ESRM433/SEFS533
Lab 7

Objectives:

- Locate lidar data from coordinate points
- Model wetland boundaries using lidar DTMs
- Compare outputs to national wetland database

Data and Software:

- Wetlands Data from US Fish and Wildlife Service
  - https://www.fws.gov/wetlands/Data/Data-Download.html
- Downloads from Washington DNR lidar Portal
- CloudCompare
- ArcGIS Pro

What you will turn in:

- Submission Template in PDF or DOCX file format submitted via Canvas

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Welcome to Lab 7 for ESRM433/SEFS533!

For this lab, we are going to be working toward answering a question about wetlands.
We've spent a lot of time working with canopy height models and lidar metrics describing forest structure. We've essentially treated DTMs as just a step in the process of normalizing vegetation point clouds, but ground models derived from lidar can be extremely powerful in the delimitation and detection of wetlands.
We are going to be working mainly within ArcGIS Pro for this lab. For a deeper dive into working with lidar in ArcMap check out this book:

Keranen, Kathryn, and Robert Kolvoord. Making Spatial Decisions: Using GIS and Lidar: a Workbook. Esri Press Academic, 2016.

We are going to step adjacent to forest ecology and work with lidar in a hydrology context. From Making Spatial Decisions: Using GIS and Lidar:
"Wetlands have been protected in the United States since the 1970s under the Federal Clean Water Act. Once wetlands are identified, they can be declared subject to the Clean Water Act of 1977 and protected. These depressed topographical areas can collect and store water as well as provide a rich habitat for many plants and animals.
Wetlands have traditionally been delineated using field inventories. Such inventories require considerable time in the field by experienced scientists to make observations. Lidar, combined with the use of GIS, offers an opportunity for off-site delineation of wetlands."

There are two scenarios in this lab. The first you will be walked through, but the second you will be on your own. For both scenarios you will be referring back to the National Wetlands Inventory (NWI) data https://www.fws.gov/wetlands/

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Scenario #1: Turnbull

You are a volunteer for "Friends of Turnbull National Wildlife Refuge". You need to determine if the NWI's wetland polygons are accurate for the depressional wetlands at the refuge. The wetland is considering investing money to get all the depressional wetlands mapped using lidar, but only if the lidar results significantly improve the already existing polygon data with the NWI database. Three of the wetlands with polygons in the NWI database have been selected to be used for the assessment, and if you are able to delineate any additional wetlands in the area, that aren't in the NWI database then you'll get an extra gold star.
https://www.fws.gov/refuge/Turnbull/

You are given coordinates for the 3 wetlands, and the person giving you the coordinates really helps you out by including the EPSG code (hint, you should do this if passing off coordinates to friends or colleagues, or at least include the datum and projection information such as WGS 84 or NAD83 / UTM zone 11n).

Turnbull wetlands: EPSG 3857 Lat,Long decimal degrees

1. 47.4167, -117.5861
2. 47.4195, -117.5799
3. 47.4141, -117.5812

Scenario #2: Mount Rainier

You are about to start a research project on alpine depressional wetlands. First step is to validate the location and area of wetlands in your study area. Unfortunately, the only lidar data available for the area is a 2007 DTM. The point cloud and surface model aren't available from the DNR lidar portal! You could contact the agency directly to request the full lidar data, but you think you can get the job done just using the Vendor DTM.

The bounding box for you study area is:

Mt Rainier study site: EPSG 3857 Lat,Long decimal degrees

- West -121.7227 (1,334,061 EPSG 2927)
- East -121.7145 (1,336,116 EPSG 2927)
- North 46.7777 (529,096 EPSG 2927)
- South 46.7739 (527,713 EPSG 2927)

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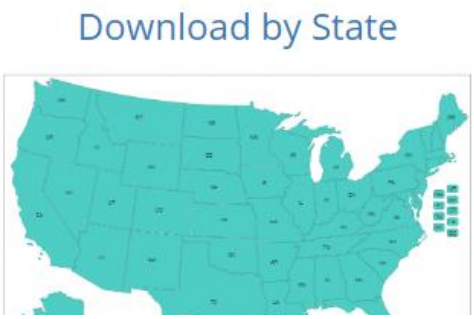
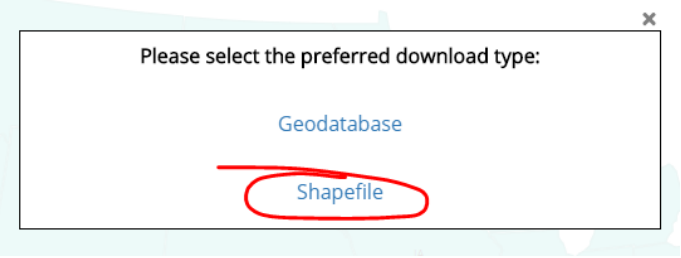
Scenario #1: Turnbull

PART 1:

The first step is to go and grab a copy of the NWI shapefiles for Washington State. A web search using that phrase leads you to: https://www.fws.gov/wetlands/data/data-download.html



You want to download by state. If you get an error from the website, reload the page. The fws.gov site is being a little buggy.



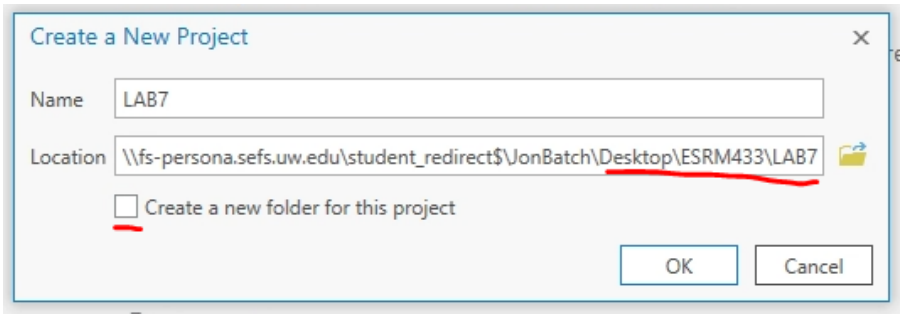
Click on Washington and grab the shapefiles. If you are a GIS wiz, you can grab the Geodatabase but I am assuming folks will just have the shapefiles downloaded.

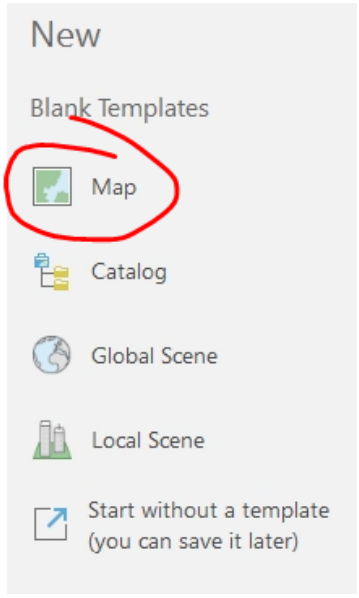
Unzip the data and put it in your Desktop/ESRM433/LAB7 folder. It's a big file so extract the zip file in your LAB7 folder, then delete the zipped version. There are shapefiles for:

- WA_Wetlands
- WA_Wetlands_Historic_Map_Info
- WA_Wetlands_Project_Metadata
- Washington

We only need the WA_Wetlands data but the project metadata has some interesting links in it so I would suggest check it out as well.

Start ArcGIS Pro and create a new Map for LAB7. If you already have a folder for LAB7 you don't need to create a new folder for the project.

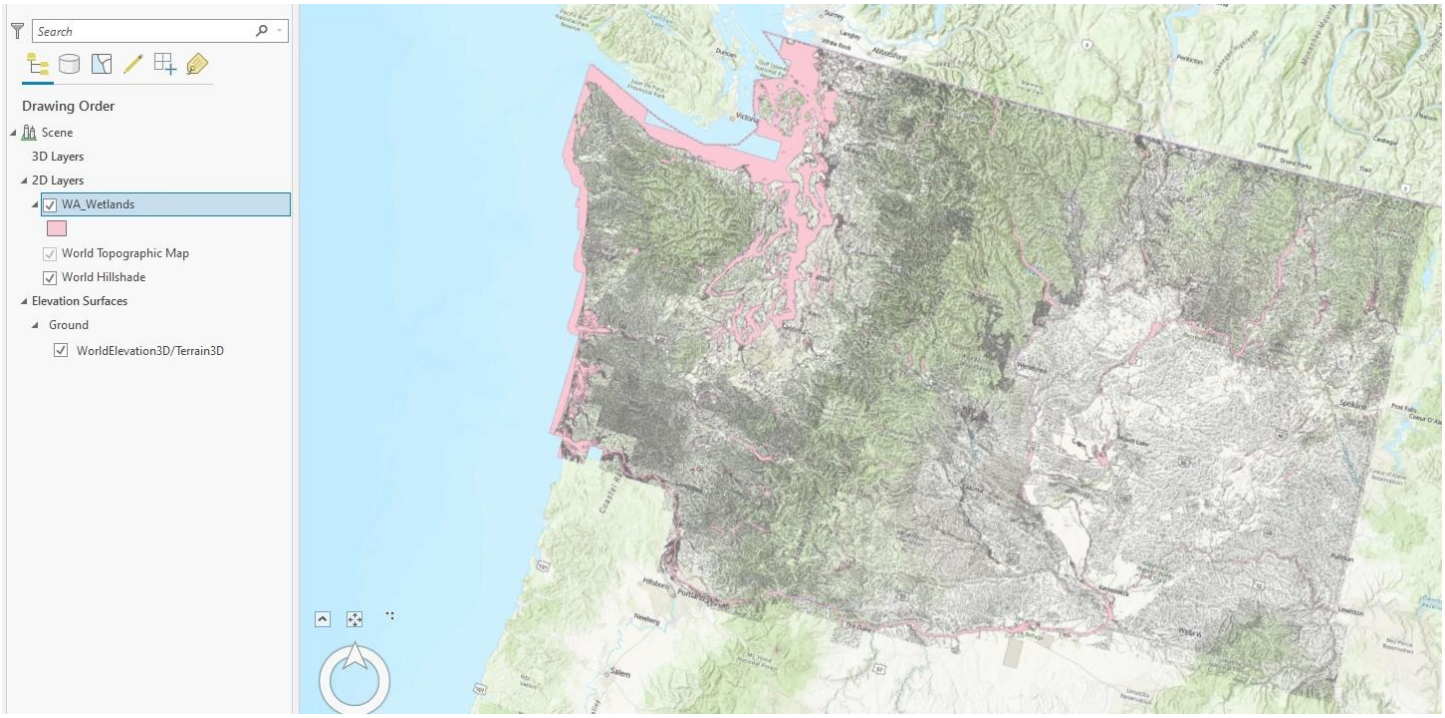




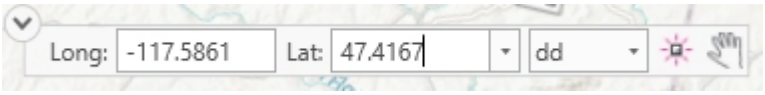
Drag and drop WA_Wetlands.shp into your ArcGIS Pro Map. WA_Wetlands.shp

