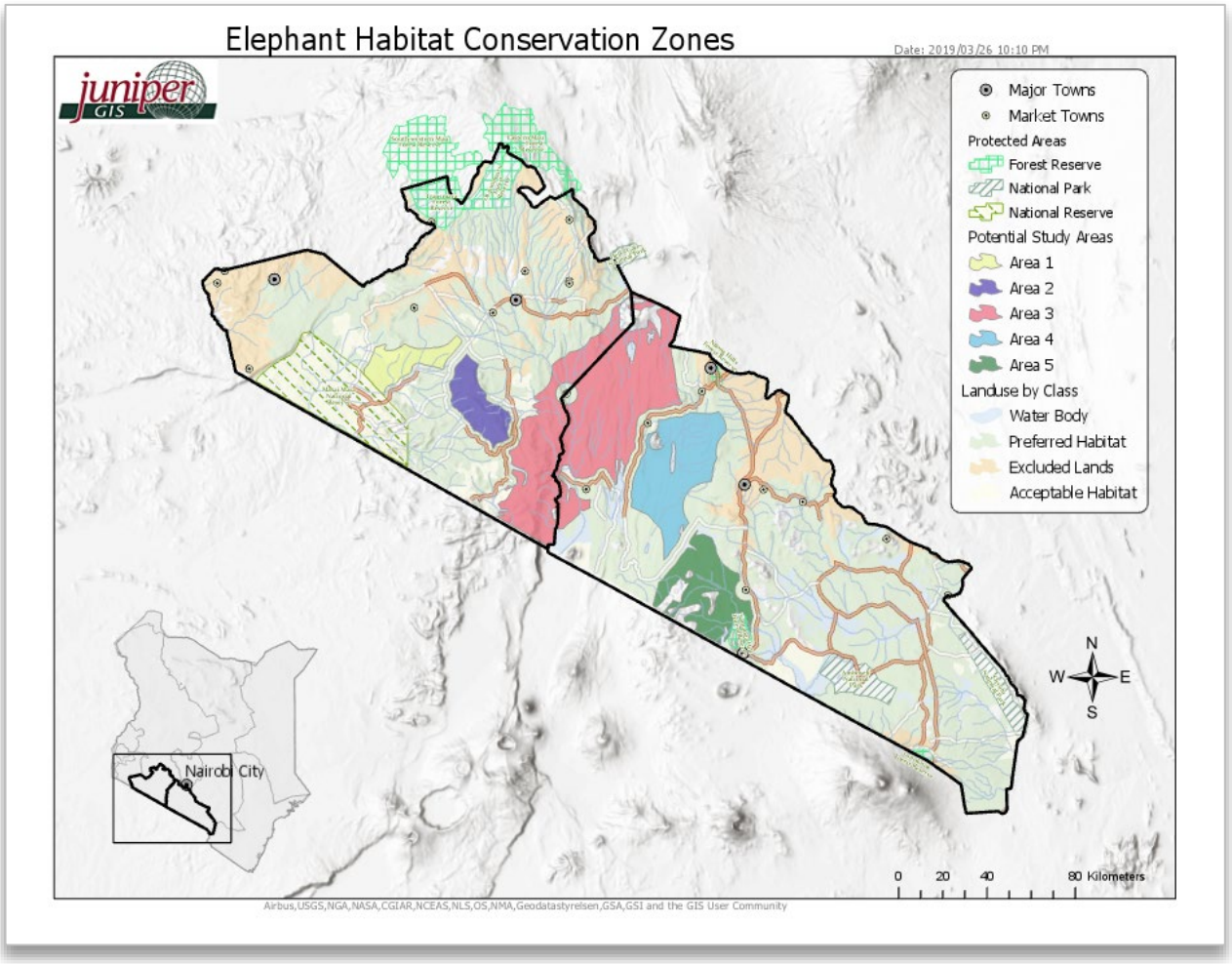
ArcGIS Pro for Environmental Analysis



Advanced ArcGIS Pro
Lab Exercises

Continuing and Professional Education
Davis, California
Karen Beardsley, Instructor
December 2024

Contents

Course revised May 2021 *(additional edits made for version ArcGIS Pro version 3.2 in December, 2024 by Karen Beardsley).*

DATA SOURCES FOR CLASS EXERCISES

Data used in Juniper GIS courses come from a variety of sources, and in some cases, has been modified for use in exercises. While Juniper GIS Services, Inc. has been granted permission by the data source agency to use selected data sets for these class exercises, Juniper GIS Services does not have permission from these agencies to re-distribute this data in any form.

Juniper GIS instructors highly recommend that the best learning experience for these exercises is to repeat them using data from your own organization.

ArcGIS Pro for Environmental Analysis—Introduction

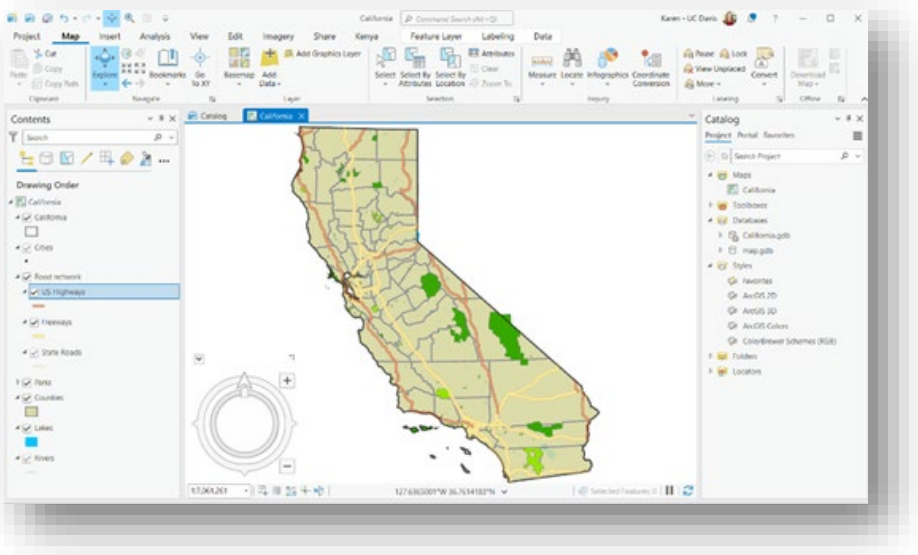
Section One: Course Objectives and Overview

Course Objectives

- Provide an in-depth introduction to ArcGIS Pro
  - Overview of ArcGIS Pro
  - Briefly discuss Geographic Information System (GIS) concepts
  - Become familiar with the ArcGIS Pro interface and operation
  - Be able to use ArcGIS Pro and its embedded Catalog, extensions, toolboxes, etc.
  - Learn how to use GIS for analysis
  - Effectively present data in map layouts.
  - Provide opportunities to ask questions and participate

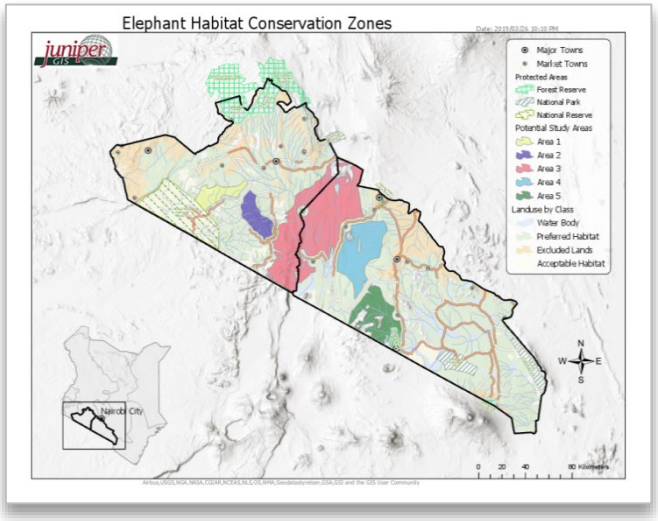
Course Overview

- **Section One** – An ArcGIS Pro Overview
  - Exercise – ArcGIS Pro project using local data
    - Explore the ArcGIS Pro interface
    - Perform queries
    - Classify and symbolize data
    - Perform Analysis
    - Create a layout



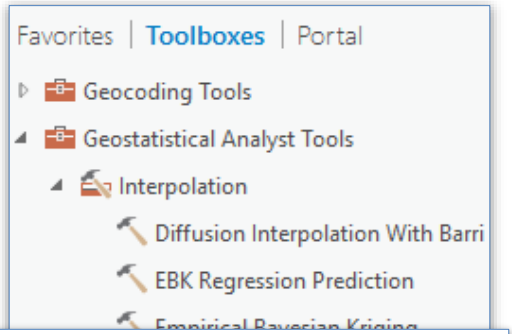
◈ **Section Two** – Using ArcGIS Pro in an Analysis Project – Determining areas to set aside as Elephant Habitat Conservation Zones. This will be similar to a typical GIS project and lead you through the process from beginning to end.

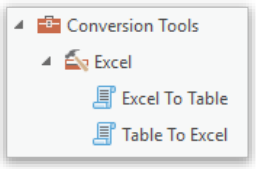
- Work with Catalog to examine and prepare data
- Create a map in a ArcGIS Pro project and set properties
- Use selection methods to select the data for the project
- Work with Symbology, Labels, and Annotation
- Work with Tables
- Perform basic geoprocessing and analysis

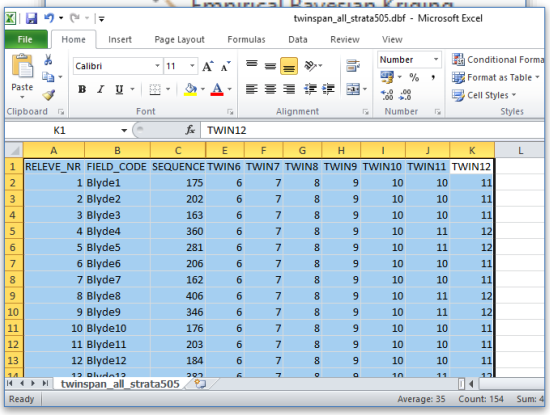


◈ **Section Three** – Geoprocessing, Analysis, Editing, and Working with Excel.

- Use Geoprocessing tools for Analysis
- Work with Excel
- Create a finished layout

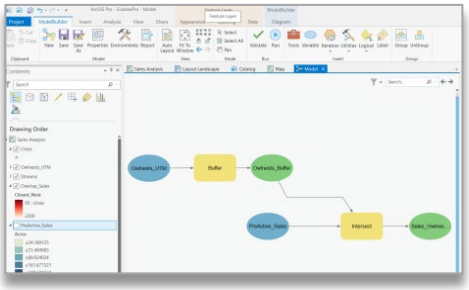






◈ **Section Four** – ModelBuilder and Spatial Analyses

- Create analysis models
- Use ModelBuilder and for Analysis



Course Presentation

- Lecture/Power Points to present concepts

- Demonstrate key ArcGIS Pro operations

- Hands-on Exercises

  - Exercise manual notations

    - **Commands** and key **names** are in **Bold**
    - Shortcut notation: "Select **Map>Add Data>XY Point Data …"**
    - "Click" means left-click; right-clicks will always be called out.
    - "Activate" means to click once on a dataset so that it is active or highlighted and context specific menus are relevant for that dataset.
    - Screen grabs for most steps or to show buttons or tools. The screen grabs may not always match the steps exactly and might be from older versions of the software when there is no significant change. Use the screen grabs as a guide and not as an absolute unless specified.
    - *Additional notes are in italics*
    - Less detailed call-out of steps as we progress through the exercises.

  - First part of each step usually describes what the step will do, and then is followed by step-by-step instructions. This helps in understanding the purpose of the operation and minimizes the "What did I just do?" syndrome.

