GIS LAB: INTRO TO GIS, GPS DATA, VISUALIZATION, AND MAPMAKING

LEARNING OBJECTIVES:

a) Become familiar with typical Geographic Information System (GIS) software, using QGIS
b) Learn display and visualization of vector layers
   - understand the differences between vector and raster data
   - understand the different types of vector data
   - visualize vector elements reflecting their attributes
c) Learn display and visualization of raster layers
   - apply color gradients to raster layers
   - produce hillshade maps from an elevation layer
d) Import GPS data collected in the field
   - learn hand-digitizing, entry of attribute data, and new layer creation
e) Learn the fundamentals of mapmaking
   - unambiguous display of data layers and features
   - feature labeling

INSTRUCTIONS:

1) Open QGIS

We are using QGIS version 2.18 (“Las Palmas”). Place files on your desktop, so they are easy to find while running QGIS: folder “GIS_LAB” contains Raster, Vector, GPS, and Student Data folders. The folder contains the QGIS searchable manual (version 2.8, the most updated). Keyboard shortcuts are given for PCs, but should be easy to reproduce in Mac (i.e., PC “right-click” = Mac “option-click”)

2) Set Coordinate Reference System

***Explanation**: Transposing a spherical world onto a flat map requires a "projection", a mathematical method for flattening the world, and a "datum," which applies a coordinate system. Latitude and longitude, which we will use today, are widely used and easily understood; however, the use of degrees can be problematic for certain operations, such as distance measurements (how many feet in a degree?!). To handle those problems, the meter-based UTM (Universal Transverse Mercator projection) was developed. Collectively, QGIS refers to the datum and projection, which are tightly interrelated, as the Coordinate Reference System (CRS). A widely used CRS we will mostly use today is WGS84 ("World Geographic Datum").*

Project Menu > Project Properties
Select CRS
    enable 'on the fly' CRS transformation
        *note: this permits data layers not in this CRS to display properly (usually!)
    select coordinate reference system to “WGS84” (EPSG:4326)
        *note: this is a lat/long system
Select General
    set Canvas units to Meters
Click OK

3) Add and Visualize Provinces Data

Add Vector: button on left, or from Layer Menu
select `Provinces.shp`, from the Vector folder (click Desktop to find shortcut)
    move the cursor around, and watch your coordinates change (bottom of window)
    try the zoom in/out/last, and pan (hand) tools
    to zoom out fully, right-click Provinces in the Layer panel, select Zoom to Layer Extent

4) Add and Visualize Roads Data

Add Vector: button on left, or from Layer Menu
select `Roads.shp`
Change visualization to categorized symbols: thick lines for highways, thin for small roads

***Explanation**: Often you want a map to indicate more about each feature than it's location. For example: the type of reserve (national park, national forest, etc.) may be indicated with different color borders; the type of habitat (forest, scrub, marsh) can be drawn with different fill colors; the population of towns can be reflected by the radius of the circle representing them; and the speed of a road can be indicated using line widths.*

double-click "Roads" in layers panel
select Style
change Single Symbol to Categorized Symbol in pull-down menu
select "CATEGORIA" (*Category*) from Column pull-down
click Classify (below)
*this automatically gives a different color (in the color 'ramp') to each category
select all symbols (use click then shift-click, or ctrl-A)
right-click on blue selection, choose Change color; select black, or a dark gray
Select both "Autopista" categories
right-click, choose Change width, enter 0.7
Repeat process to set:
roads "Pavimentada" to 0.5
"sin Pavimentada" to 0.3
"Camino de Verano" & "Sendero o Vereda" to 0.1
*note: use Ctrl-click to select multiple, non-adjacent symbols
click OK

5) Add and Visualize Rivers Data

Add Vector: button on left, or from Layer Menu
select `Rivers.shp`
change visualization of rivers to be a thin blue line
double-click "Rivers" in layers panel
choose Style
modify Width and Color; blue, and around 0.26 would be fine

6) Add and Visualize Protected Areas Data

Add Vector: button on left, or from Layer Menu
select `ProtectedAreas.shp`
Change visualization to hollow polygons
double-click "ProtectedAreas" in layers panel
select Style
select Single Symbol from pull-down menu
where colored boxes (on left) are labeled “Fill” & “Simple fill”, click "Simple fill"
under Symbol layer type, change Simple fill to "Outline: Simple line"
set Color and Pen width; maybe red, or yellow
hit Apply to check, then OK when done
*note: choose a color that is not confusing with province borders, and other layers
Label each park with its name
double-click ProtectedAreas
select Labels
select “Show labels for this layer”; choose Label with "NOMBRE_"
Feel free to drag this and other layers, in the Layers panel, to re-arrange their drawing order