It is a big file so it will take a bit to load, your Map will also likely transform to match the projection of the shapefile. Let it load and take a look at how much data is present in the shapefile, but then turn

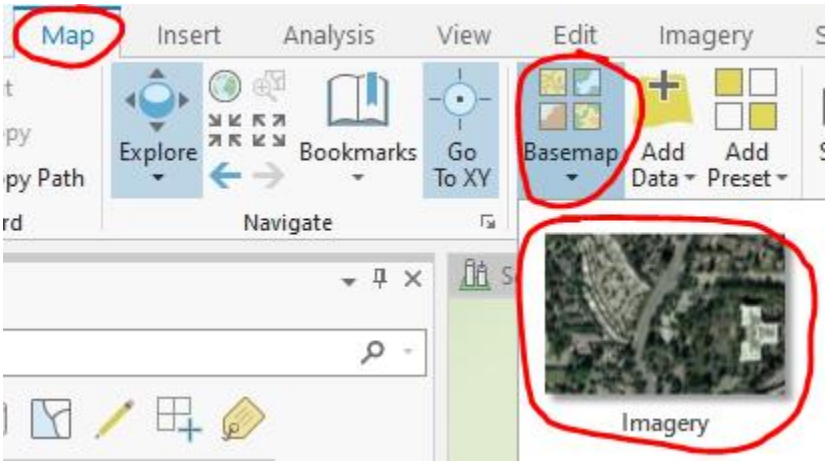
the layer off until you are zoomed into an area of interest so ArcGIS Pro doesn't keep trying to load the entire dataset constantly.



We have 3 coordinates to look at. Quickest way to get there is to use "Go To XY". The input box is at the bottom of the screen. Note that it wants Long then Lat, and I gave you data as Lat then Long.



You can turn on different basemaps in ArcGIS Pro. Turn on Imagery.



You can now zoom in and run “Go To XY” with our coordinate, to see the wetland of interest.

A nice thing about coordinates in EPSG 3857, is that google maps uses this projection. You can open google maps and just paste in the coordinates in LAT, LONG decimal degree format (which our coordinates are in), and google maps will zoom you right to that location.

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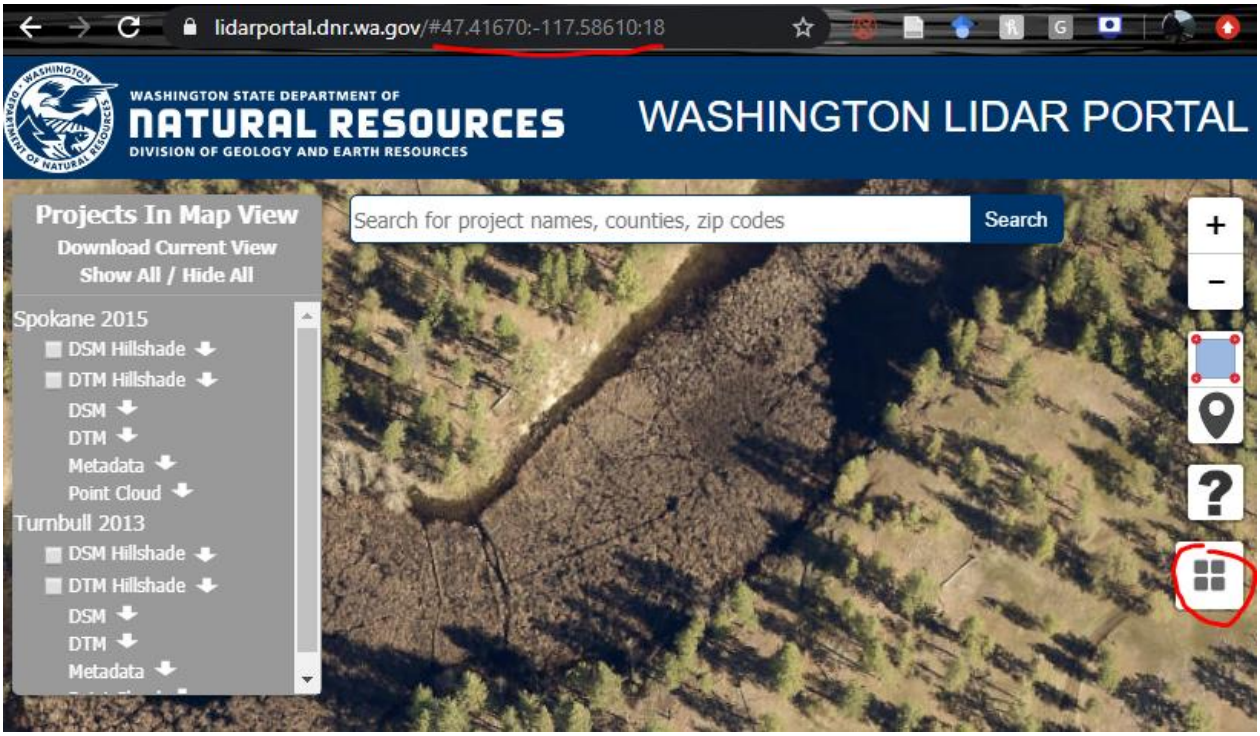
A lot of web mapping applications use EPSG 3857. For instance, the DNR lidar portal. If we add our coordinate information into the web address and select a zoom level of 18, it'll take you right to our wetland.

/#47.4167:-117.5861:18



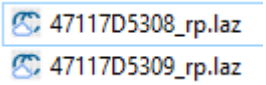
Determine the location of the 4 wetlands of interest and draw a box around them to download the data. Make sure to grab the Metadata. Should be 3 files that are 134.9MB

Take a moment to look over the metadata. Looks like they colored this point cloud with photos, just like the Pack forest lidar. Very cool.

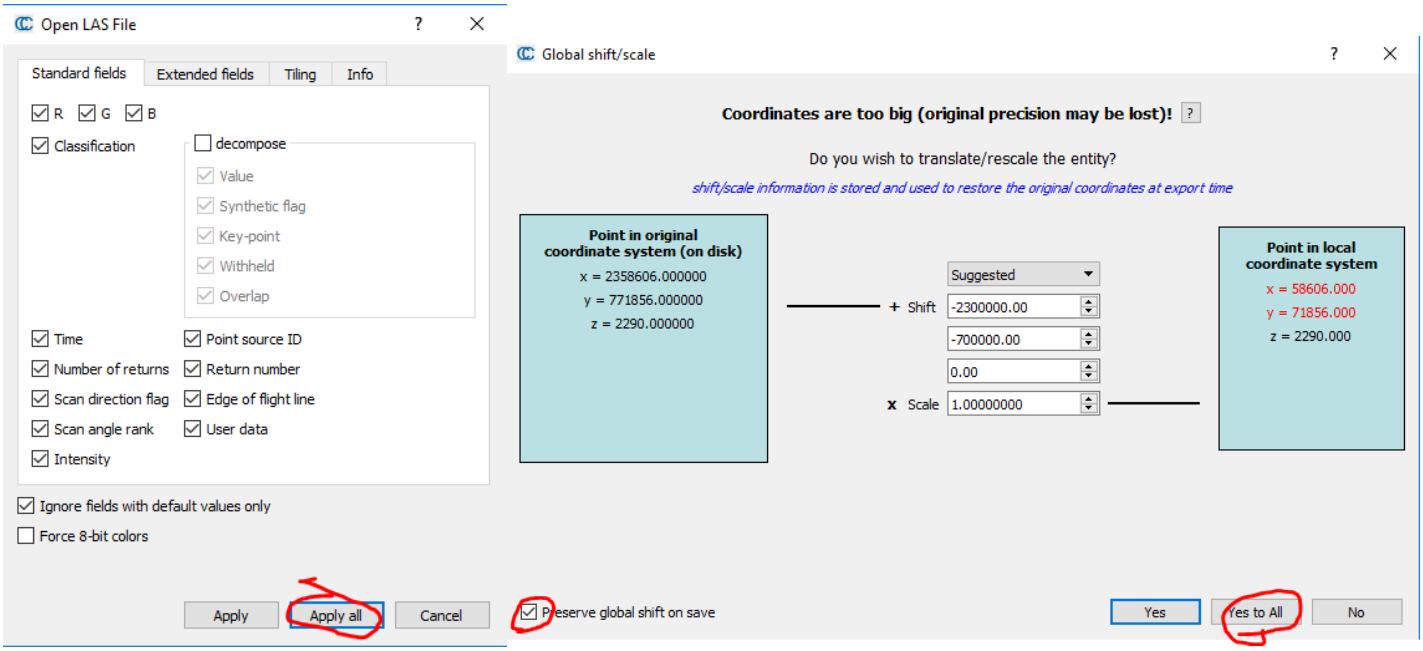
We are going to give RStudio a break and not use it for this lab. We will mostly be working in ArcGIS pro. ArcGIS pro and other GIS programs like QGIS are able to work with lidar. Unfortunately, ArcGIS can't take laz files as imports, only las. Remember, laz files are just compressed versions of las files.

There are a few work arounds, we can install an addon in ArcGIS to be able to deal with laz files, we can convert the laz to las with lidR, or we can use CloudCompare to open the laz and resave them as las. We're going to use CloudCompare.