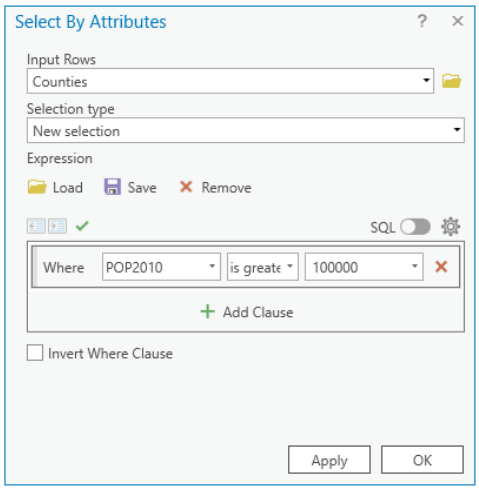
1. Let us create a query to find out how many counties had more than 100,000 people in 2000.

   → Select **Map>Selection** group> **Select By Attributes** from the menu.

   → Select "**Counties**" for the layer, and make sure that the selection type is "**New selection**."

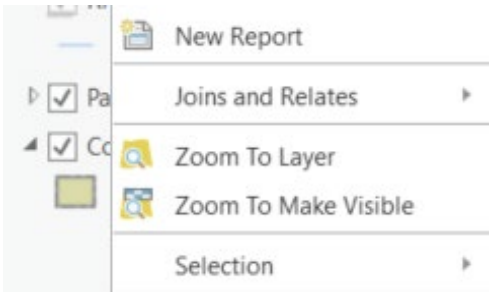
   → Click **New expression** and then add a clause where **POP2010 is Greater Than 100000** by selecting **POP2010** as the field, then **is greater than** as the requirement, and lastly the threshold value of **100000**.

   → Click then **OK**.



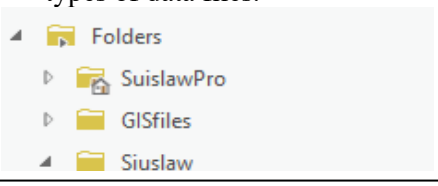
- Some steps will show how to get "unstuck" where there are common problems. If you do get stuck, read the next line or two, especially if the lines are underlined, as this might help.

→ When the new map opens, click the **Add Data** button and add in both of the Fish-bearing layer files. To see the streams, you may need to right-click the layer and select **Zoom To Make Visible**. *When they come in they will have all the properties you set – name, display scale, color and definition scale. Now any time you need either or both of these layers, you don't have to spend time recreating the definition, colors, etc.*



- Exercise Data - Most exercises use off-the-shelf data, with real quirks like you will find on the job, rather than data created especially for the exercises.
  - Because the course data is used in different classes, the full path to the data folders might be slightly different from that shown in the screen grabs for some of the dialog boxes. ***If in doubt, always use the path as specified in the written step.***

1. Expand the **C:\Davis\ArcGISPro_EnvAnalysis\Kenya** folder by clicking on the "+" symbol to the left of the name and notice the different types of data files.



- **Exercise Organization**: The exercises are built around common tasks and common problems so that they duplicate as much as possible actual working scenarios, while allowing us to demonstrate most ArcGIS functions. There is purposely some repetition in the exercises so that you get more practice on the functions performed most often. Most exercises build on the previous exercises so it is important to follow and complete the steps. Feel free to experiment after you have completed the steps.

Terminology – tools and conventions used in Microsoft Windows and ArcGIS Pro.

- Basemap: Serve as a reference map on which you overlay data from layers and visualize geographic information. Can be made of multiple feature, raster, or web layers.

- Geoprocessing: A framework and set of tools for processing geographic and related data. Geoprocessing tools can be used to perform spatial analysis and manage GIS data efficiently.

- Layer: A representation of spatial data in a map or scene.

- Layout: An arrangement of one or more maps and supporting elements such as a title, legend, and text. A layout is typically shared as a printed map, poster, or PDF.

- Map: A project item used to display and work with geographic data in two dimensions.

- Portal: A portal is a connection to ArcGIS Online or ArcGIS Enterprise. In ArcGIS Pro, you sign in to a portal to share your work and use content shared by others.

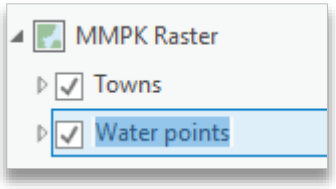
- Preset layers: A prebuilt layer embedded in ArcGIS Pro that only requires a data source.

- Project: A collection of related geographic datasets, maps, layouts, tools, settings, and resources saved in an .aprx file. Projects can reference and include items from your organization's portal or your saved network files.

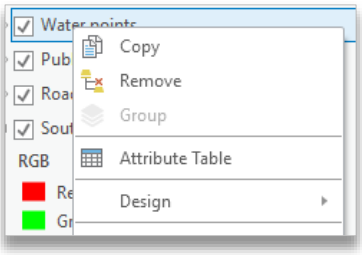
- Scene: A project item used to display and work with geographic data in 3D. Scenes can be viewed in global view (suitable for maps with large geographic areas) or local view (suitable for maps with small geographic areas).

- Task: A set of preconfigured steps that guide you through a workflow. Task items are also project items.

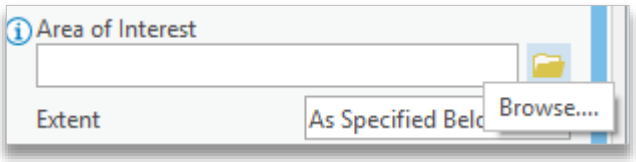
- Mouse Options
  - Left Click Options (Any time the manual says "click" it is a left click)
    - Click once to select or activate an object.
    - Double-click to select and activate/open file/start program.
    - Click, pause, and Click to edit a file or layer name.



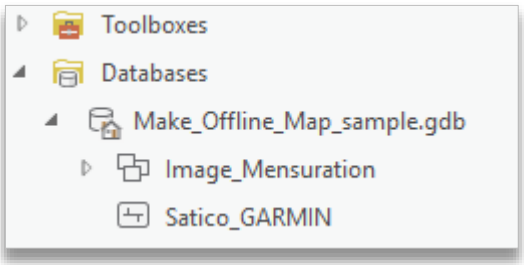
  - Right-click – Opens a **Context** menu, which means the options will vary depending on the object you click. (Right-clicks will be called out in the manual; also, when the manual calls for opening the context menu, this means to right-click the object.)



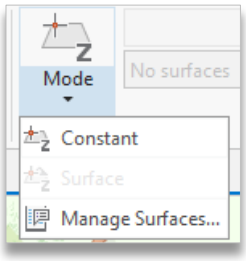
- Working with Folders and Files.
  - **Browse\Open Folder Button**. – Opens a dialog box so you can navigate to folders, usually for finding or saving files.

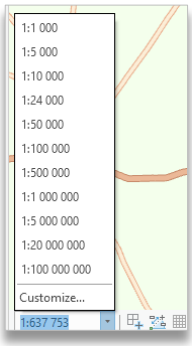


  - **Expanding\Shrinking Folders & Layers** – this is an easy way to see the contents in a folder, geodatabase, or data frame or to show or hide the legend for a layer. In ArcMap a + or – sign was used to indicate whether a folder/layer could be expanded. In Pro an open sided triangle indicates that a folder can be expanded. A solid triangle indicates that it is already expanded.

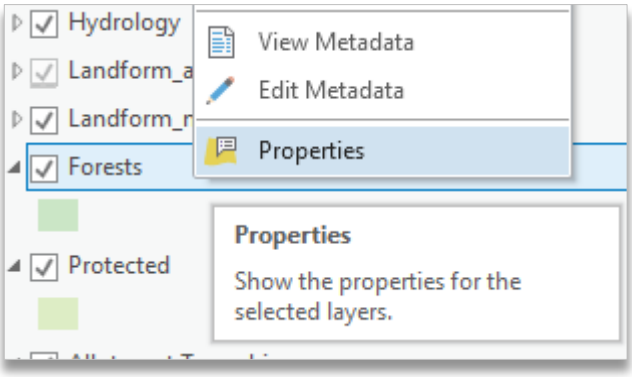


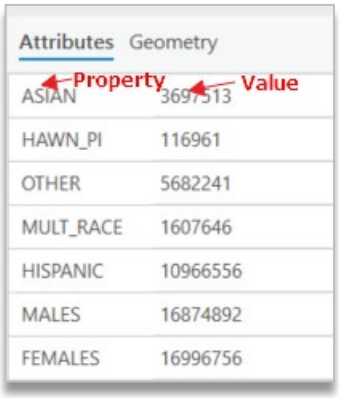
- **Drop-down\Pick List** – provides additional tools or a list of commands, values, etc.



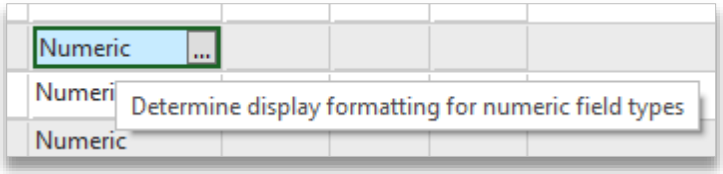


◈ Properties & Values – Many times in ArcGIS or other Window's programs, you will make changes to objects by selecting a property and then changing the value for that property. The properties can be the value of a field, the color of a symbol, or anything. The naming of the Property and Value sections are seldom explicit and usually implied, as in the Fields dialog to the right. For example, an attribute table will have a field called ASIAN and the property may be Double with the Value of 3 697 513.





◈ … The Ellipsis – this indicates another dialog box will open up.

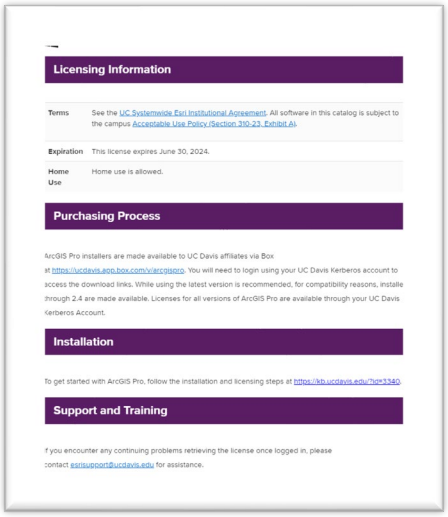


◈ Copy/Paste – used to copy an object or text to the "Clipboard" (a temporary storage place in memory, not a physical location) and then paste that object into another application or location.

- Ctrl + C = Ctrl Key and the C Key will copy any highlighted text or object.
  Ctrl + V = paste
- Right-clicking an object will often display a Copy option. Right-clicking in a blank text area will provide an option to paste the last thing copied.
- Not all options work in all settings.
- Maps can be copied and renamed in Pro as one Pro project can contain multiple maps and layouts.
- In Pro, if two aprx files are open, one can copy across maps and layers between Pro projects.

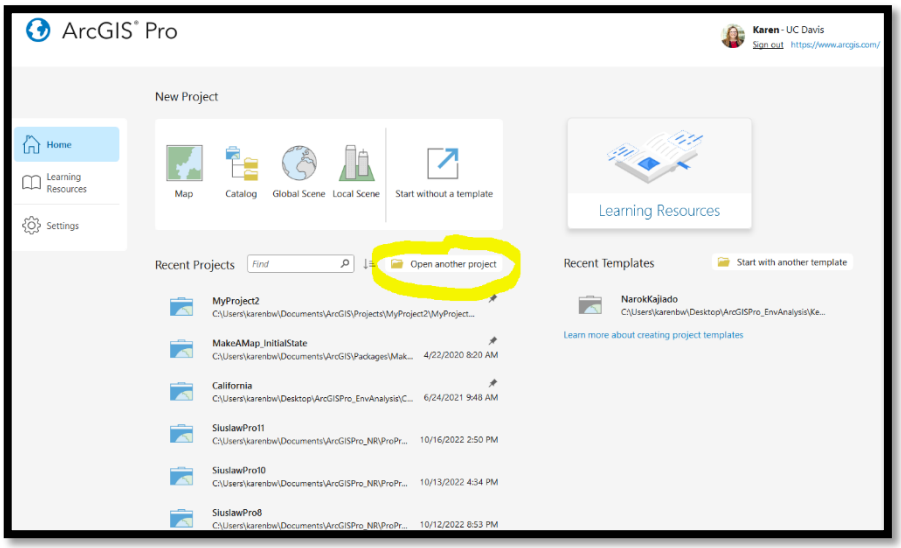
Exercise 1: ArcGIS Pro Sampler — California

This exercise provides an overview of the ArcGIS Pro interface and some basic functions. Most of the data comes from the ESRI ArcGIS Data disks. UC Davis Affiliates can download ArcGIS Pro with their UC Davis Kerberos credentials.