7) Add and Visualize Elevation (Digital Elevation Model, or DEM)

Add Raster: button on left, or from Layer Menu
select **`w001001.adf`**, from the GIS_LAB/Raster folder, subfolder "alt100_wgsdd"
right-click layer name (in Layers panel), rename as "DEM"
drag layer to beneath all other layers
zoom in to Cayambe-Coca national park
Change visualization to elevational bands

Explanation: *While we are accustomed to displaying satellite imagery in Google Earth and similar tools, sometimes maps will get overly cluttered if they have a lot of features, labels and text displayed on top of a satellite image. Often it is more useful to display a blank background, or polygons representing distinct habitat types, or (as we will do today) a visualization of elevation, like you will see in many classic topographic maps. To do so, we need a digital elevation model, a pixelated image in which each pixel, or cell, carries data indicating the altitude. How you display those altitudes is entirely up to you, it can be in a continuous greyscale 'ramp,' or in bands by color category, which we will explore below.*

double-click "DEM", select Style
set Render type pull-down to "Singleband pseudocolor"
set Color interpolation to "Discrete"
set the minimum and maximum elevation
under Load min/max, choose "Min/max", "Full" extent, and "Actual"; click Load
*note: if min/max will not load, or if you prefer, you can set these values by hand to 0 and 4500 (the max altitude in our study area)
under Generate new color map, choose a color ramp
*note: there are many choices here, pick one that you like. You want a 'broad' color range, and one that 'feels like' elevation. You also can 'invert' the ramp, to reverse the order of colors
Now create color categories: set Mode to "Equal interval"
set Classes to 12 (you'll probably return to change this soon)
click the Classify button
this divides the available elevations into 12 classes, and assigns a ramp color to each
click Apply
*Do you like the number of classes? Increase the number to 18 or more ... how does it look?
When you are finished with your modifications, click OK

Hillshading: create a layer that creates the shades cast on your DEM by low-angle light
Raster Menu > Terrain analysis > Hillshade
choose the DEM layer
save the output file to the StudentData folder
use default setting for Z factor (elevation is enhancement), illumination (light source)
drag the resulting hillshade layer to just above the DEM, in the layers panel
Modify the hillshade layer's transparency
double-click the layer, select Transparency, and choose a value between 60-90%
chevere, no cierto?

**Note: While the DEM and hillshading look great at a <u>national</u> level, realize that the DEM resolution is 100x100m, which will look 'blocky' at the local scale we will use for our trail map (zoom in to see). Instead, we'll use the QGIS plugin OpenLayers to display a Google satellite image as the background.*

8) Save Map Project

Explanation: *unlike saving edits to a layer, saving the Project preserve all the layers, their display order, and all the custom visualizations you've created*
Project Menu > Save As
give your map a name, and place into the StudentData folder (may need to navigate up 1 level)

9) Create New Layer for Hiking Trail

***Explanation**: During our hike we recorded a GPS 'track.' But for map making, we may not want to use every detail of the track. What if we walked off the trail, and don't want that detour represented in the trail map? Therefore, we will import the GPS track onto a temporary layer, then digitize the level of detail that we want to represent, by tracing the GPS track onto a new Trails layer. Here, you will create that layer.*

Layer Menu > New > New Shapefile Layer
set Type as "Line"
set CRS to "EPSG:32717, WGS84 / UTM zone 17S
 *note: this CRS is in UTM (meters), not Lat/Long (degrees), to measure trail length in meters
create attributes for trail features
 *note: in GIS, features are like rows in a spreadsheet, and attributes are like columns; thus, each feature (here, a trail) can contain multiple pieces of data. The attribute names you will enter next are like the column headers, i.e., the title of each data column
 "trailname" - Text data - Width 32; click Add to attributes list
 "descrip" - Text data - Width 80; click Add to attributes list
 "length" - Decimal number - Width 6 - Precision - 2; click Add to attributes list
 click OK
save file in StudentData folder as "CayambeTrail"