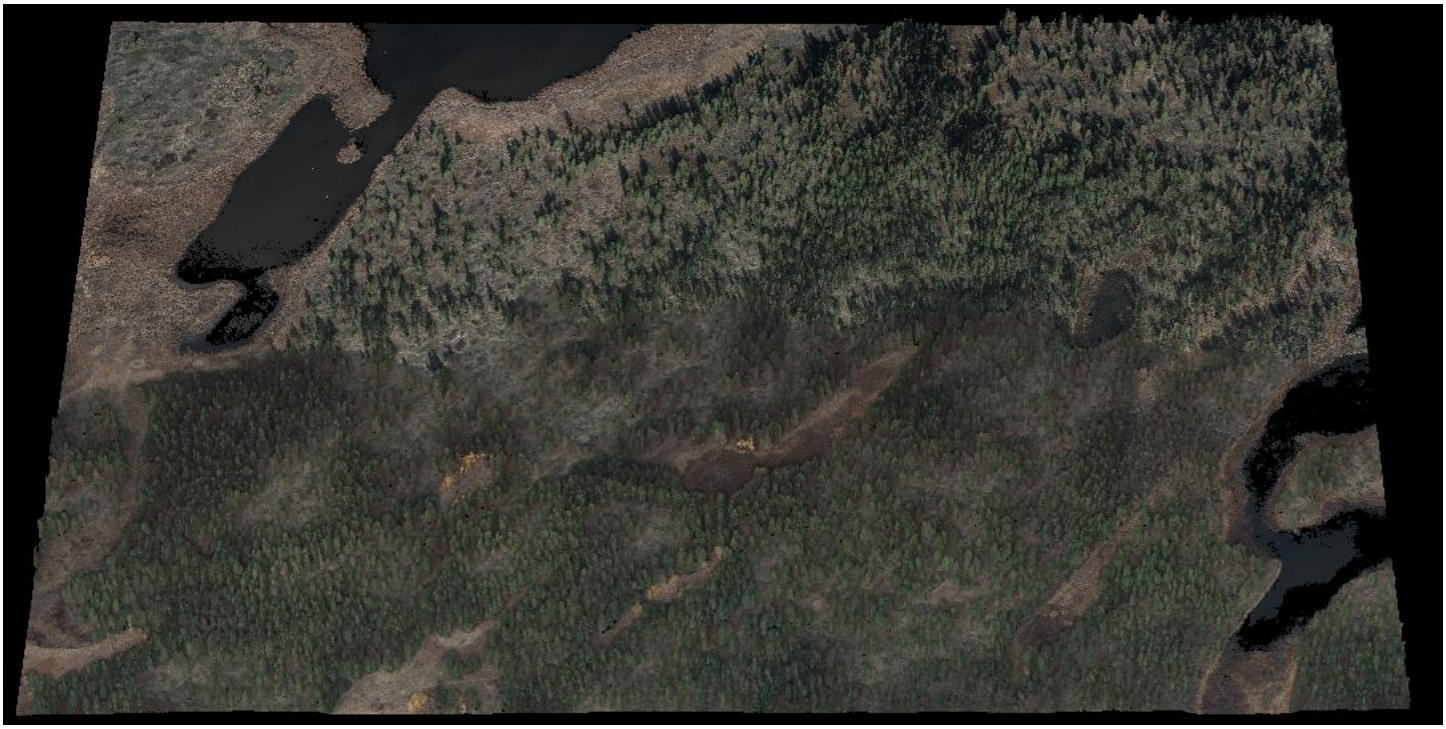
Open CloudCompare and drag in your 2 lidar tiles:



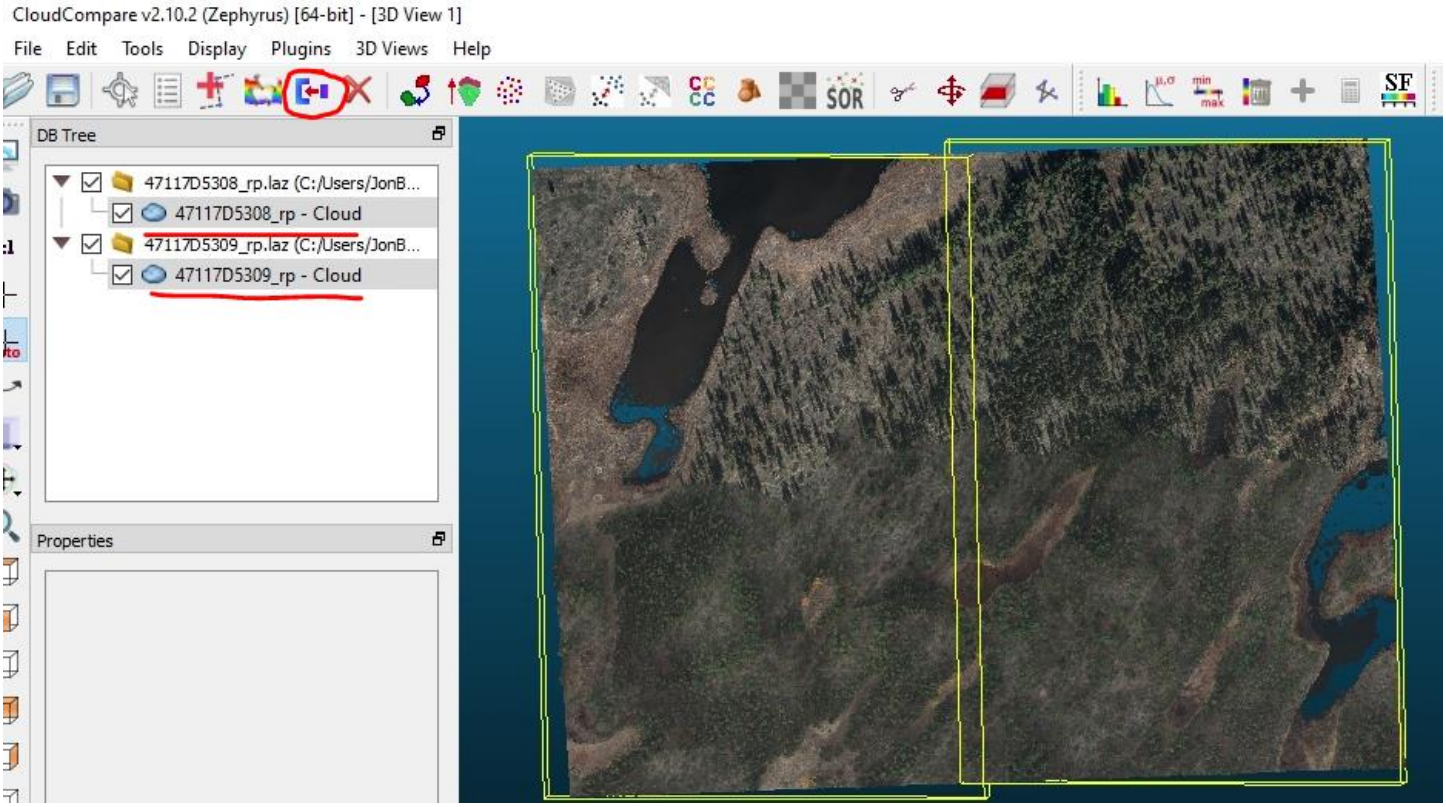
Open LAS file, Apply all. Global shift/scale, Yes to All. Make sure the Preseve global shift on save box is checked



Do this for both tiles. Loading into CloudCompare is a little slow on Madrona. If we just used lidR for the conversion, we wouldn't have to load the points into a GUI and the process would be faster, but these are really cool full color lidar point clouds, so we are going to want to view them with CloudCompare.



Highlight all both tiles, and merge them together (Edit>Merge or the button on the tool bar). You don't need to generate a scalar field with the original cloud index.



Now that they are merged, we want to extract just the ground points. Remember, typically ground returns are classified as 2 and unassigned points are 1. For the full list of standard classifications for las files:

https://desktop.arcgis.com/en/arcmap/10.3/manage-data/las-dataset/lidar-point-classification.htm

Just as we did in the previous lab, we are going to separate the ground points from the point cloud. Have the cloud selected, the active scalar field be set to Classification and use the 'Filter by Value' tool (Edit>Scalar fields>Filter by Value or the button on the tool bar).

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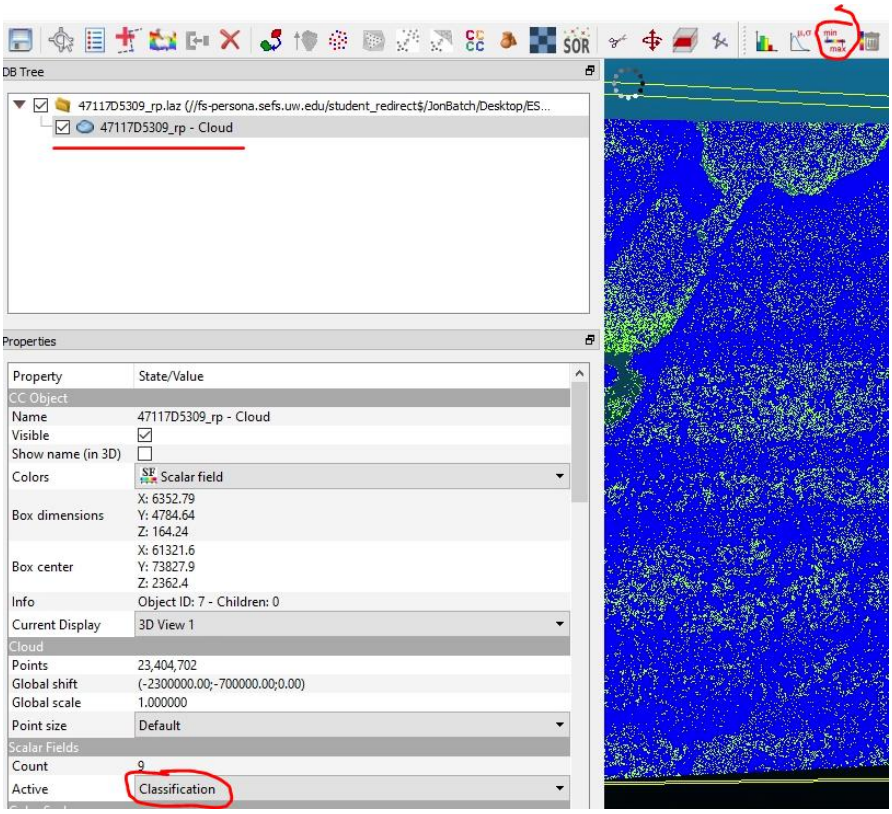
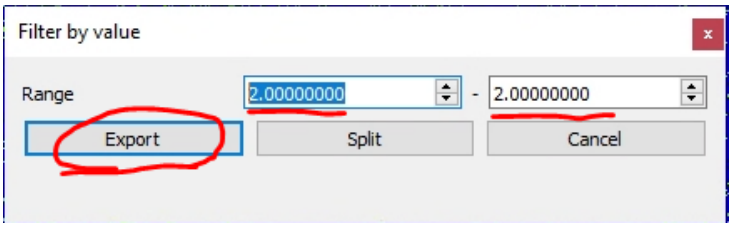
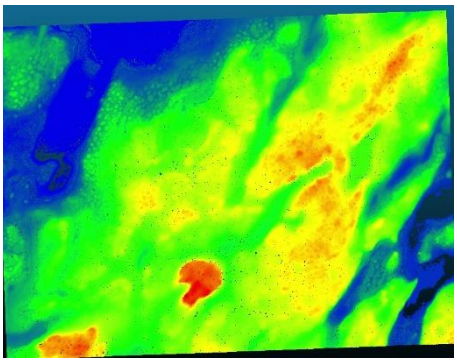




The range you want to filter is 2 to 2. You are just going to export the points classified as 2 from the cloud. Click Export.