Exercise Organization: Read each exercise step first before completing that step. Most exercises build on the previous exercises so it is important to follow and complete the steps. Feel free to experiment after you have completed the steps.

1. If there's not a shortcut already pinned to the taskbar, search for ArcGIS Pro and then select it to open ArcGIS Pro. In the dialog box click on "**Open another project**" to the right of **Recent Projects.**



→ This will open up a new window then select **Open Project** to navigate to **C:\Users\<your_kerberosID>\Documents\ArcGISPro_EnvAnalysis\California** and select **California.aprx**. The map should look similar to the illustration on the next page.

→ ***NOTE:*** *You should have set up your UC Davis computer account prior to the first day of instruction. Lab data can be found in a* ***.zip*** *file on* ***Canvas*** *and should have been saved on the UC Davis remote computer in the directory given. If needed, we will review this on the first day of class.*

2. In the below screengrab, the ArcGIS Pro user interface includes a ribbon with various kinds of views and panes.

→ The numbering corresponds to the labelled numbers below:

1. The **ribbon** at the top of the user interface organizes commands on a series of tabs.

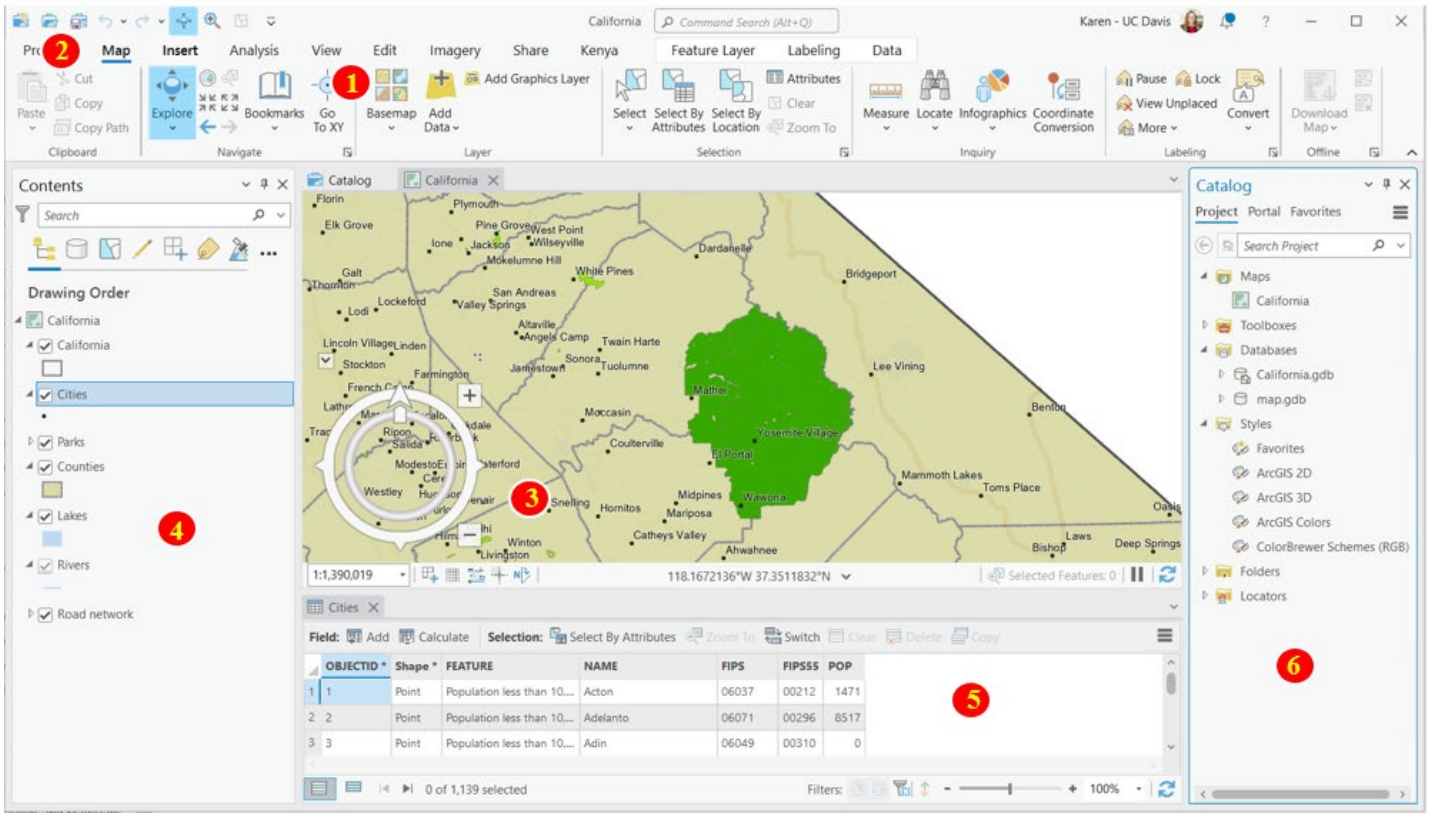
2. The **Project** tab on the ribbon provides access to common file operations, customization options, licensing information, and more.

3. Data is displayed in **views** such as this map view.

4. The **Contents** pane displays items related to the active **view**. When a map view is active, it displays the map's layers, similar to the table of contents in ArcMap

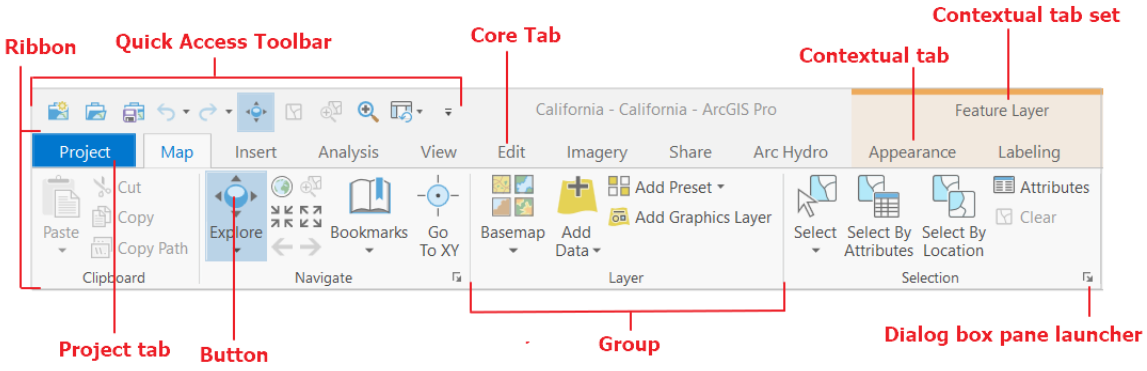
5. In addition to maps and scenes, a project can contain views of tables, layouts, charts, and metadata

6. The items in your project are managed in the **Catalog** pane. You can create items, connections, and favorites in this pane. If this pane is not visible, you can open it by choosing **View, Catalog Pane.**



3. When we take a closer look at the ribbon user interface….

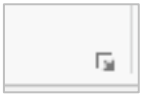
→ ArcGIS Pro uses a horizontal ribbon across the top of the application window to display and organize functionality into a series of tabs.



(Screenshot from earlier ArcGIS Pro version)

→ There are two types of tabs: core tabs, which are always visible, and contextual tabs, which appear and disappear as needed. The **Project, Insert, Analysis, View**, **Edit, Imagery** and **Share** tabs are core tabs. Depending on the active view, additional tabs such as **Map, Appearance, Labeling** or **Layout** tab will appear.

→ A **Group** is a collection of similar functionality that is grouped together and named at the bottom of the ribbon. Groups frequently have a small pane launcher in the lower right-hand side.



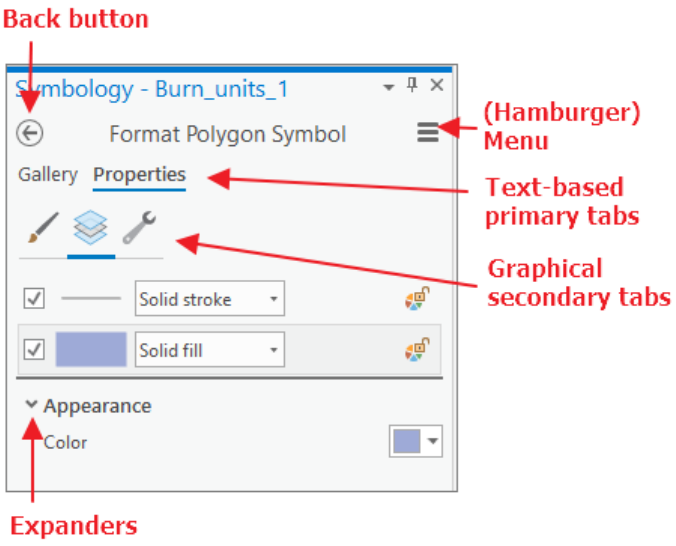
→ A view is a window that represents the primary work area of the application and provides a visualization of your data. For example, a view can be a map, scene, table, layout, or chart.

→ You can have multiple views open at the same time. Only one view is active at any given time. However, the work you do in one view may affect the visualization of data in another view.

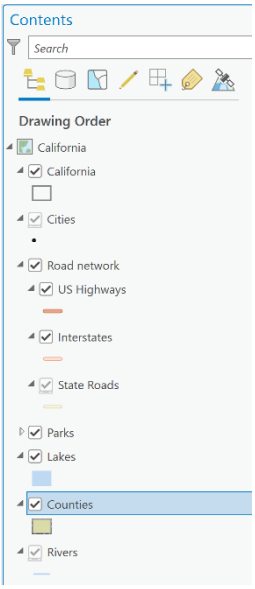
4. ArcGIS Pro utilizes numerous panes as they are dockable windows that can even be moved to a separate monitor. Common panes are the **Contents** pane (a list of your map contents), the **Catalog** pane (an inventory of the items in your project and commands to manage them), and the **Geoprocessing** pane (a list of geoprocessing toolboxes installed with ArcGIS Pro).

→ There are often a series of nested functionality on a pane that is presented as text-based primary tabs that may each contain graphical (or icon based) secondary tabs.

→ The menu button is usually in the form of a ‘hamburger” icon.



5. Let us first look at the list of layers in the **Contents** pane.

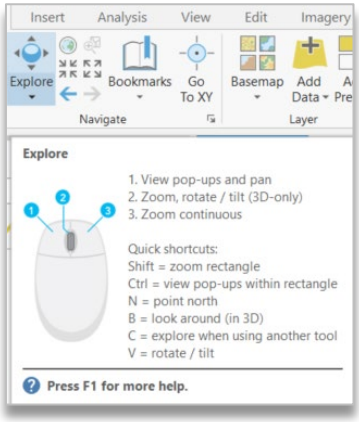


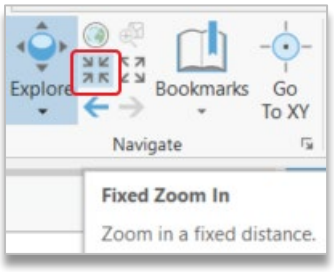
→ At the top, there is a **map** symbol with the word **California** next to it—this is the name of the map view (known as data frame in ArcMap). If the view contained a scene then this would be a scene view.

→ The **Road network** content item is a **group layer** comprised of **US Highways, Interstates** and **State Roads**.

