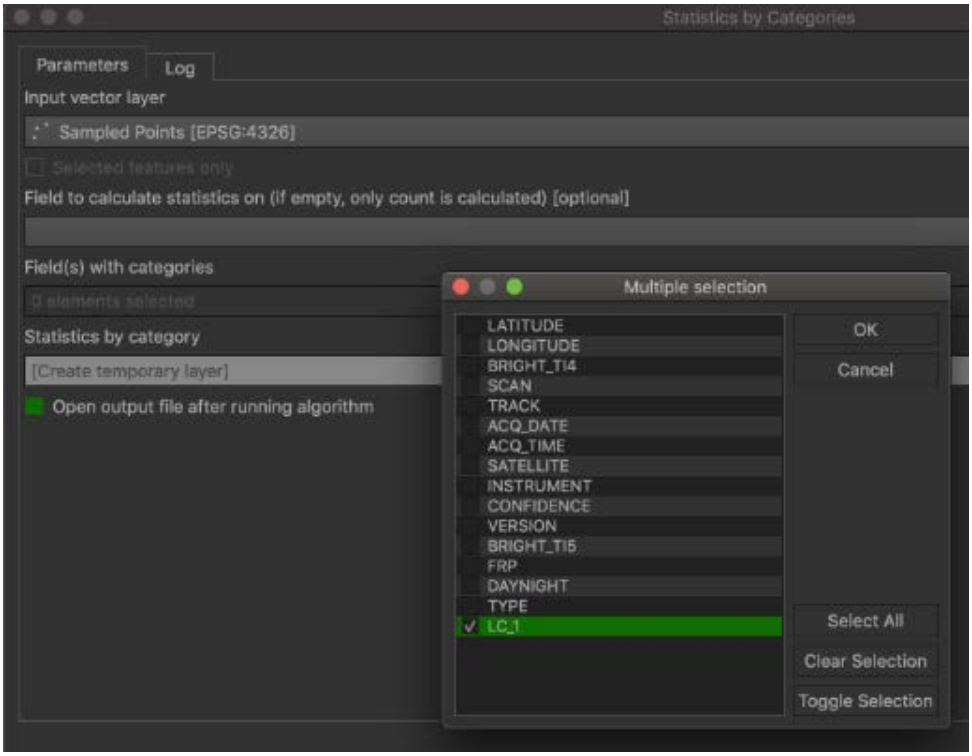
Then change the symbology of your newly created points layer using the same process we used for the land cover raster, this time choosing Categorized and setting the Column input to the name of the variable we just added. I named my variable LC, but any name is fine. You should be left with something that looks like this:



Notice that the paired colors remain consistent throughout -- magenta points are always on top of the blue land cover, green on green, etc. This is a good sign that we have extracted the right information to our points layer

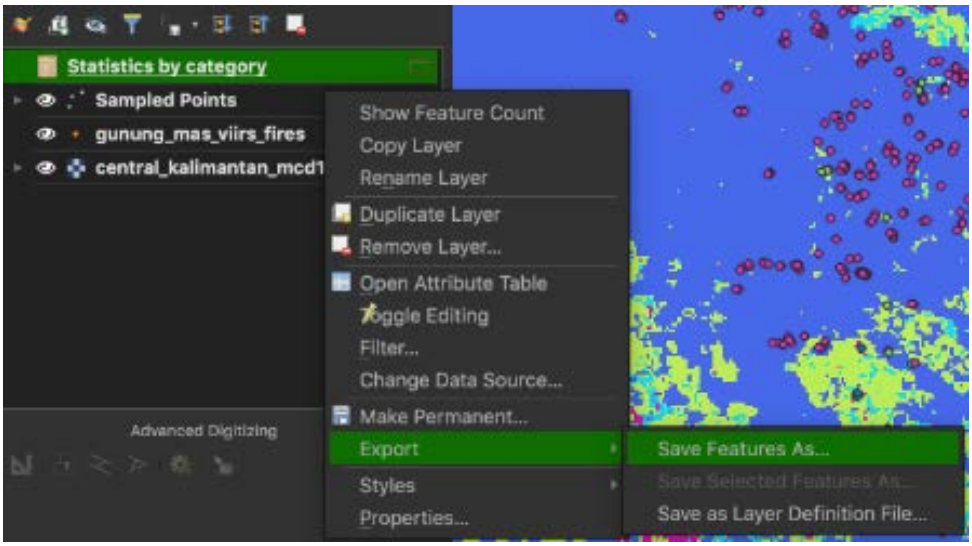
3- Calculate statistics

Now select the Statistics by Categories tool from Vector Analysis. Since we want to get statistics about each land cover class, select your land cover variable in the “Field(s) with categories” dialogue and run the tool.