If you color by height you should get a cloud looking like the one to the right ->



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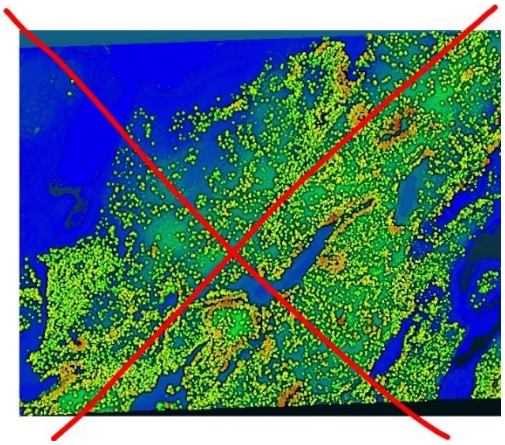
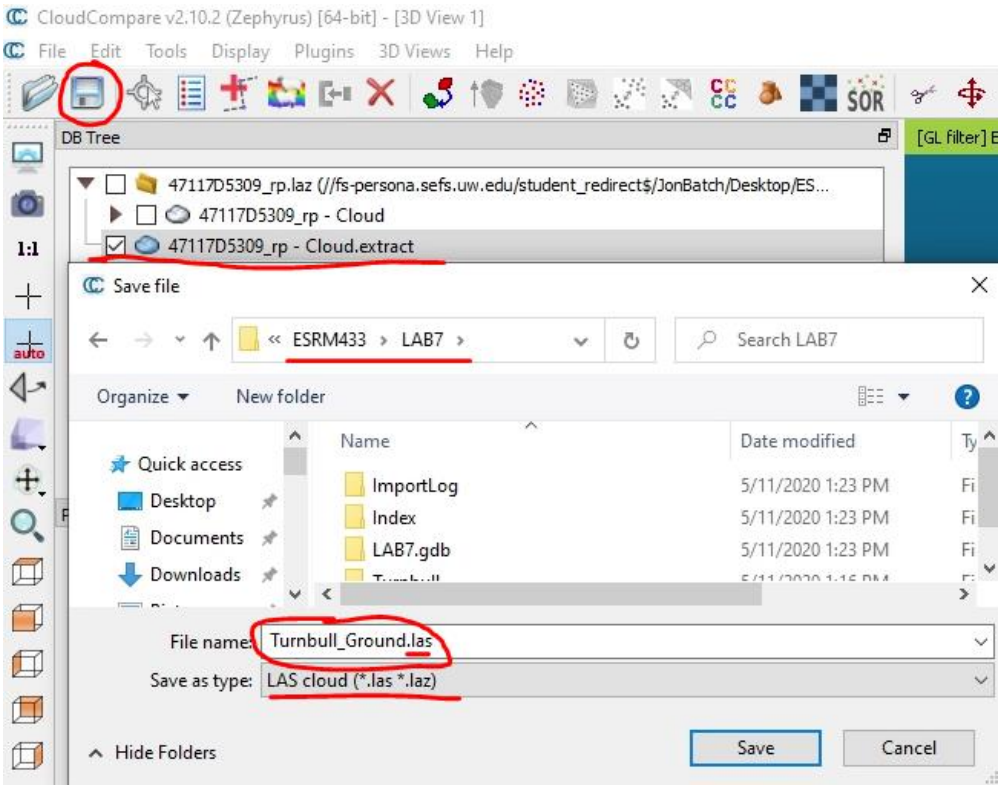


IMPORTANT, make sure you only have the ground in your Cloud.extract. If you have trees, none of the following steps will work.

Highlight your ground points cloud and save it as Turnbull_Ground.las. Saving it as a las is important. Ultimately all we needed to do was convert it from a laz to a las, but we took advantage of CloudCompare to merge and filter the cloud.



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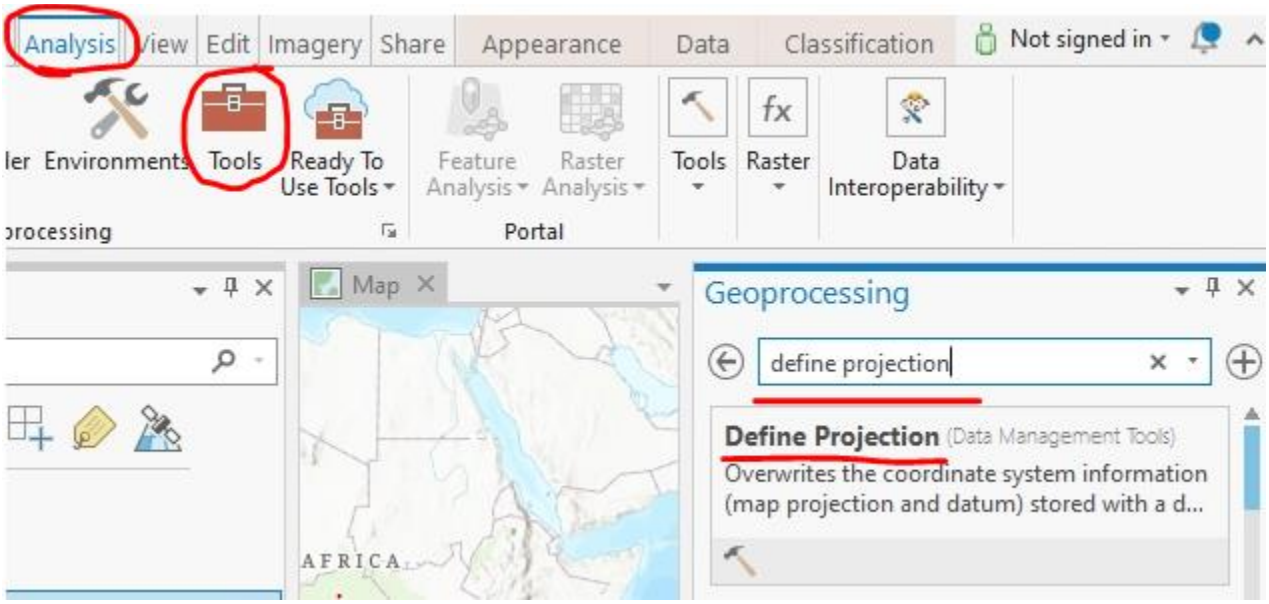
Add your Turnbull_Ground.las to ArcGIS Pro and zoom to the layer (just drag and drop).

It is point cloud data that you imported into ArcGIS, but arc won't render the points until you are zoomed in.

If you zoom out, you'll notice that the tile was not placed correctly. This is because it doesn't have the CRS defined in the las. Go to Analysis > Tools > Define projection



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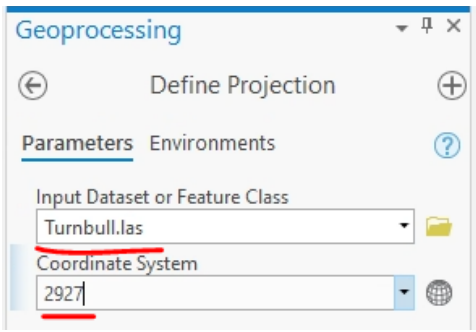
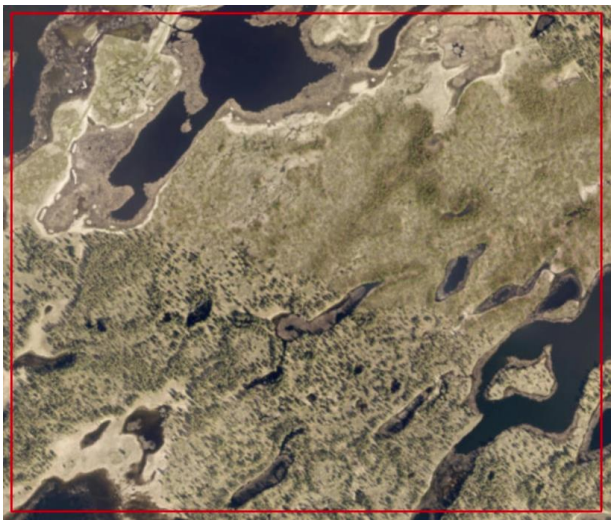
Input dataset is your las file.



You can enter the four digits that you know so well for the Coordinate System and click run.