→ Note that the check marks for **State Roads, Cities** and **Rivers** are grayed-out. This indicates that features on those layers are not visible because we are beyond their display scale.

*To move around your map and learn about your data, ArcMap uses several different tools: Identify, HTML Pop-up, Pan, and Zoom. In ArcGIS Pro, the functionality of those tools is combined in the **Explore** tool on the **Map** tab. There are also keyboard shortcuts for navigation in ArcGIS Pro. See below graphic.*

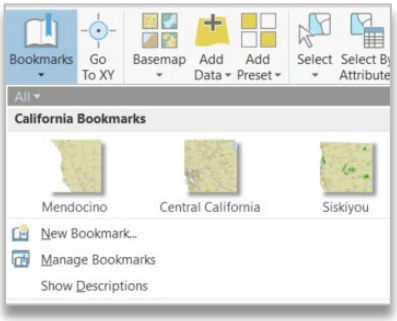




→ Use your mouse wheel or **Fixed Zoom In** button to zoom into the area around the northwest quarter of California and you will see **State Roads** appear. Zoom in some more until the **Cities** appear. If needed, zoom in until you can see the city labels.

→ Use the **Previous Extent (1)** button or the **Full Extent (2)** button to zoom back out.

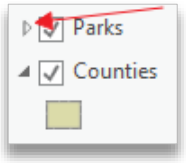
→ Another way to zoom is to use a "Spatial Bookmark." Select **Bookmarks>Mendocino**. This zooms into a previously specified area. Zoom back to the full display.



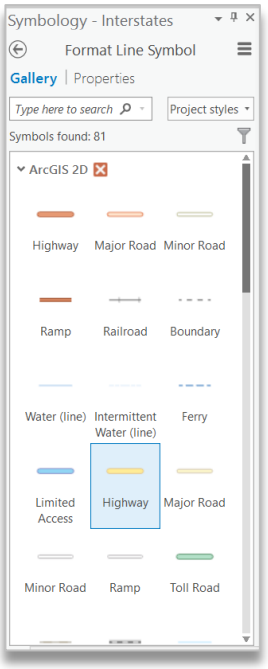
The other layers are straightforward; check to turn layers on or off.

→ Click "**Parks**" off to hide the state and national parks.

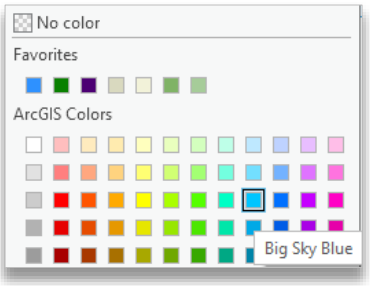
→ Notice the open sided triangle symbol to the left of the check on/off box. This shrinks or expands the layer legend. Since in this case we can tell what the Counties are and we really do not need to see the legend for them, **click** on the solid black triangle next to the **Counties** layer. The legend for that layer is now gone.



6. As you can now see, ArcGIS Pro uses dialog boxes and panes for more functionality and advanced settings and workflow (ArcMap would use dialog boxes and windows for this).



7. Let us make a few quick changes to the symbols.



→ From the **Contents** pane, **right-click** on the pale blue legend symbol below the **Lakes** layer. This will open up a box with color choices—select a slightly darker blue, such as Big Sky Blue. *Note that if you did not see this menu then you probably used a left-click command.*

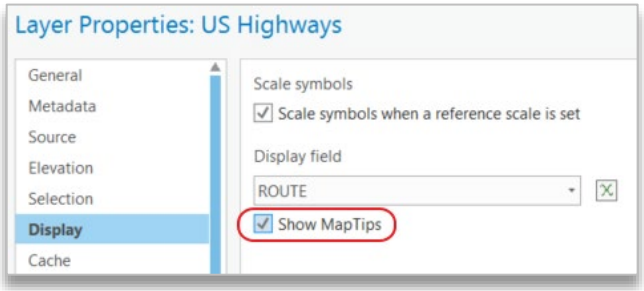
→ Expand the **Road network** group and then **left-click** on the symbol for the **Interstates** layer; this will open up a **Symbology** pane on the right with more symbol choices. Under the **Gallery** tab, select the yellow "Highway" symbol. *Note that there are two "highway" symbols. You may need to scroll down to find the yellow one.* Now the roads show as thicker yellow lines with a darker border.

→ Let us change the name of the layer from "Interstates" to "Freeways" by **left-clicking** on the layer name so that you get a text edit box around the layer name. ***(The trick is to left-click once to activate the name, then left-click again to activate the editing mode).*** Then type in the new name.

8. Next, we will work with the layers a bit. Most layer options are accessed through the "context menu" which is opened by **right-clicking** on the layer name.

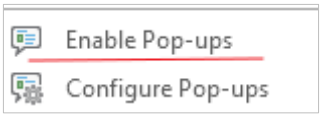
→ **Right-click** on "**US Highways**" and then click on the **Attribute Table** to open up the attribute table for the layer. The route number is stored under the ROUTE field. Close the attribute table.

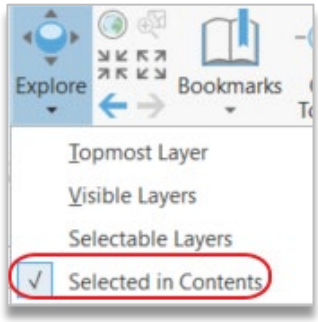
→ Then right-click again on **"US Highways"** and select **Properties**. Then select **Display** and ensure that ROUTE is selected under the **Display field** and tick the **Show MapTips** box.



→ Click **OK** and then hover your mouse pointer over some of the **US Highways** to see how **MapTips** work. You should see the name of the highways. *Note that if you don't see these names, you may need to 'activate' the map by clicking in the map or on the California map name at the top. It only works for US Highways, not Freeways!*

9. Next, we will explore using pop-ups.





→ Zoom out if needed so you can see some of the lakes.

→ From the **Contents** pane, right-click on "**Lakes**" and **Enable Pop-ups** if it is not already enabled.

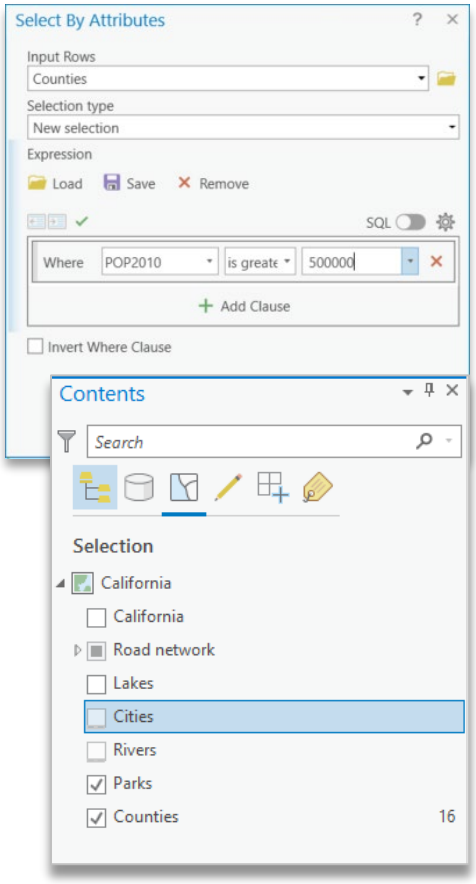
*Note that this may open up the **Pop-ups** pane on right where the pop-up window can be customized. Close this pop-up window for now, if needed.*

→ Then on the map view, click on any of the lakes visible to you and a pop-up pane will open on the right displaying the attribute table details.

→ By default the pop-up will display the results of layers listed at the top in the **Contents** pane, unless you change this and then Pro will remember your preference in every map thereafter. Under the **Map** tab, click on the drop-down arrow underneath the **Explore** tool to select the option to query, in this case, **Selected in Contents**.

→ The pop-up window can be easily customized to only show the fields you want or even images or charts can be added. We will do this in another exercise.

10. Next, we will try a query to find out how many counties had more than 500,000 people in 2010.



→ Click on the **Counties** layer in the **Contents** pane to activate it. From the **Map** tab, inside the **Selection** group, select **Select By Attributes**. This opens the **Select By Attribute** tool dialog box.

→ Under Where select "**`POP2010`**" "**`is greater than`**" "**`500000`**". You will need to type in this amount as ArcGIS Pro will try and populate this value from the existing values in this field.

→ Click the **Apply** button then move dialog box to the side to see the map. *Note, if you click on Apply the changes will be made but the dialog box will stay open. If you click on OK, the changes will be made but the dialog box will close.*

→ Zoom out a bit and you will see all the counties in California that meet the criteria highlighted in cyan.

→ You can also check how many are selected if you click on the **List By Selection** in the **Contents** pane. *16 Counties should be selected.*

→ Under the **Map** tab and **Selection** group, click on the **Clear** button.

→ Try a few more queries if you want. What happens if you query on population 2010 less than 100,000? Clicking OK closes the **Select By Attribute** tool dialog box. How many counties will be selected: _____?

→ On the ribbon, under the **Map** tab, click on the **Clear** button under the **Selection** group to clear any selections.

11. Next we will create a thematic map showing some census data for Counties. *For this exercise we will mostly select the defaults; in a later chapter we will go into more detail on symbology.*

→ From the **Contents** pane, make sure that **List By Drawing Order** is selected.

→ Turn off the **California, Road network group** and **Lakes** layers to eliminate some clutter. *(Also turn off **Parks** if it is still showing on the map.)*

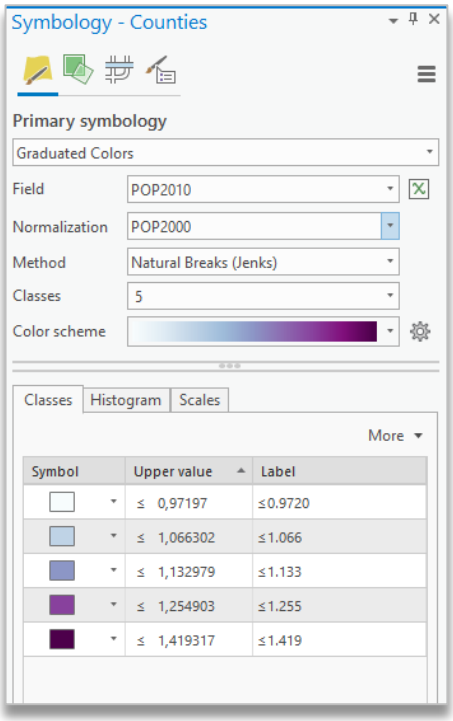
→ **Right-click** on the **Counties** layer and select **Zoom To Layer** to make sure that all the counties are visible.

→ **Right-click** on the **Counties** layer, select **Symbology** to open up **Symbology** pane.

→ Under **Primary symbology** drop-down, select **Graduated Colors**.

→ For **Field** pick **POP2010**.

→ For color scheme, pick **Blue-Purple**.



→ Now you have a thematic map showing the number of people in each county.

12. Next we will use the **Symbology** pane to look at population growth/loss over a 10 year period by normalizing (dividing the population in 2010 by the population in 2000 for each county).

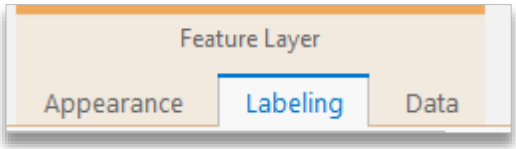
→ Open the **Symbology** tab again if needed and for **Normalization**: select **POP2000**. Now you have a map showing the population growth in each county from 2000 to 2010. *(Population 2010 divided by Population 2000.)* How has the map changed? *Higher values indicate greater rates of change.*

→ If you have time, experiment with a few more choices. Return to the color ramp and normalization after you have experimented.

13. Now we can label the counties. *(Again, we will just hit the basics in this step; in another chapter we will go into detail on labeling in ArcGIS Pro.)*

→ **Right-click** the **Counties** layer and select **Label**.