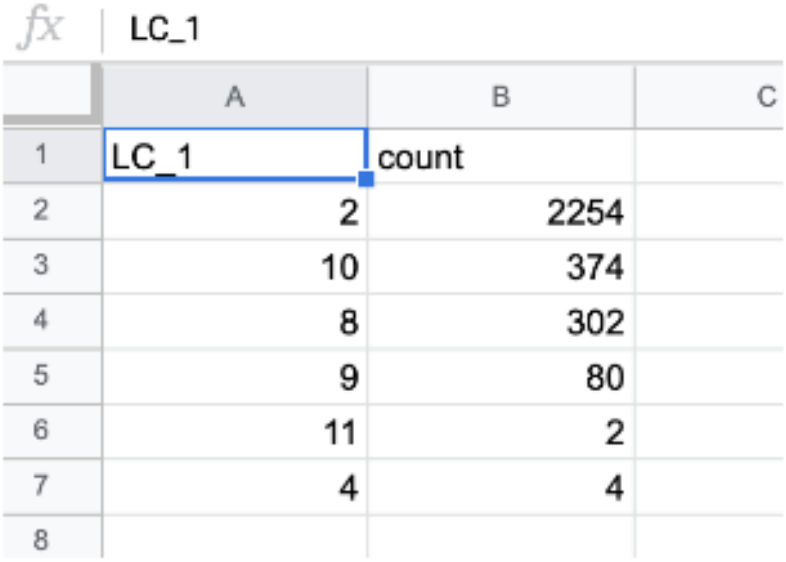
4- Export results

Right-click on the new table we have created and export it as a csv file, following the sub-menu path shown here:



5- Open results

Now open this summary in Google Sheets. It should look like this:

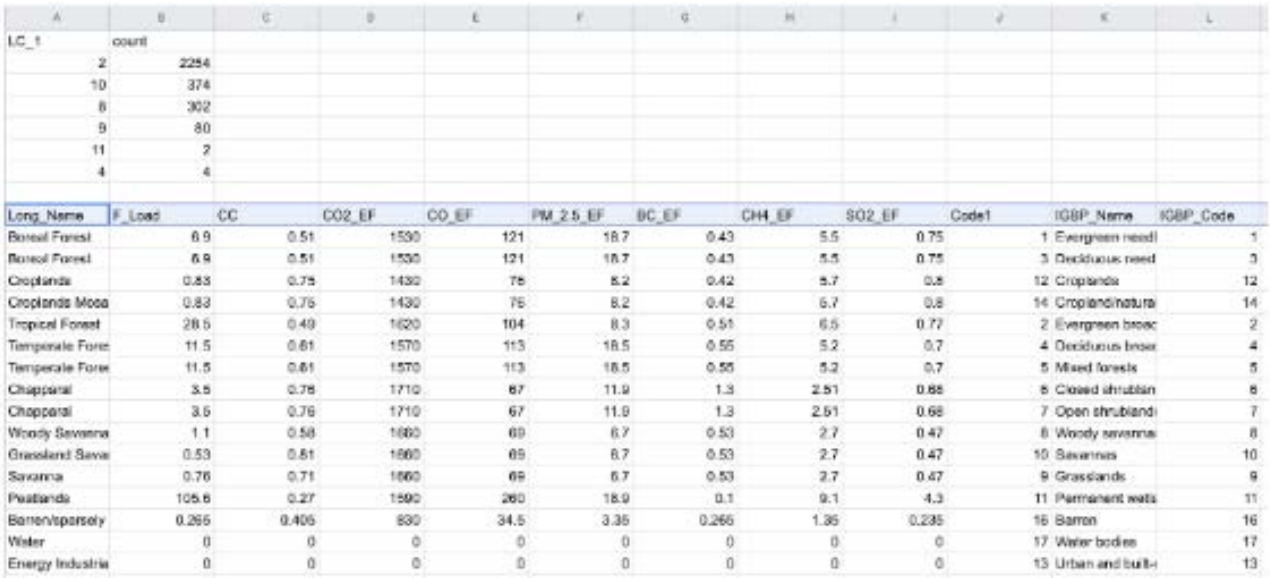


fx | LC_1

	A	B	C
1	LC_1	count	
2	2	2254	
3	10	374	
4	8	302	
5	9	80	
6	11	2	
7	4	4	
8			

6- Prepare data for calculation

Now open the provided emission factors lookup table called “em_ef2.csv.” Together they should look like this:



LC_1	count
2	2254
10	374
8	302
9	80
11	2
4	4

Long_Name	F_Load	CC	CO2_EF	CO_EF	PM_2.5_EF	BC_EF	CH4_EF	SO2_EF	Code1	IGBP_Name	IGBP_Code
Boreal Forest	6.9	0.51	1530	121	18.7	0.43	5.5	0.75	1	Evergreen needl	1
Boreal Forest	6.9	0.51	1530	121	18.7	0.43	5.5	0.75	3	Deciduous need	3
Croplands	0.83	0.75	1430	75	8.2	0.42	5.7	0.8	12	Croplands	12
Croplands Mosa	0.83	0.75	1430	75	8.2	0.42	5.7	0.8	14	Cropland/natura	14
Tropical Forest	28.5	0.49	1620	104	8.3	0.51	6.5	0.77	2	Evergreen broac	2
Temperate Fore	11.5	0.61	1570	113	18.5	0.55	5.2	0.7	4	Deciduous broa	4
Temperate Fore	11.5	0.61	1570	113	18.5	0.55	5.2	0.7	5	Mixed forests	5
Chaparral	3.5	0.75	1710	67	11.9	1.3	2.51	0.68	6	Closed shrublan	6
Chaparral	3.5	0.75	1710	67	11.9	1.3	2.51	0.68	7	Open shrublands	7
Woody Savanna	1.1	0.58	1660	69	6.7	0.53	2.7	0.47	8	Woody savanna	8
Grassland Sava	0.53	0.61	1660	69	6.7	0.53	2.7	0.47	10	Savannas	10
Savanna	0.76	0.71	1660	69	6.7	0.53	2.7	0.47	9	Grasslands	9
Peatlands	105.6	0.27	1590	260	18.9	0.1	9.1	4.3	11	Permanent wetla	11
Barren/sparsely	0.266	0.405	880	34.5	3.35	0.266	1.36	0.235	16	Barren	16
Water	0	0	0	0	0	0	0	0	17	Water bodies	17
Energy Industria	0	0	0	0	0	0	0	0	13	Urban and built-	13

7- Join results and emission factors tables

The variable LC_1 in our summary table corresponds to the IGBP_Code variable in the lookup table. Normally, we would use a join to match the emission factors with each of the land cover classes, but Google Sheets does not support joins, so we will do the matching by hand. Drag all columns from the lookup table to each of the summary table rows where LC_1 and IGBP_Code match. This should be the result

LC_1	count	Long_Name	F_Load	CC	CO2_EF	CO_EF	PM_2.5_EF	BC_EF	CH4_EF	SO2_EF	Code1	IGBP_Name	IGBP_Code
2	2254	Tropical Forest	28.5	0.49	1620	104	8.3	0.51	6.5	0.77	2	Evergreen broa	2
10	374	Grassland Savai	0.53	0.81	1660	69	6.7	0.53	2.7	0.47	10	Savannas	10
8	302	Woody Savanna	1.1	0.58	1660	69	6.7	0.53	2.7	0.47	8	Woody savanna	8
9	80	Savanna	0.76	0.71	1660	69	6.7	0.53	2.7	0.47	9	Grasslands	9
11	2	Peatlands	105.6	0.27	1590	260	18.9	0.1	9.1	4.3	11	Permanent wetl	11
4	4	Temperate Fores	11.5	0.61	1570	113	18.5	0.55	5.2	0.7	4	Deciduous broa	4

8- Emissions calculation

We now have all of the information we need to calculate emissions using the formula:
Emissions = EF * CC * F_Load * (N * Area) ,

where N is the number of fires in each category, Area is the estimated average fire area in square meters, and all other variables are held constant for each fuel (land cover) type.

For demonstration purposes, we will assume that each fire burns approximately 1 square kilometer of fuels. Knowing that, here is the formula I typed into Google Sheets to calculate black carbon emissions by land cover class: =D2*E2*I2*(B2*1000)

Below I have my results from applying the same formula to each land cover class. Note that all emissions are calculated in grams so you may need to convert to larger or smaller units depending on the scale of your analysis.

LC_1	BC (g)	Long_Name
2	16053326.1	Tropical Forest
10	85095.846	Grassland Savanna
8	102118.28	Woody Savanna
9	22879.04	Savanna
11	5702.4	Peatlands
4	15433	Temperate Forest

Homework

How would you repeat this for a week (7 days) of fires in Europe? Where would you get the fire data? Where would you get the land cover data?