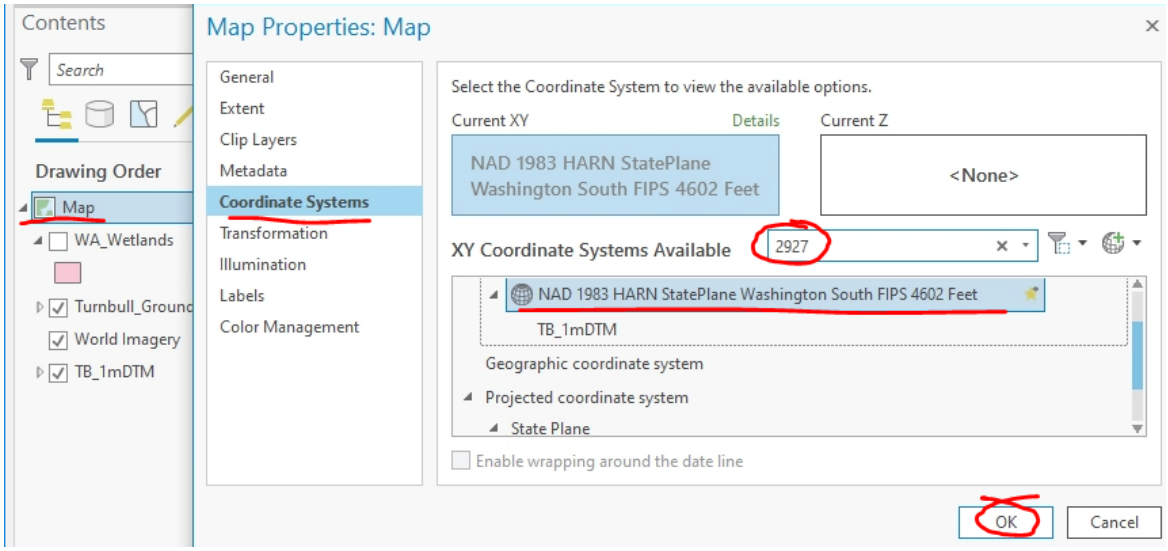
The define tool doesn't reproject or transform the data, just lets the GIS program know where the x,y coordinates originate and the units being used.

Now if you zoom to the Turnbull_Ground layer, it should be correctly geographically located.



Lets also change our map projection in ArcGIS Pro to match the coordinate system that we will primarily be working in. Right click on the 'Map' in your Contents pane and go to Properties.

Coordinate Systems, change it to 2927and click OK.



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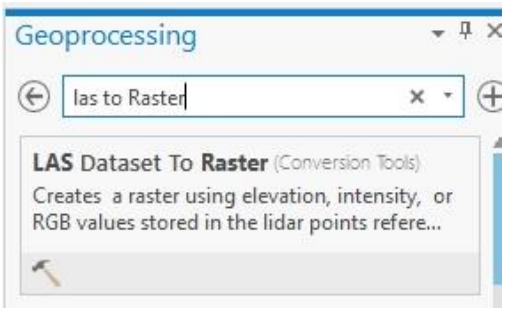
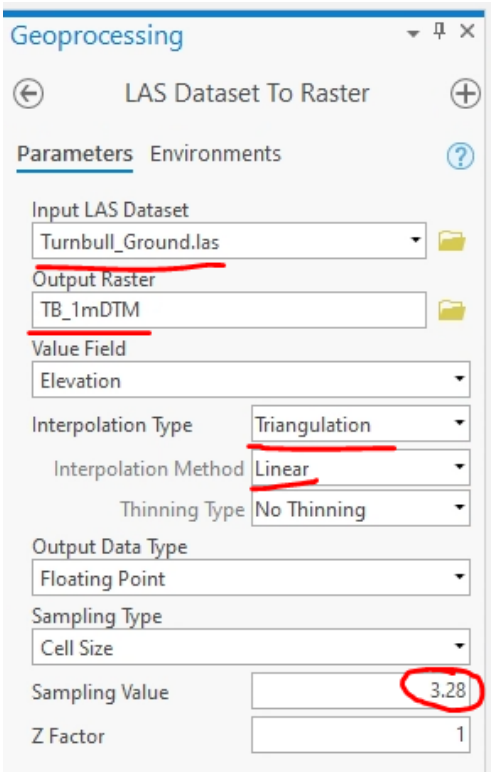
Our work flow will be to create a DTM, create topographic contours, smooth the DTM it, identify the depressions in the DTM, and then select the contour lines that most closely match the boundary of the wetlands.



DTM

As in the Above step, in your Analysis tool box, search for LAS to Raster. We could make just a TIN from our data and derive contours directly from the TIN and skip making a raster, but future steps in our process will require a raster, so we might as well just make it initially.

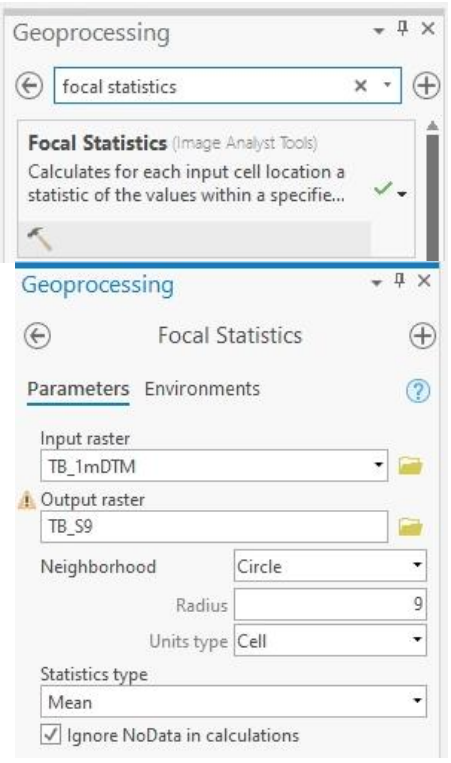


Make a 1m resolution DTM using linear Triangulation. You can make a DTM using Binning to check out the difference.

Save it as TB_1mDTM.

The default location for saving it will be in the LAB7 geodatabase. This is fine for it to be saved there. If you close it and need to reopen it, just look up “geodatabase” on line for more information.

Z factor is how exaggerated or subdued we want our elevation values. If we set it to 2, our z values will be doubled, 0.5 our z values will be halved.



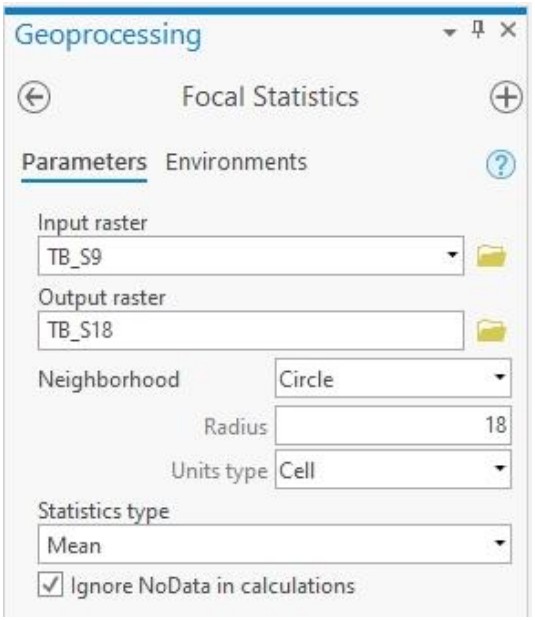
We now want to use focal statistics to smooth our DTM. This is the same as the smoothing we did in lidR.

We want to smooth our DTM so our contours will be less jagged and more representative of a sloping hill and less influenced by small variations in our ground data.

We also want to produce a an extremely smooth DTM that we will use to detect depressions at our site. We want it to be very smooth so we get less false positives for depressions. If it was left jagged, we would identify small depressions all over the raster.

Your input should be your TB_S9

Output: TB_S18.

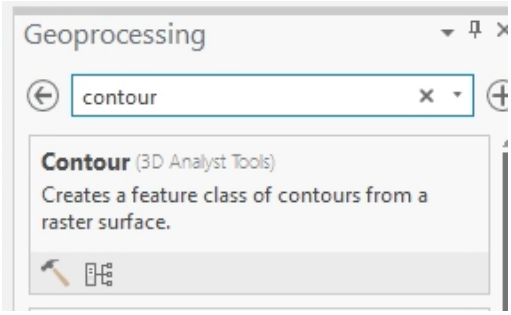


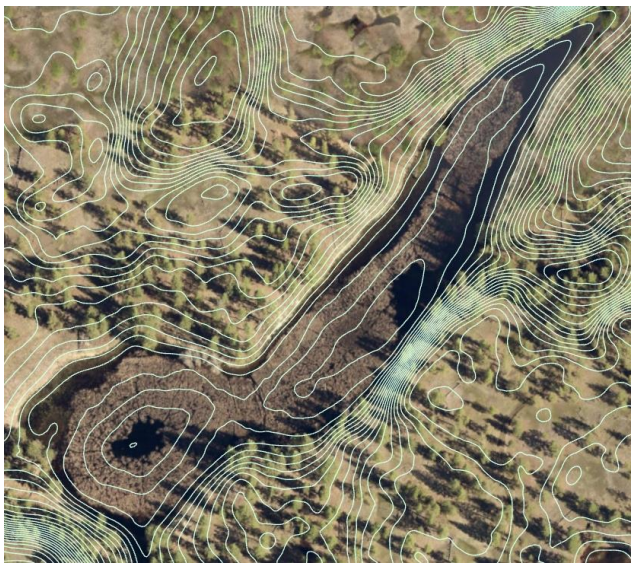
Lets make some contours!

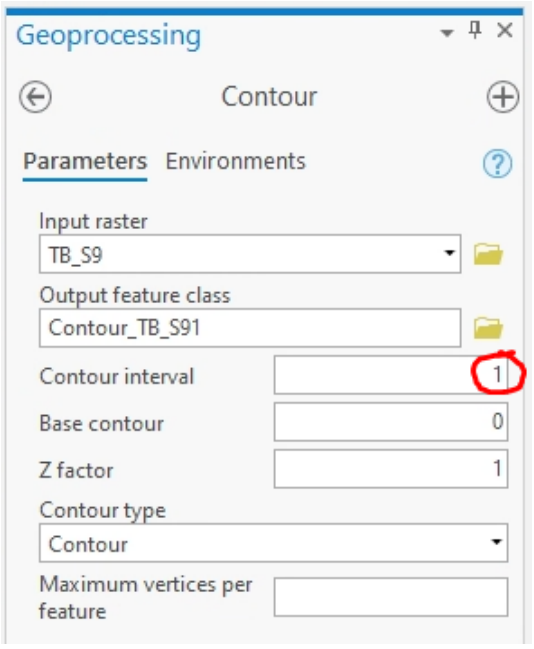
Make contours for:

- TB_1mDTM
- TB_S9
- TB_S18

Our units are feet so a contour interval of 1 places a contour line every foot in elevation.