10) Import GPS Waypoints and Tracks

***Explanation**: Here we will import the GPS points into temporary layers, as discussed above. We'll pull the data from the handheld GPS you used, where they are stored in a file in GPS exchange Format (.gpx), now a widespread format used and recognized by many different brands of GPS and GIS.*

connect the GPS via usb cable, and turn it on
open the GPS in your computer
 Windows: open My Computer, and click on Garmin device (wait for device drivers to install)
 Mac: Garmin device should appear on desktop, like a USB drive, once drivers install
open the “Garmin/GPX” folder
*Not in 2017: find the Track file you took in Cayambe-Coca, and copy to your computer
find any Waypoints files (by name, or date) you took, and copy to “GIS_LAB/GPS” folder

in QGIS, select Vector Menu > GPS > GPS tools
 *note: Mac users must first activate GPS Tools: Plug-ins Menu/Manage and Install Plugins
 choose the "Load GPX file" tab, and browse to your saved Track file
 *2017: load Track from “cayambe_coca_hike_2016.gpx” in “GIS_LAB/GPS”
 *2017: load Waypoints from “cayambe_coca_plots.gpx” in “GIS_LAB/GPS”
 select Waypoints or Tracks boxes for each file; click OK (repeat for each saved file)
temporary layers should now appear, for waypoints and for tracks
to find the Track, zoom in to the Western border between Cayambe-Coca and Antisana Parks
 or, right-click on that temporary layer, select Zoom to Layer
 *note: as we continue, you will need to zoom in and out on various details of the map
find your Diversity Plot waypoint(s) in Antisana Park; are they displaying in the correct location?
 right-click on the waypoints layer and show Attribute Table: what columns (fields) are there?b

11) Display Google Satellite Imagery

***Explanation**: Google makes satellite imagery simple to use in a GIS project (if you have an internet connection; imagery cannot be downloaded). Here we will display a satellite image of the Cayambe-Coca area to help us visualize the area in which we worked. If you don’t have internet, you can stick with the DEM (ask your professor for a higher-resolution DEM raster for Cayambe-Coca).*

activate OpenLayers plug-in
 Plugins Menu > Manage and Install Plugins
  search for OpenLayers Plugin, and install
Web Menu > OpenLayers Plugin > Google Maps > Google Satellite
 Google Satellite will appear in the Layers Panel, drag to place it beneath your layers
 *note: depending on connection speed, the imagery may not load well; try re-zooming to reload

12) Digitize Trail Data from GPS Track (field data)

***Explanation**: See comments from the earlier step in which you created a new trail layer. Now, we will hand-digitize (i.e., create new geographical features using the computer mouse) a trail using the gps track as a guide. The new trail will be a feature on our trail layer, where we can apply the same visualization techniques learned earlier. You may need to turn off the satellite imagery layer if its refreshing is too slow.*

set snapping: 'stickiness' settings that lock your cursor exactly onto existing features
- *note: snapping ensures exact coordinate matches, by 'sticking' the digitizing cursor to an existing point; without it, you could only try to manually hit that point, but you'd always miss by a bit.
- Settings Menu > Snapping Options
- set Snapping mode to "Advanced"
  - deselect all layers except the GPS track and Roads, and you new CayambeTrails layer
  - set Mode "to vertex and segment", tolerance to 10 pixels (not "map units")
  - set Tolerance to 20 pixels ... *you can change this layer if the stickiness "radius" is too big*
- Click OK

select your CayambeTrails layer, in Layers panel ... (*not the gps tracks layer)

click Toggle Editing button (pencil) on toolbar
- *note: in Layers Panel you will see a pencil icon next to CayambeTrails, showing that you are editing

click Add Feature button (second button to right of pencil)

Digitize new trail feature:
- move the mouse -- see how your cursor behaves near the GPS track, feel the snapping?
- left-click on the road, nearest our trail, to start digitizing
- move cursor along our Trail track, and left-clicking to make a new vertex; repeat to draw the trail
  - *note: there's a balance between making <u>lots</u> of vertices, which give a nice smooth curved look to the trail, and having too many, which requires excessive digitizing work and is not noticeable when zoomed out. Consider the zoom level you'll use for your map when deciding how finely to digitize the trail. Notice that curves require more points, straightaways need fewer. .
  - *note: Pan and Zoom tools work while you are digitizing, just select and use them to view the map in more detail, then click on the Add Feature button to resume digitizing. Alternatively, the mouse wheel zooms in/out, and the arrow keys will pan while digitizing.
  - *note: we also could save the entire track as a feature, and then edit it to delete the detours that aren't really part of the trail; this method requires a lot of work, both approaches are valid.
  - to end the trail, left-click on the last point, to make a vertex, then right-click to 'close' the feature
    - you'll be prompted to enter a name and description; for now, leave length as Null
- click Current Edits button (two pencils), and choose "Save for Selected Layer(s)"

you may wish to change the visualization of the trail line, so it stands out

remove the GPS Track layer (no longer needed): right-click the layer name and select Remove
- *note: we are still in an "editing session" (see the pencil icon across your layer in the Layers panel)