→ Labels will be applied using any field with the title "name" in it if another field has not been selected.



→ You can also click on the **Labeling** tab and explore selecting various options, such as changing font size, type and color.

→ Make the size **7 pt** and the font **Calibri.**

14. Now that we have a great map (kind of), let us get it ready for printing by making a layout. *We will cover a few basics now, and go into further detail later.*

→ Select the **Insert** tab. Then **New Layout**, and from the **ANSI – Portrait** grouping, select **Letter (8.5" X 11")**. This will open a new blank layout.

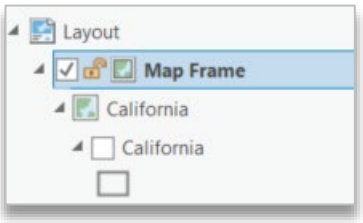
→ Select **Map Frame** from the **Map Frames** group. Then pick **Default Extent** option under **California** group.

→ Then click on the blank page and draw a box covering most of the page for the California map.

→ The California map will be added to the layout. You can drag the border of the map frame so that it fills more of the Layout page.

*Note: if you add a Legend, it will automatically add all the layers visible under the **Contents** pane. You can then toggle these layers in the Legend on or off as you need, but below we will show you a shorter way to only include the layer/s of interest.*

→ Expand the **Map Frame** under the **Contents** pane (*if needed*), click on **Counties** once to select it, then click on the **Insert** tab > **Map Surrounds** group > **Legend** and draw a square in the upper-right of the map to insert counties as a legend item.



→ Insert a **North Arrow** of your choice from the **Map Surrounds** group. Select the **North Arrow** then draw a box in the lower left-hand side of the map as a placeholder for the **North Arrow.** It can also be resized if needed.

→ Also add a **Scale Bar** and a **Title** for the map. Include your **Name** in the bottom right corner of the map.

→ You decide to change the color ramp for the **Counties** layer. In ArcGIS Pro you can work in either the **Layout** or **Map View**. In **Layout View** you just need to first activate the map view by right-clicking on **Map Frame** and selecting **Activate** or right-click on the map itself to then select **Activate**.

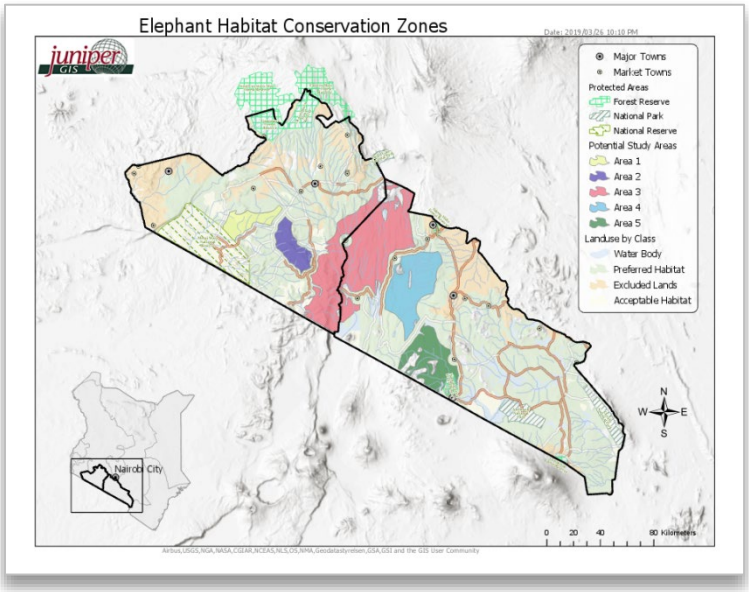
→ Change the symbology to a different color scheme. *(Be sure this color ramp makes cartographic sense, or you will lose points when you turn in your lab!)* When you are finished making changes to the **Map Frame** in **Layout** view, deactivate the **Map Frame** by clicking on the white cross in the red square in upper right-hand side of screen (looks like a "close" or "exit" button), or from the **Layout** tab on the ribbon, there is a **Close Activation** button under the **Map** group.

<u>Lab Exercise 1:</u> Save your project and then export your Layout as a PDF (**Share>Export Layout**). You will submit this PDF as your assignment for **Lab Exercise 1** on Canvas. Please name the PDF **Lab1_<your_name>.pdf**.

Section Two: Using ArcGIS Pro in an Analysis Project

Identifying Potential Elephant Conservation Areas

In the next several chapters we will organize an ArcGIS project to help us find potential sites to set aside as elephant habitat in the districts of Narok and Kajiado in southwestern Kenya. This is not an exercise in modeling and habitat studies but is designed to let us explore ArcGIS Pro capabilities in a fairly realistic project. These exercises were updated from ArcMap and ArcCatalog.



If this were an analysis class, we would spend several hours defining the criteria and diagramming the analysis steps. However, since the purpose of the class is to learn ArcGIS Pro, we have taken the liberty of simplifying and defining the criteria and study area. Any wrong assumptions about elephant habitat and the data are solely the responsibility of the authors. We have also made some changes to the normal process to illustrate different ArcGIS functions. This means that while the exercises are realistic, they might not always be the best example of analysis procedures, but the process of collecting, analyzing, and presenting data will provide experience in using ArcGIS in a likely scenario.

In this analysis exercise we will identify preferred habitats based on land use, then subtract out restricted lands and buffer zones. The data was downloaded from the International Livestock Research Institute (ILRI), the United Nations Environmental Program (UNEP) and other sources in Kenya. See the following page for more information on the data.

The first step is to examine the data in Catalog view to get a sense of what we have to work with. Then we will create a map view, set properties, and bring data into the map view. After that we will explore the attribute data, clip or select features to match our study area and begin the analysis.

Course Data - Taken from the ILRI Website in 2007. http://www.ilri.org/gis/

DISTRICT LEVEL BOUNDARIES (1998): Coverage represents second level administrative boundaries (districts) in Kenya as at 1998 and their respective names. It does not contain the districts created after 1998.

VILLAGES: This is a point coverage showing the villages in Kenya according to Almanac Characterization Tool (ACT) database. It shows a total of 28815 villages.

ANNUAL RAINFALL: This coverage shows the annual rainfall distribution in millimeters per year for Kenya. It was done by the Japanese International Co-operation Agency (JICA), National Water Master Plan, Kenya.

'89 CENSUS DATA FOR ALL ADMINISTRATIVE LEVELS: The coverage showing total population numbers, population density, as well as households and household densities done up to the fifth administrative level (sublocation) in 1989 for Kenya.

LAKES: Coverage showing the lakes of Kenya.

DISTRIBUTION OF WATERPOINTS: The coverage shows distribution of water points and related features in Kenya as described in the Almanac Characterization Tool (ACT) database. The water points in this coverage include dams, falls, rapids, springs, wells and water holes. The features here are in 4 classes, each with a unique identification number as shown: (1) Springs, wells, or water holes (3) Falls (4) Rapids (6) Dams Long: Longitude Lat: Latitude.

RIVERS: This coverage shows the rivers of Kenya done by Japan International Cooperation Agency (JICA), National Water Master Plan, Kenya.

NATIONAL ROAD NETWORK (WFP): This coverage shows the road network of Kenya excluding western Kenya. It was created by the World Food Programme, WFP. Code representing each road type as shown (2) Primary and secondary roads (3) Tracks, trails or foot paths (8) Connectors Rdlntypex: Actual category of road Rdlnstat: Code representing the state of road as shown below (1) Functioning (4) Compiled road connector (5) Compiled from adjacent/more recent sheet (9) Schematic roads Rdlnststtx: Actual state of the roads.

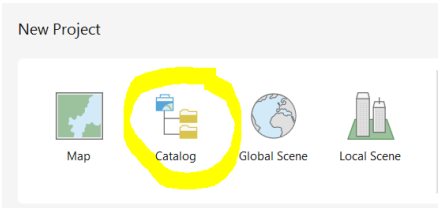
LAND USE DERIVED FROM LANDSAT IMAGES: Coverage showing general land use classes derived from 1980 landsat data by the Japan International Co-operation Agency, JICA, National Water Master Plan, Kenya. Lunum: Land use number: (1) Forest (2) Woodland (3) Bushland (dense) (4) Bushland (sparse) (5) Grassland (6) Barren land(SG) (7) Barren land (R) (8) Swamp (9) Water body (10) Water (artificial) (11) Agriculture (dense) (12) Agriculture (sparse) (13) Plantation (14) Town Landuse: Type of land use as in lunum above.

PROTECTED AREAS: Coverage showing protected areas in Kenya. It is a subset of the Africa protected areas database from the World Conservation Monitoring Center's (WCMC) which manages a database on the worlds protected areas. Areaname: Name of protected area Iso3: The International Standards Organization's code for identifying countries Size: The area of site in hectares Year: The date of original designation, unless a major change in objective or size necessitates a change. Iucncat: An IUCN Management Category. In order to facilitate comparison of sites with widely ranging management objectives, (running from (I-VIII)

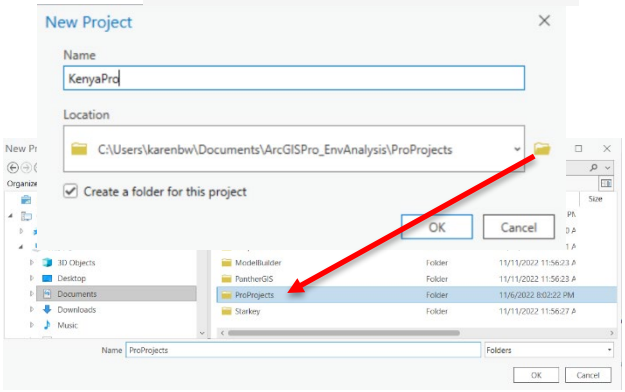
FORESTS: The coverage shows the Kenya forests according to Food and Agriculture Organization of the United Nations. Lu: An identification code for land use type. In this case it if (F1) representing land use as forests. Lunum: Land use number. Forest (1) and (0) lakes within forest zones.

WETLANDS: This coverage shows the wetlands in Kenya according to International Union for Conservation of Nature (IUCN) The wetlands are inclusive of lakes, rivers, salt pans, fresh water marshes, mangroves and alkaline/ saline lakes.

Exercise 2: Working with Catalog



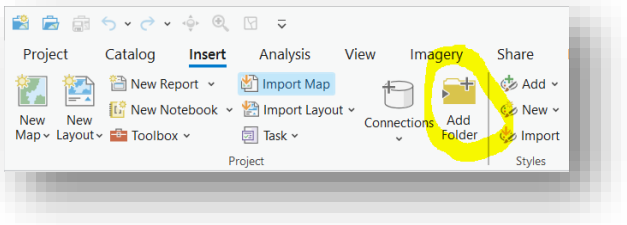
1. First we will use ArcGIS Pro's Catalog view to organize and then explore our data. We will begin by making a new project.



→ Open **ArcGIS Pro** and under **New Project** select **Catalog** to create new project with Catalog view active. You will need to click on the folder icon, then navigate to where your data **ProProjects** folder is located. Click once on the **ProProjects** folder so that it shows up under Name. Then click **OK**. This takes you back to the **Create a New Project** window, and you will create the project called **KenyaPro** in the ***C:\Users\<your_kerberosID>\Documents\ArcGISPro_EnvAnalyis\ProProjects*** folder. Keep the option to **Create a new folder for this project**.

(**Note** that throughout these exercises, the instructions will indicate ***"C:\Davis\"*** or simply "**…**\" instead of ***"C:\Users\Documents\<your_kerberosID>\". Remember to use the correct path—not "C:\Davis.")***

→ Then click on the **Add Folder** button under the **Insert** tab, **Project** group on the ribbon and browse to …**ArcGISPro_EnvAnalysis\Kenya** to connect to this folder.