If none of the contours model the shape of the wetlands well, you can change the interval to being greater or less than 1. Contours of an interval of 0.3 may be needed in some locations. For this site, an interval of 1 is sufficient.

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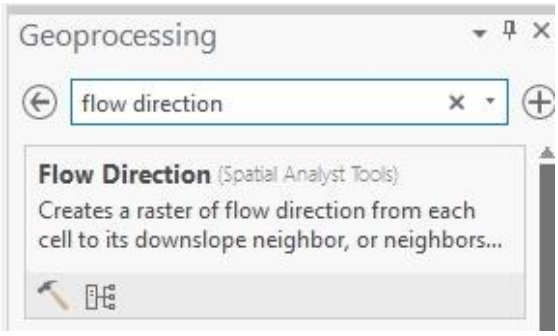
QUESTION 1: Include screen shots of your three different sets of contour lines zoomed into our example wetland (as above). Label each clearly. Which seems to model the wetland the best? Why?

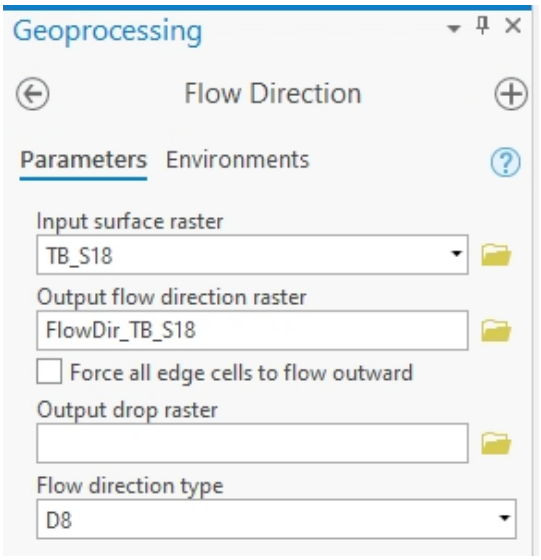
FLOW DIRECTION AND DEPRESSIONS

If all we needed was to delineate the obvious wetlands, we could just select the contour line that best matched and be done. However, we can look for depressions in the area that may be the site for a wetland that isn't as obvious.

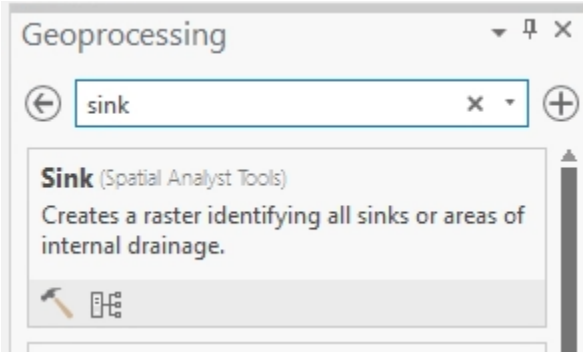
We can find depressions using the flow direction and sink tools within ArcGIS.

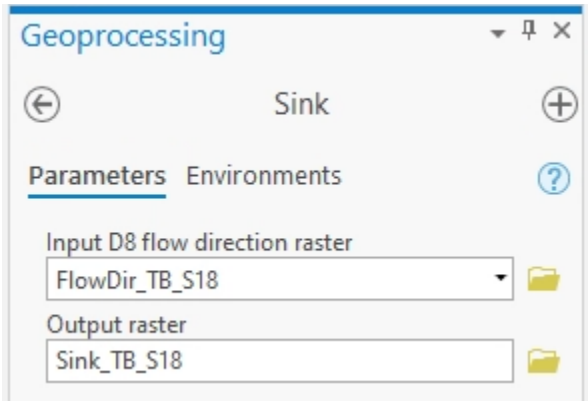


Using your extra smoothed DTM, determine the flow direction. Essentially, which way a drop of water would roll at an point in the raster. Please fill free to check out the results from your other DTMs to see how they compare.



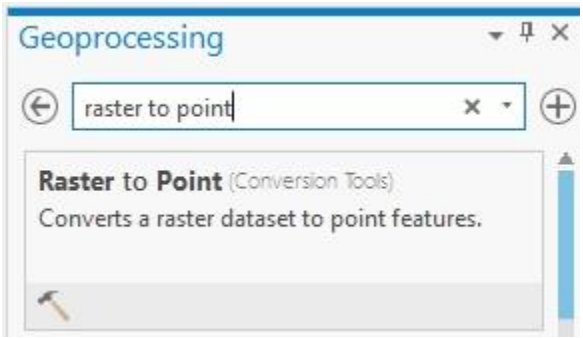
Next to find the sinks were water would accumulate in the DTM. A simple elevation metric wouldn't work if your site was sloped at all. A lower elevation wouldn't necessarily indicate a sink.





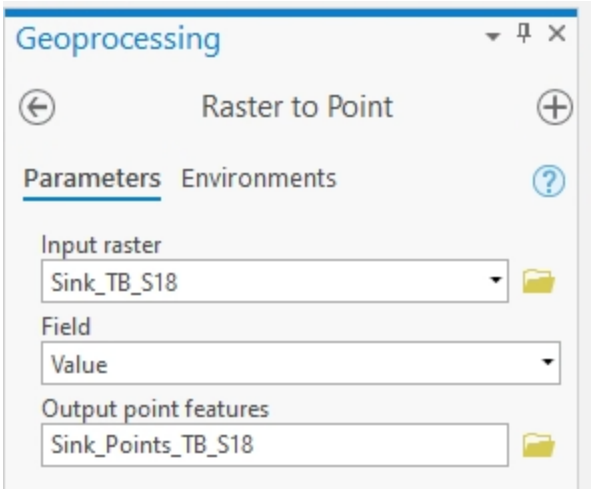
Careful keeping your names consistent. It is easy to get lost with all the files being generated.

Sink_TB_S18 lets me know that the output is the sinks generated from the Turn bull raster that was smoothed 9 and then 18.



Your sink output is a raster so there will be small pixels located at each sink, but for us to see them better, lets turn those pixels into points.

Our sink points are not necessarily going to be wetlands, but they are locations that we should at least look at and it helps narrow down the possible locations.



Once the raster is points, you can change the symbology of points by double clicking on the icon in the contents pane.

QUESTION 2: Include a screenshot of your full extent of sink points and label the image as you would a figure in a paper. A discription so a reader knows what they are looking at. More than a single sentence is needed.

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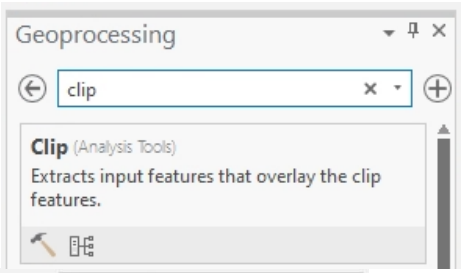
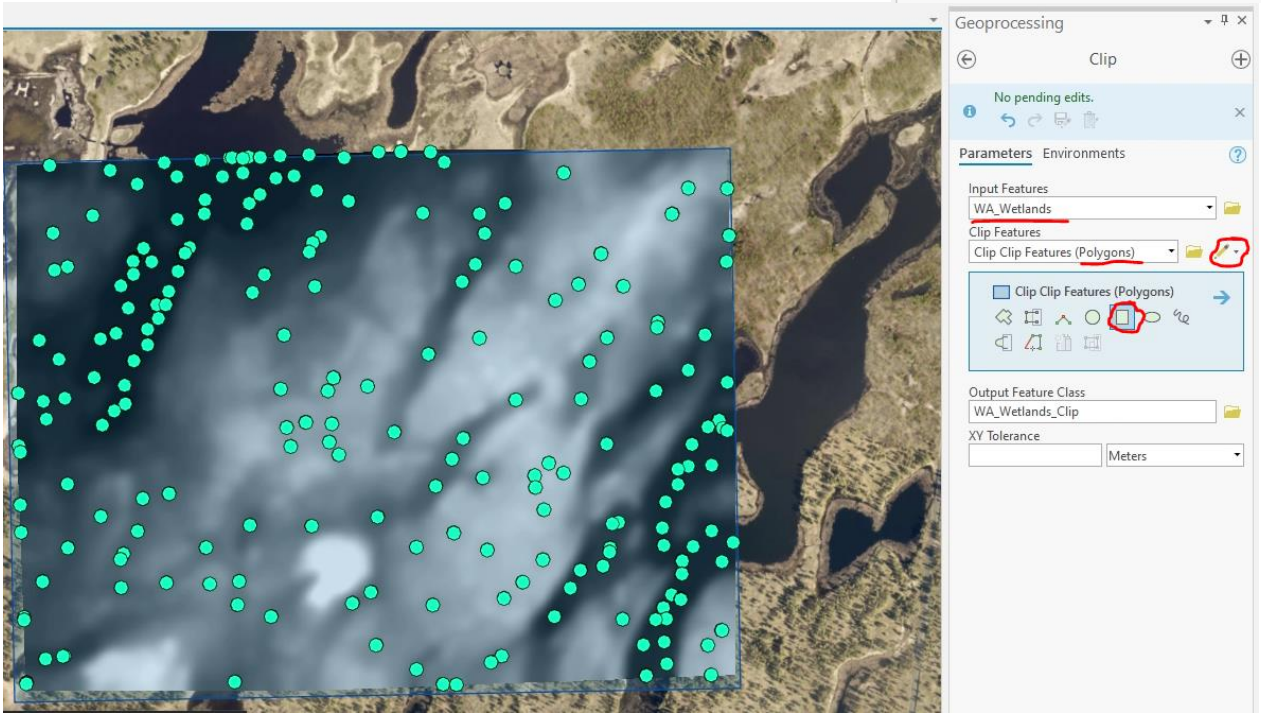
Lets bring our NWI data into our scene. We need to clip the data so we aren't trying to load the entire data set and bog down the computer.