13) Calculate Trail Length

***Explanation**: Once features are created in a layer, we can use the GIS to calculate a number of types of 'geometry', including polygon area, line length, distance between points, and much more. These geometry calculations are one of the great and powerful tools that GIS has to offer. Here, we will use these tools to calculate the length of the trail, which would be useful for example if you were creating a guide map to all the hikes in the reserve, and wanted to rank them by length or estimated walking time.*

open Attribute Table of trails layer (right click on layer name in the Layers panel)

click Open Field Calculator button (abacus)

select Update existing field; select "length" in pull-down menu

in Function list panel, expand Geometry, and double-click $length
- *does the Output preview show a small fraction? This can happen if the units reverted to decimal degrees (1 mile ≈ 1/60 of a degree!); ensure Canvas Units are set to meters (in Project Properties)
- click OK; sometimes QGIS doesn't auto-update the table, click on "length" header to show
- close Attributes Tables

Save edits and close
- click Current Edits button (two pencils), and choose "Save for Selected Layer(s)"
- unselect the Toggle Editing button (single pencil) to exit the edit session
  - *note: this second step will prompt you to save if you haven't already done so; it is <u>very</u> important to save your edits frequently, so as not to lose your hard work.

14) Make New Layer from GPS Research Points (field data)

open the Attribute Table of the Waypoint layer we imported from the .gpx file
right-click on the name (in Layers panel) of the Waypoint layer and choose "Save selection as ..."
- format: ESRI shapefile
  - *note: this format is an industry standard, compatible with ESRI's widely used ArcMap software
- click Browse (under "Save as"), navigate to StudentData folder, and give the layer a name
- click Browse (under "CRS"), select WGS84 (if not already selected)
- select "Add saved file to map" checkbox
  - right-click the new layer, check Attribute Table to ensure elevation data saved properly

remove the GPS Waypoint layer (no longer needed): right-click the layer name and select Remove

15) Add Field Data to Research Points Layer, and Visualize Data

select the newly created research points layer
click Toggle Editing button (pencil) on toolbar
open the layer's Attribute Table
- *note: there will be some unnecessary columns which are GPS-standard; just ignore them

add column (field) for species diversity data
- click New field button
  - enter "NumSpp" for Name; choose Whole number (integer); set Width = 3

enter diversity data from field research plots
- click into the "NumSpp" cell for each plot, enter diversity data (from field notebook or data sheet)
  - *2017: enter plot diversity as 11, 18, 32, 9, 66, 44, 98, 21, 52, 71

close the Attribute Table, Save your edits, and Toggle Editing to off
display the diversity plots using circles that represent the diversity of each plot:
- right-click your new Plots layer, select Properties
- select Style
  - change Single Symbol to Graduated in pull-down menu
  - select "NumSpp" from Column pull-down
  - click Symbol, choose filled circle (the default), and a color for all the parcelas
  - click Method, and choose Size
  - set Size from 1 to 12 (you can change this later)
  - set Classes (at far right) to 5
  - set Mode to Equal Interval (although for biological data we might prefer Standard Deviation)
  - click Classify to create the 5 categories
  - click Apply ... do you like what you see? If not, change some values, then click OK

label each point with its species richness (# of spp.)
- double-click the layer, select Labels, turn on Label this layer, and choose "NumSpp"

save the Project (ensure all updates are saved before making a final map)

16) Export and Close the Project

Zoom out to the Cayambe-Coca trail, the Antisana diversity plots, or both
Check that all your symbols (lines, points, colors) and labels are visible
Change anything that you wish to modify, until you are satisfied.
Export your mapping project
- File Menu > Save as Image ... choose format, and save to StudentData folder, and email to yourself!

Advanced mapping:
- On your own time, you can proceed to create a map for printing (see QGIS manual page 301), with scale bar, legend, north arrow, etc., but for today we will end here.

Felicitaciones, ahora tu estás (casi) un experto en el mundo de SIG!