→ Expand the **Folders>Kenya** folder from the **Contents view** (you could use the **Catalog** pane, but the **Catalog view** provides us with more options). *Please note that in some of the screen grabs, the first part of the path might be different.*

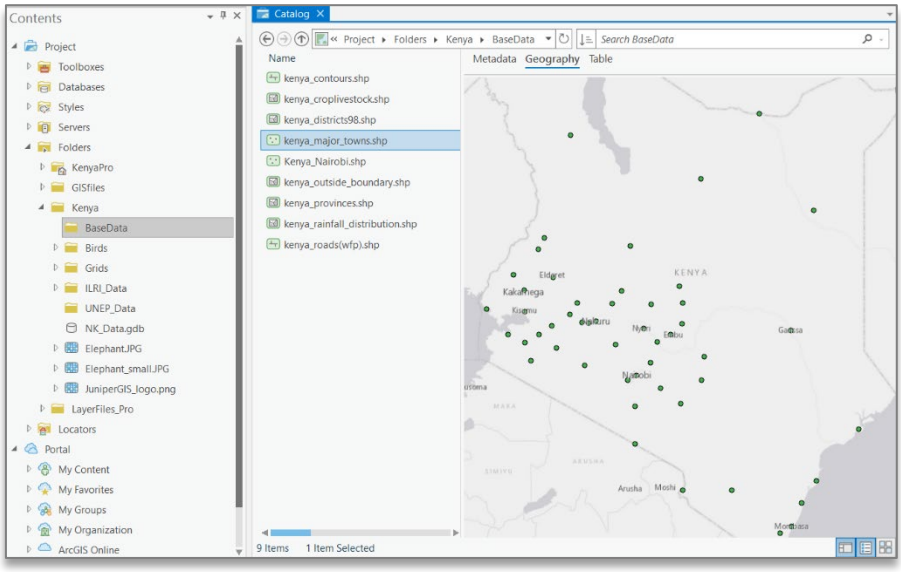
→ Expand the **NK_Data.gdb** geodatabase by clicking on it from the **Contents** pane. The data in here has been converted from the shapefiles in the …**ArcGISPro_EnvAnalysis\Kenya\ILRI_Data** folder, and then clipped and projected for our project area. This will be our primary workspace.

→ Expand the **BaseData** folder. This contains several Kenya-wide shapefiles from ILRI that we might use for a layout or for reference.

→ Click on Kenya_major_towns.shp to activate it, then on the right, click on the **Geography** tab.

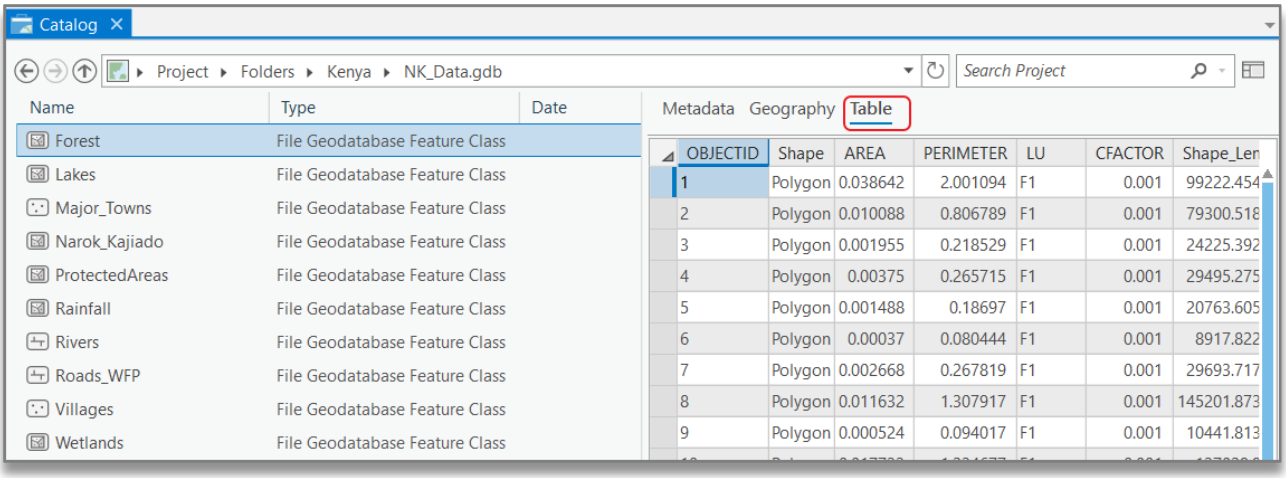
→ Expand the **UNEP_Data** folder. This has some countrywide data from UNEP, most of which is similar to the data from ILRI.

→ Expand the **Grids** folder. This contains the hillshade grid we might use in layouts.



→ Examine any of the other data.

→ From the **Contents** pane, select the **Forest** feature class in the **NK_Data** geodatabase and then select the **Table** tab. You will see **Area** and **Perimeter** fields near the left side of the table and **Shape_Length** and **Shape_Area** fields near the far right. When data is converted to a geodatabase feature class, these last two fields are automatically added and calculated. The values in the **Area** and **Perimeter** field were copied from the original shapefile format and may not match the values in the **Shape_Area** or **Shape_Length** fields because the data in the Geodatabase has been clipped and projected.



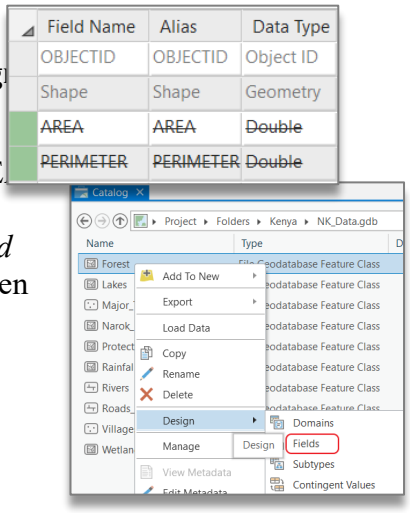
Normally, when converting from coverages or shapefiles, the old Area and Perimeter fields should be dropped as a good practice. We left these in here so you could see the difference. Anytime you have data from a geodatabase with an Area or Perimeter and a Shape_Area or Shape_Length field, be sure to use only the Shape_Area or Shape_Length fields because these fields are automatically updated when doing edits. The Area and Perimeter fields here are showing the values in degrees, which are not very useful, while the Shape_Area and Shape_Length fields are in the projected units – meters – which are more useful.

→ Since we will not need the **Area** and **Perimeter** fields, we will delete them.

→ Right-click on the **Forest** feature class then select **Data Desig > Fields**.

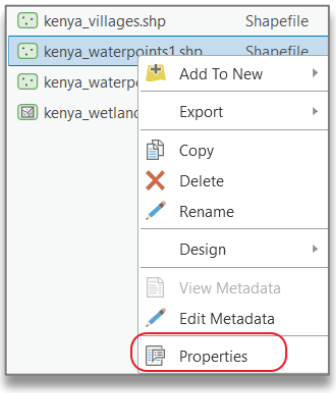
→ From the Fields table, click in the gray area to the left of ARE and PERIMETER and click on **delete**. *(To select both at one time, hold down the **CTRL** key to select the second one after the first is selected.)* They should be highlighted green for deleting.

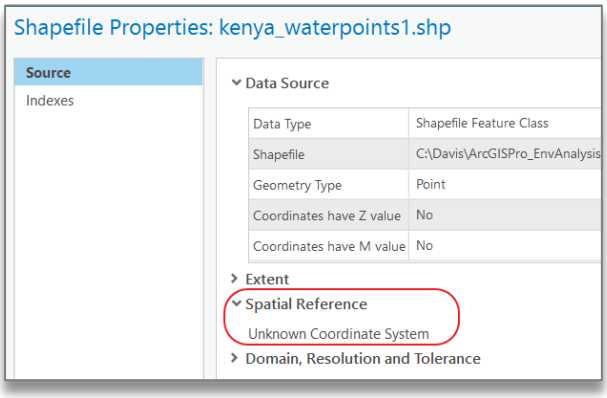
→ Click on **Save** from ribbon above (**Fields** tab) and **Changes** group and the rows will be deleted. Close the **Fields** table.



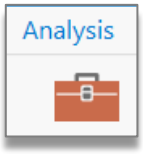
2. Click on the **ILRI_Data** folder from the **Contents** pane. *(Click on the **Catalog View** instead of the Fields: Forest (Design View) if needed.)* In a later exercise, we will add the Kenya_Waterpoints1 shapefile into our map, but we should make sure that the projection is defined.

→ To verify that there is no coordinate system, right-click on the **kenya_waterpoints1** shapefile and then select **Properties.** It will open up the **Shapefile Properties** dialog box and under **Spatial Reference;** it should show "**Unknown Coordinate System**". Click **OK** to close dialog box.



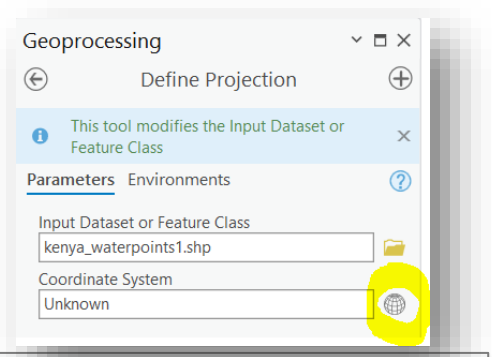


→ To change this, click **Analysis** tab of the ribbon and select the **Tools** button to open up the **Geoprocessing** pane.



→ Under the **Find Tools** search box, type "**define projection**". Open up the tool.

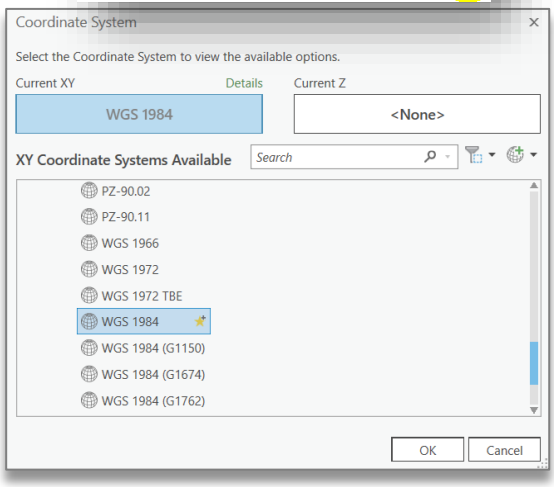
→ Drag **kenya_waterpoints1.shp** into the **Input Dataset or Feature Class** option and then click on the globe button on the right to select the appropriate projection.



→ Click on **Geographic coordinate systems** to expand this list.

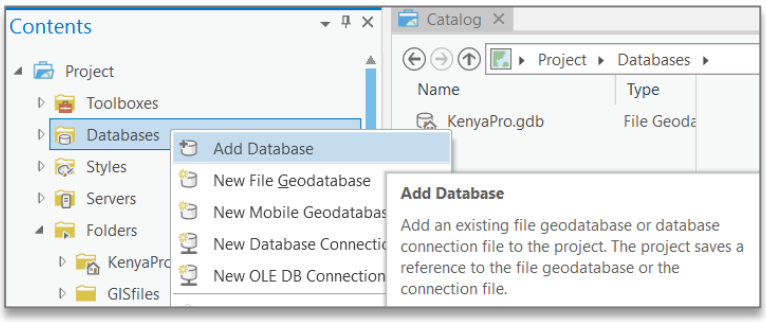
→ Then go to **World** and then to **WGS 1984**. Click **OK**. The current coordinate system should now show WGS 1984.

→ Then click on **Run** to execute geoprocessing tool.



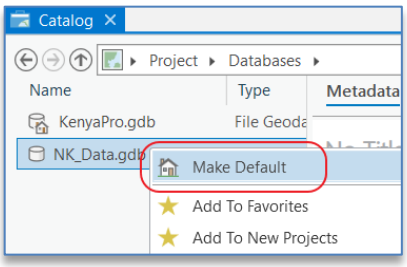
3. ArcGIS Pro will by default create a new geodatabase with the same name as the project name (**KenyaPro.gdb**) and this is very useful when running various geoprocessing tools. However, as we already have a geodatabase, we will change the default project settings to use the NK_Data.gdb as the default for our project.