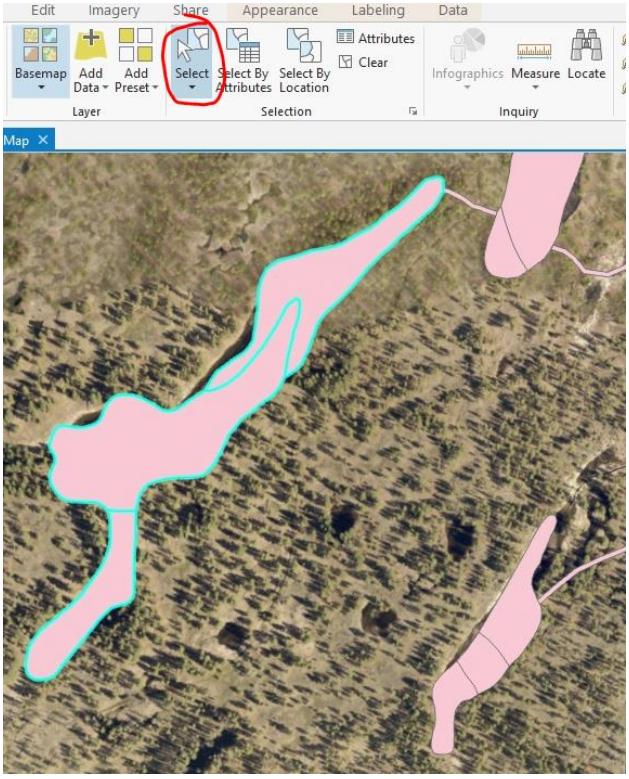
The easiest way to do this is to use the clip command but select the pencil edit button to use a polygon to sellect the area we want. You can turn on one of the DTMs to use as a guide.



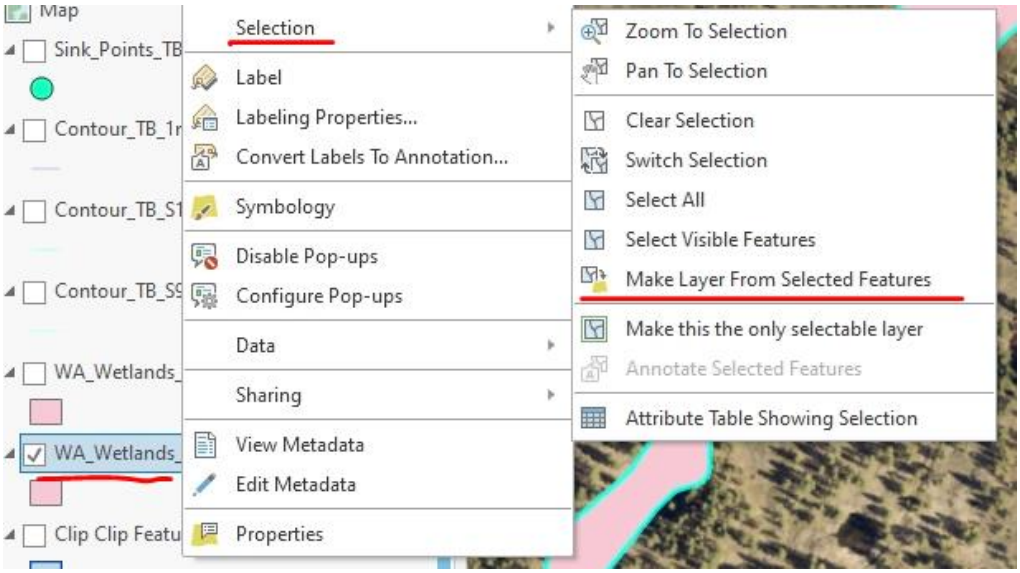


Back to the three wetlands of interest. The polygons in the NWI data are devided into sections for each wetland, to denote how often they are flooded PEM1C vs PEM1F.
https://fwsprimary.wim.usgs.gov/decoders/wetlands.aspx

We want to select only the three wetlands of interest to us for a new layer. Use the Select tool and highlight the polygons for the three wetlands we want (only one of the three is highlighted in the image to here). Shift + Click add to your selection, Ctrl + Click remove from your selection.



With all of the polygons you want selected, right click on your WA_Wetlands_Clip and make layer from selected features.



Similarily, Sellect the contour line that best matched the wetland for the three wetlands of interest. PLUS, include at least 3 additional wetlands that were identified as sinks, that were not in the NWI shapefile.
IMPORTANT, You can use any of the contours you created so far, or if they don't seem to work well, you can create a different contour set to use. A finer interval of TB_S9 may produce better results. Producing different contours will be important to remember for your second senario.

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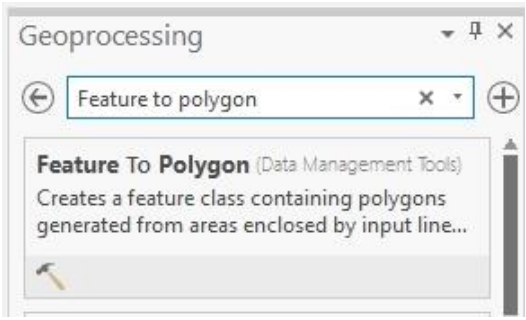
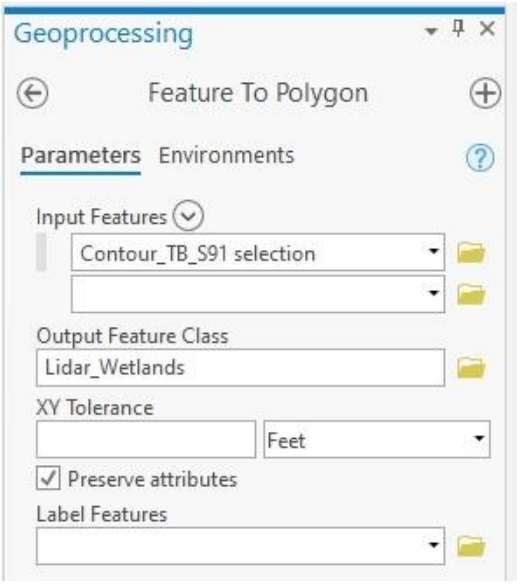


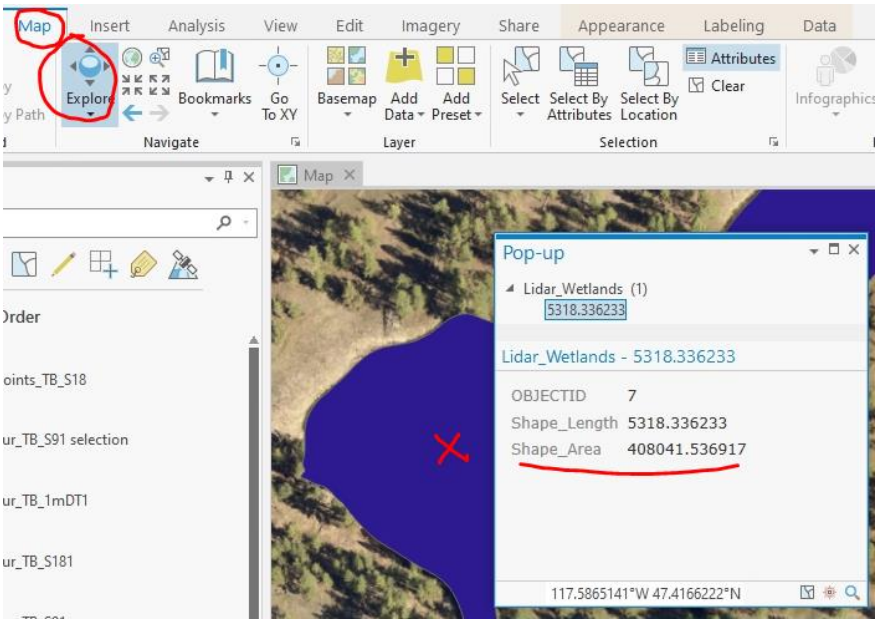
We now need to turn our line feature into polygons.

Your selection from the contour set is the input and name the output: Lidar_Wetlands.



You should now have your own polygon layer of wetlands that you deliniated using lidar!

If you use the explore button and click in one of your polygons, you will see the Shape_Area. Our units are in feet, so this would be square feet.



QUESTION 3: Complete this table in the submission template: NWI area will be the combined acres of the polygons for each wetland.

Wetland (EPSG 3857)	NWI Area (acres)	Lidar Area (acres)	Area over or under estimated in NWI
1. 47.4167, -117.5861			
2. 47.4195, -117.5799			
3. 47.4141, -117.5812			
TOTAL ACRES			

QUESTION 4: Complete this table in the submission template:

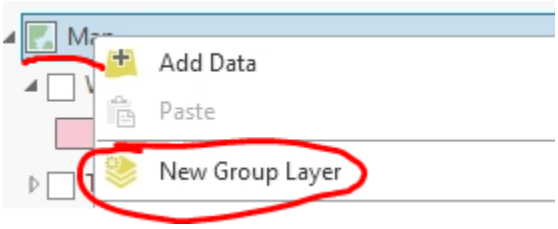
New Wetland location (EPSG 3857)	Lidar Area (acres)
1.	
2.	
3.	
TOTAL ACRES NEW	

QUESTION 5: Create a map of the NWI polygons for the three wetlands. Include a Title, North arrow, and scale bar. Label the wetlands 1, 2, and 3. Lables can be added as additional text or inserted once in word. Include the map as a full page screen shot and discribe the process to produce the map (simple for this one, just clipped the NWI data).
https://pro.arcgis.com/en/pro-app/get-started/add-maps-to-a-layout.htm

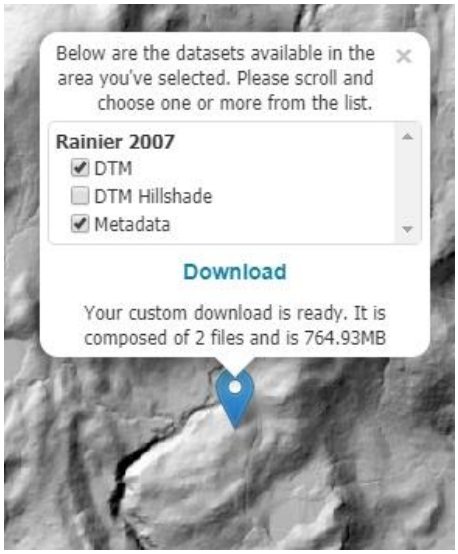
QUESTION 6: Create a map of the Lidar Polygons for the three wetlands and the additional wetlands you identified. Include a Title, North arrow, and scale bar. Label the wetlands 1, 2, 3, and additional. Lables can be added as additional text or inserted once in word. Include the map as a full page screen shot and discribe the process to produce the map (complicated for this one. The process must describ every step taken and why it was done, including the steps to identify sinks and why the contours sellected were chosen).

Scenario #2: Mount Rainier

We created a lot of layers getting Scenario 1 done. Some of the setup for Scenario #2 will be the same. To clean up your working area, you can right click your map and create a new group layer to put all your Turnbull layers in, and then collapse the layer and turn it off. You will need the WA_Wetlands layer for Scenario #2. This is not a required step, but it is helpful to keep your layers organized.



You need to download the Rainier 2007 DTM. You can just search ‘Rainier 2007’ in the search bar to find the location. You want the DTM to use and the metadata to look at, but you don’t want the entire DTM as it is several giga bites in size. You can find a corner of your bounding box either by looking in ArcGIS or you can simply use the same method with the DNR website as we did before. Enter the coordinates for the NW corner: 46.7777, -121.7227 in the web address for the site with a zoom level of 16.

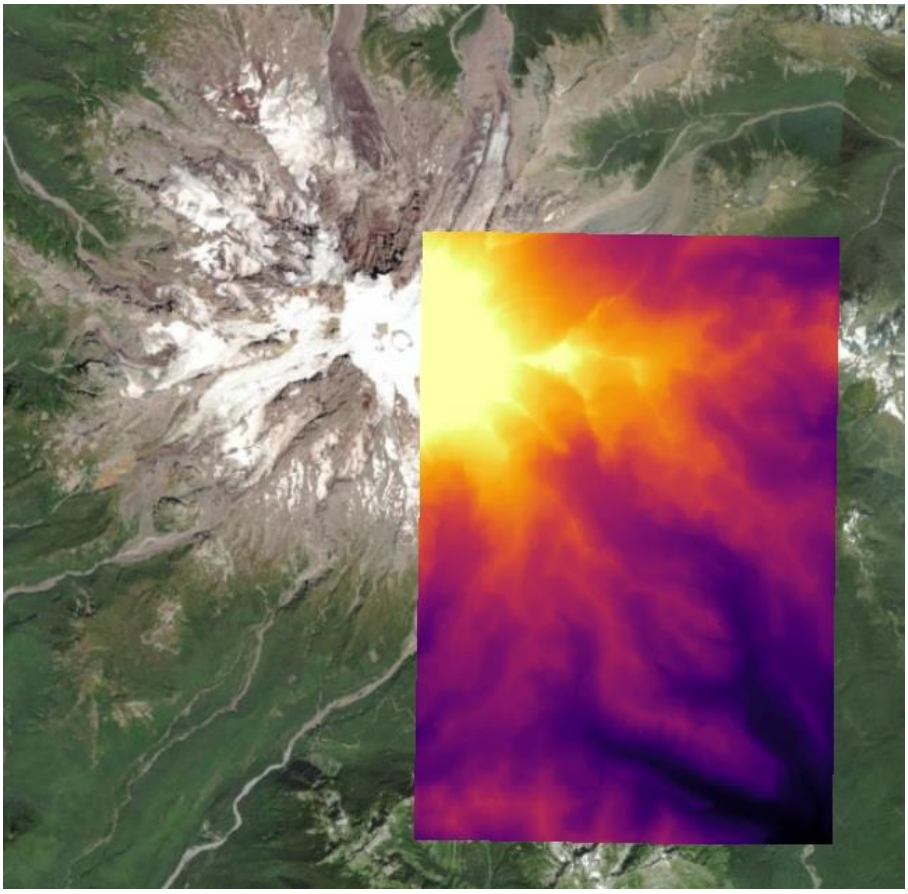


Don't download the DTM Hillshade. None of the following steps will work with the hillshade.

Unzip the file and delete the zip file. You should have the rainier_2007_dtm_7.tif and associated metadata. Take a moment to look at the metadata pdf.

Drag and drop the dtm into ArcGIS Pro.

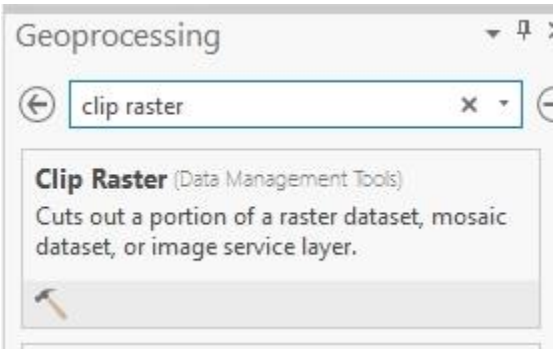
Fill free to color it anyway you like:



We want to clip the raster to only our area of interest.

Use the toolbox search to find 'Clip Raster'

You should have changed your maps projection to 2927 so the input values for Clip Raster will be feet.



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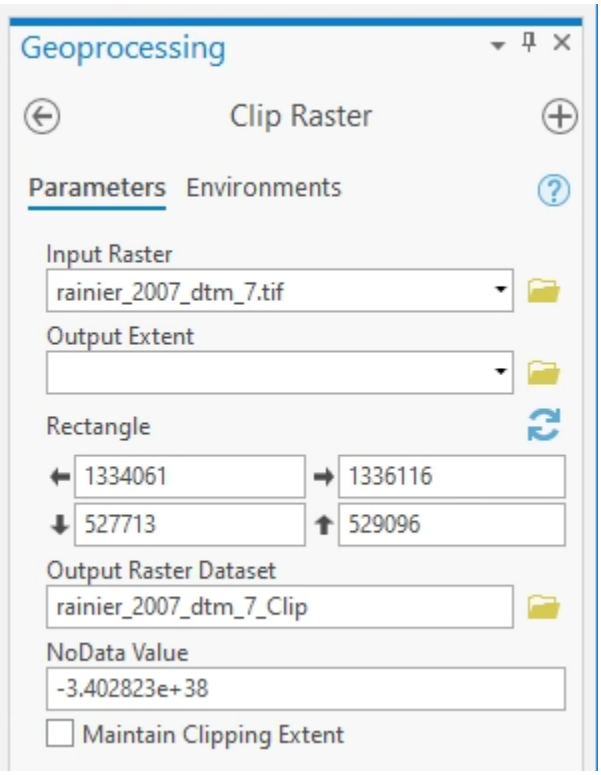
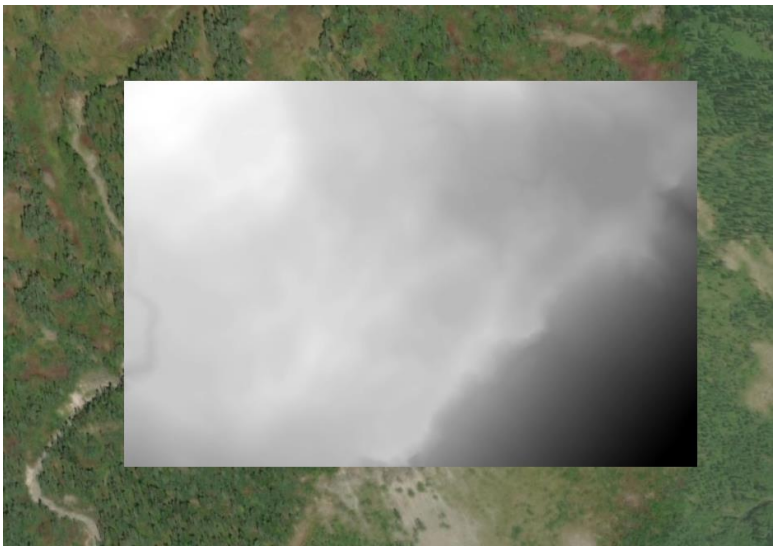
Mt Rainier study site: EPSG 3857 Lat,Long

- West -121.7227 (1,334,061 EPSG 2927)
- East -121.7145 (1,336,116 EPSG 2927)
- North 46.7777 (529,096 EPSG 2927)
- South 46.7739 (527,713 EPSG 2927)



Note that you may need to restart ArcGIS. I was getting errors trying to create the clip until I restarted ArcGIS and it worked fine. Classic turn it off, turn it back on



You now have your extent determined and a lidar derived DTM to work with.

<u>Your next steps:</u>

- Clip NWI data to DTM extent (same method as above)
- Create contours using the DTM
- Decide if you need to smooth the DTM
- Create flow direction using your DTM (smoothing is your call, and what level of smoothing)
- Determine sinks
- Create polygons for your sinks that are wetlands
    - You may need to play with smoothing and contour intervals to get a good fit
- Compare your delineated wetlands to the wetlands in the NWI data

QUESTION 7: Complete this table in the submission template: NWI area will be the combined acres of the polygons for each wetland. Your call what CRS to use. Just define it. Add more rows if needed.

Wetland location (EPSG _____)	NWI Area (acres)	Lidar Area (acres)	Area over or under estimated in NWI
1.			
2.			
3.			
TOTAL ACRES			

QUESTION 8: Complete this table in the submission template (there should be at least one extra depression):

New Wetland location (EPSG)	Lidar Area (acres)
1.	
2.	
3.	
TOTAL ACRES NEW	

QUESTION 9: Create a map of the NWI polygons for the Mt. Rainier wetlands. Include a Title, North arrow, and scale bar. Label the wetlands according to your tables above. Lables can be added as additional text or inserted once in word. Include the map as a full page screen shot and discribe the process to produce the map (simple for this one, just clipped the NWI data). https://pro.arcgis.com/en/pro-app/get-started/add-maps-to-a-layout.htm

QUESTION 10: Create a map of the Lidar Polygons for the Mt. Rainier wetlands and the additional wetlands you identified (if any). Include a Title, North arrow, and scale bar. Label the wetlands 1, 2, 3, and additional. Lables can be added as additional text or inserted once in word. Include the map as a full page screen shot and discribe the process to produce the map (complicated for this one. The process must describ every step taken and why it was done, including the steps to identify sinks and why the contours sellected were chosen).