→ Right-click on the **Databases** folder under the **Contents** pane, then click on **Add Database** and then browse to your **NK_Data.gdb** geodatabase to select it. As you have already added a shortcut to the Keya folder, just click on **Folders>Kenya** and then select the geodatabase. Click **OK**.



→ The **NK_Data.gdb** will be added to the projects Databases folder. But to make it the default geodatabase, right-click on **NK_Data.gdb** and choose to **Make Default**.

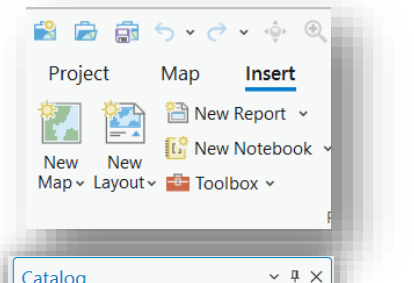
→ As we no longer require the **KenyaPro.gdb**, we will delete it. Right-click on **KenyaPro.gdb** and choose **Delete**. Click on **Yes** when prompted to confirm this action.

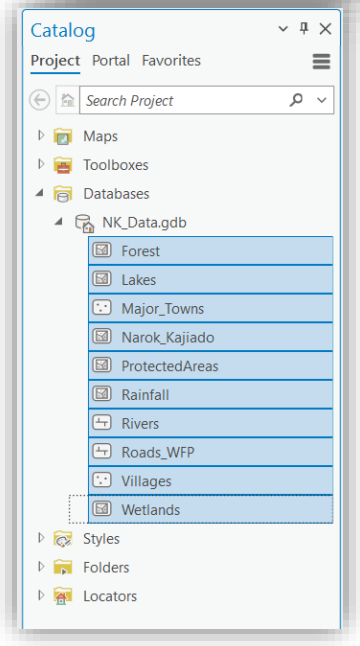


→ Close the **Catalog View** (not the **Catalog** pane)

Now anytime you need quick access to the NK_Data.gdb geodatabase, just click on the Databases folder to select it.

4. Now that we have examined the data, and made some changes as needed, we are now ready to create a map and add some data.





→ From the **Insert** tab on the ribbon, click on **New Map** to create a new map named **Map** with default basemap of the world.

→ We won't be using a basemap for a while so right-click on the basemap(s) and remove them (it may be comprised of two files: *World Topographic Map* and *World Hillshade*).

Note: the default basemap that is displayed can be set by the administrator of your ArcGIS Online's Organizational account so it may differ from that discussed above.

→ Then from the ribbon's **View** tab, select **Catalog Pane** to open up the **Catalog** pane on the right if it is not already open.

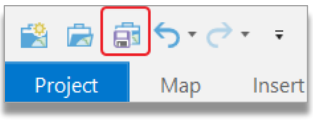
→ From the **Catalog** pane, click on **Databases** then expand the contents of **NK_Data.gdb**.

→ Then select all the feature classes, holding down the Shift key, and then click and drag them over to the map view.

→ To eliminate some of the clutter for now, turn off everything except the **Narok_Kajiado**, **Rivers**, **Roads_WFP** and **ProtectedAreas** layers.

Note: to turn on and off all the layers at once, hold down the control key when clicking on one of the layers under the Contents pane.

→ Then **Save** from the quick access bar in upper left-hand corner of ArcGIS Pro.



Exercise Summary: This was not a very exciting exercise, but it is usually where you would start a project – looking at some of the data, making a few corrections such as defining the coordinate system for a file where this was missing, and then starting a map. In the next chapter we will learn more about the visualizing data on a map and then make a few changes to our map to get organized for our analysis.

Lab Exercise 2: Please answer the following questions and upload your answers to Canvas. Answers should be written in complete sentences and uploaded to Canvas in a single Word, Text, or PDF document. Include your full name at the top of the document.

1. **What is the coordinate system of the Map frame?** *(Hint: Right-click on the map frame name (**Map**), choose **Properties>Coordinate Systems**.)*
2. Zoom in the northernmost part of the map. **What do you notice about the Narok_Kajiado** and **ProtectedAreas** layers**?** *(Hint: Change the symbol of the **ProtectedAreas** layer to be just a black outline.)*
3. Move the **Narok_Kajiado** layer to the top of the **Contents** list. **Why are the Rivers and Roads layers no longer visible?** (After answering the question, move it back to where it was.)

Exercise 3: Setting up the ArcGIS Pro project

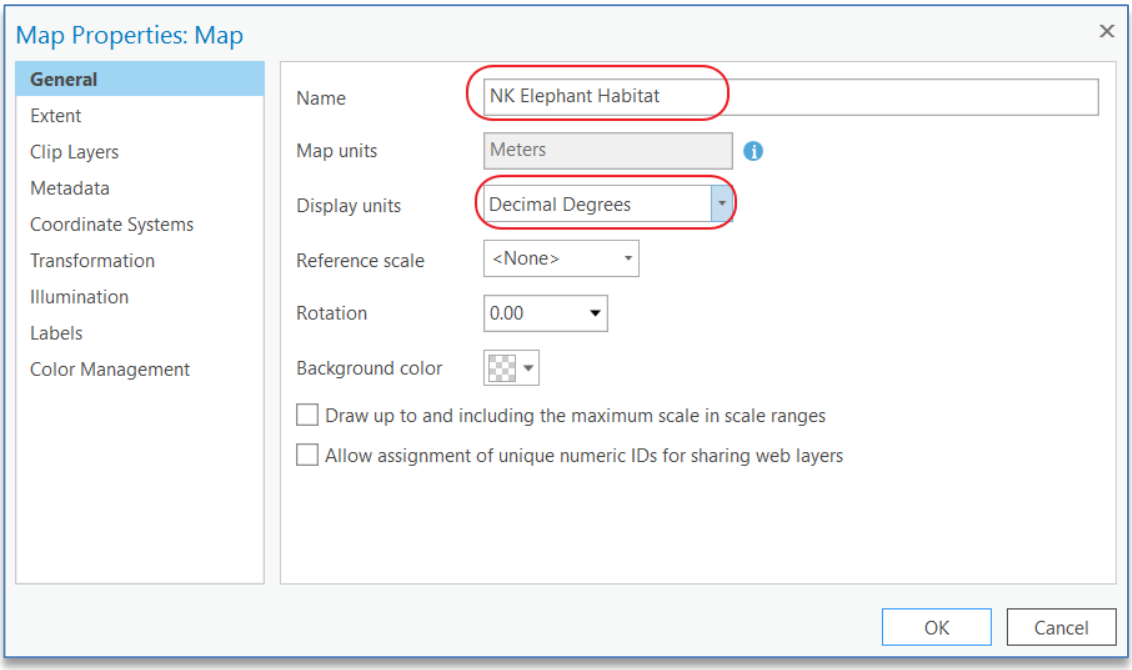
In the last chapter we created a project called **KenyaPro** in the **ArcGISPro_EnvAnalyis\ProProjects** folder, organized our data in Catalog, changed the default Geodatabase and created a simple map, and loaded some data into. Now we are ready to start working with our new map.

1. First, we will open up our project and set properties for our new map. You will recall in the previous exercise that we created a project called **KenyaPro**. We will build on where we left off last time.

   → If it is closed, start **ArcGIS Pro** and open the **KenyaPro** project you created in the previous exercise.

2. Under **Contents** pane, right-click on **Map** and open up the map **Properties**.

   → Under **General** option, change Name from **Map** to **NK Elephant Habitat** and change the **Display units** to **Decimal Degrees**.



   → Under **Extent**, click on **Use a custom extent** and then from **Extent of a layer**, select **Narok_Kajiado** then click on **OK**. If you click **Full Extent** it will take to the spatial extent of **Narok_Kajiado**. *(You may need to select "**All features**" as you select the layer.)*

→ You will need to reopen the map properties dialog box (by right-clicking on the **NK Elephant Habitat** frame and choosing **Properties**). Next we need to fill in some metadata under the **Metadata** tab.

→ Under **Title** write "**NK Elephant Habitat**".

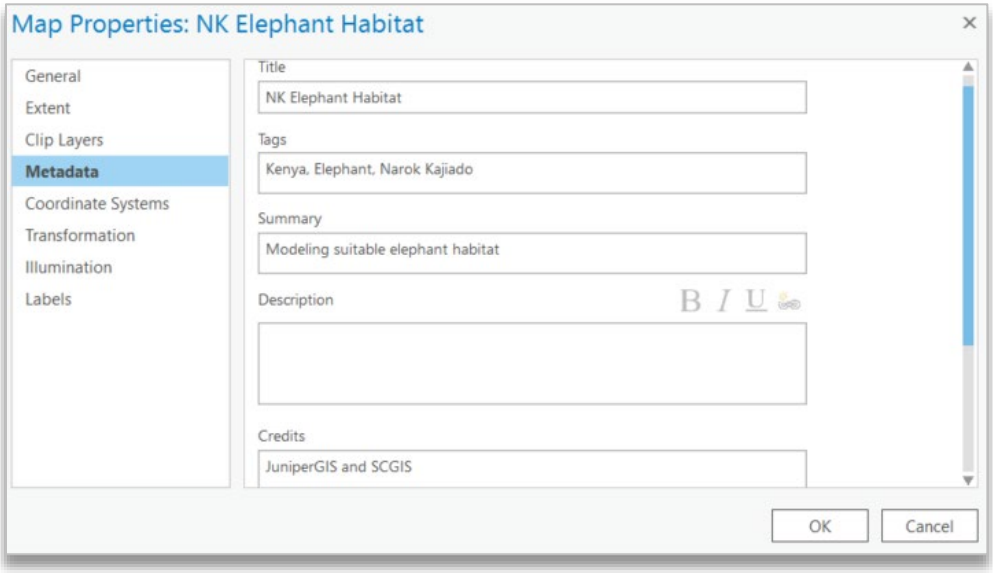
→ Under **Tags** write "**Kenya, Elephant, Narok Kajiado.**"

→ Under **Summary** and **Description**, write "**Modeling suitable elephant habitat.**"

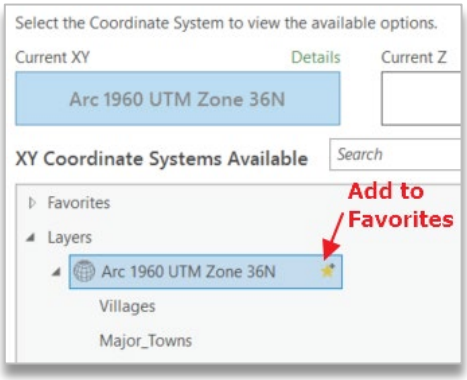
→ Under **Credits**, write "**JuniperGIS.**"

→ Under **Use limitations**, write "**Learning purposes only**."

→ Lastly, click on **Generate Thumbnail**. *Note: if it is grayed out then first click on **Delete Thumbnail** and then you will be able to generate a new thumbnail.*



→ Click on the **Coordinate Systems** tab (still under the Map properties), it should show the current coordinate system as **Arc 1960 UTM Zone 36N**. *The map inherits this from the first layer added.*

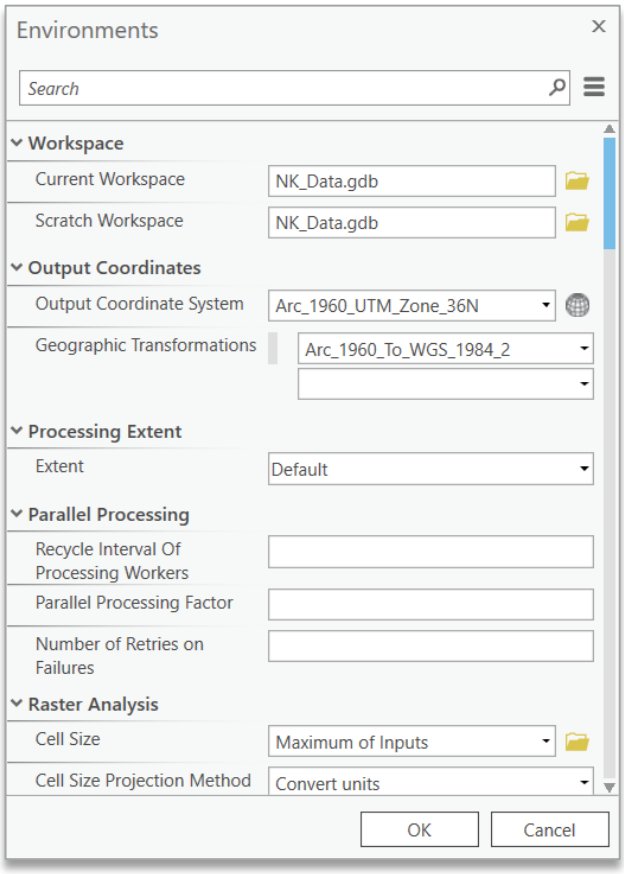


→ Under the list of available coordinate systems, under the **Layers** group you will see the Arc 1960 UTM Zone 36N listed. To the right of it is a small yellow star. Click on this to add the coordinate system to your list of **Favorites**. *(Nothing will appear to happen when you click on it.)*

→ We will leave **Transformation** alone for now (discussed later).

→ Click on **OK** to close properties dialog box and accept changes.

3. Next we should set the geoprocessing **Environments**. It is generally good practice to specify for ArcGIS the working folder, coordinate system, and processing extent for your work. The default folder is usually created when you create a project but you have the flexibility of changing it here if we so wish.



   → From the **Analysis** tab on the ribbon, under the **Geoprocessing** group, click on **Environments**.

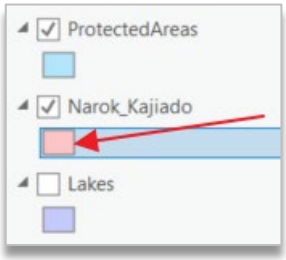
   → The current workspace should be NK_Data.gdb. *Note: if KenyaPro.gdb is listed then you missed a step in Chapter 2 where you need to set NK_Data.gdb as the default geodatabase.*

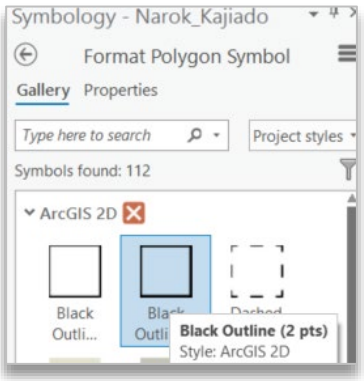
   → Set the **Output Coordinate System** to same as **"Narok_Kajiado"** from drop-down options which will set the coordinate system to Arc_1960_UTM_Zone_36N.

   → Set the **Geographic Transformation** to **Arc_1960_To_WGS_1984_2**. *(Be sure to choose the correct one—you may have to scroll down to find it! We will talk more about coordinate systems and geographic transformations later.*

   → Click **OK**.

4. Next we will make a few changes to the symbols to make the map easier to understand.

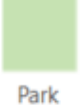




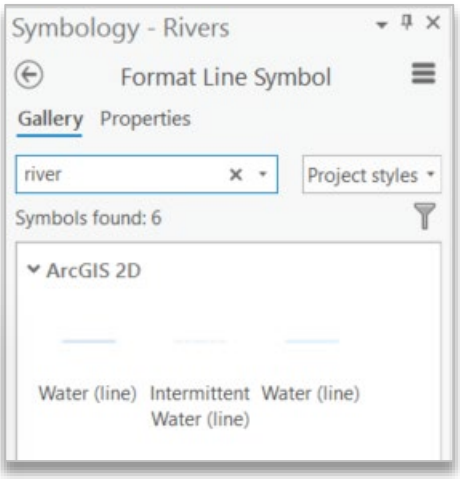
   → Click on the symbol below the layer name **Narok_Kajiado** under the **Contents** pane. *(It may be a different color than in the picture!)*

   → This opens up the **Symbology** pane with a gallery of options to choose from. Change the symbol for the **Narok_Kajiado** layer **to Black Outline (2 pts)**.

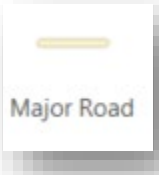
   → Change the symbol for the **ProtectedAreas** layer to **Park** for now.



→ Change the symbol for the **Rivers** layer to **Water (line)**. *Hint: you can search for river in gallery search box*.

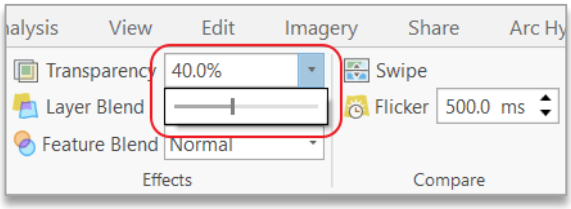


→ Change the color of the **Roads_WFP** layer to **Major Road** (Scheme 2) for now; we will do some other symbology changes later.



→ To make the appearance of the **Rivers** and **Roads_WFP** layers more subtle, lets make them 40% transparent.

→ Click on **Rivers** under the **Contents** pane then click on the ribbon's **Feature Layer** tab, then to the right of **Transparency**, type 40 then hit enter. Or you can drag the drop-down slider to 40%.



→ Repeat this process for **Roads_WFP** to make this layer 40% transparent.

→ Lastly, under the **Contents** pane, click and drag the **Narok_Kajiado** layer to the top.

5. **Save ArcGIS Pro**.

Exercise Summary: Again, this is not a very exciting exercise, but we specified a few basic properties for our map. We set the extent, added metadata, changed geoprocessing environments. We also verified that our coordinate system was correct, and set some symbology to get us started. In the next chapter we will learn about data collection, event themes and coordinate systems.

Lab Exercise 3: Create and submit on Canvas a layout (Landscape, 8.5 X 11) of your current map, as a **PDF**, making sure you have followed all the directions up to this point. Before creating the layout, set the **scale of the map to 1:1,500,000**. Include a **title** of the map, **your name**, a **legend**, **scalebar**, and **north arrow**. *Remember to only have the **Roads**, **Rivers**, **Protected Areas**, and **Narok_Kajiado** layers turned on. Name your layout **Lab3**.*

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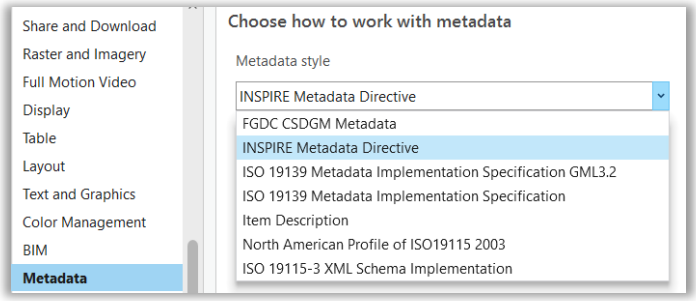
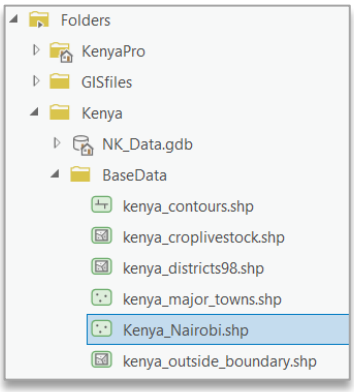
Exercise 4: Adding XY events & Projecting Data

We will first look at projecting shapefiles from one coordinate system to another, and then we will convert a table to a GIS feature class. If we had not made up the location of the Problem Elephants, they would most likely have been collected with GPS. If the GPS could not download directly to ArcGIS Pro, one of the options we have is to generate an "ASCII" text file that would contain information about each site, including the xy coordinates. In our case, the xy coordinates are in latitude/longitude, using the WGS84 geographic coordinate system and datum that is the default for GPS receivers. After we convert this to a feature class in our project geodatabase, we will project it to the **district98_36n** coordinate system to match the rest of our data.



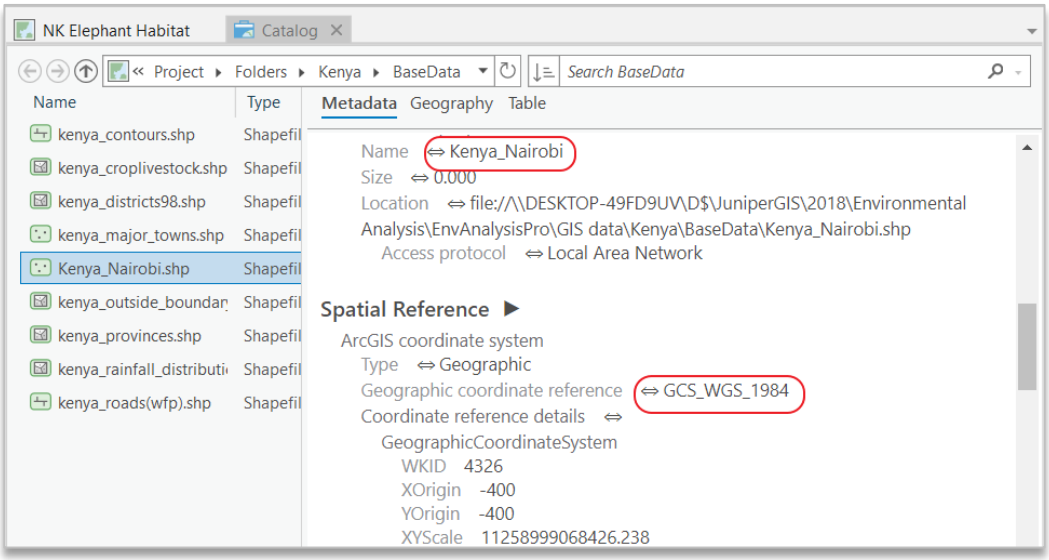
1. Our first step will change the default Metadata for ArcGIS Pro. Go to **Project>Options>Metadata**, then change the default Metadata style from "Item description " to "**INSPIRE Metadata Directive**". *(If it is already set this way, just leave it. The latest version of ArcGIS Pro should have this already!)*

2. Next, we will add the shapefile for Nairobi, the capital of Kenya, then project it to the project's default projection (Arc_1960_UTM_Zone_36N). Open the **NK Elephant Habitat** map if needed, and then open the **Catalog** pane.



→ Click on **Folders** and then navigate to the **Kenya\BaseData** folder.

→ Right-click on **Kenya_Nairobi.shp** file and choose **View Metadata**. Scroll down to **Spatial Reference** and you will notice that this shapefile is in a **Geographic Coordinate System**.

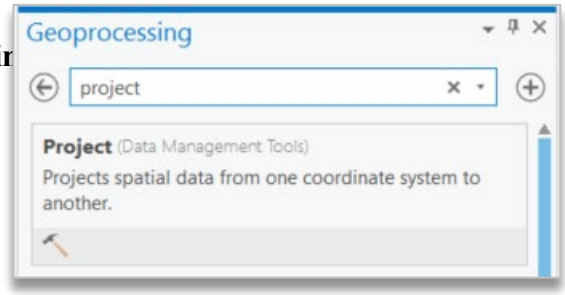


→ Then right-click again on **Kenya_Nairobi.shp** and choose **Add To NK Elephant Habitat**.

Note 1: If you do not see any reference to Spatial Reference under the metadata view, then the Metadata style is set to Item Description which only shows very little metadata. Best to change it to something like Inspire (based on European standards) from the Project > Options > Metadata settings.

*Note 2: To change the projection from GCS_WGS_1984 to Arc_1960_UTM_Zone_36N, we must use the **Project** geoprocessing tool and not the **Define Projection** tool. The latter is used when a shapefile does not have a projection file associated with it and you want to define its actual projection.*

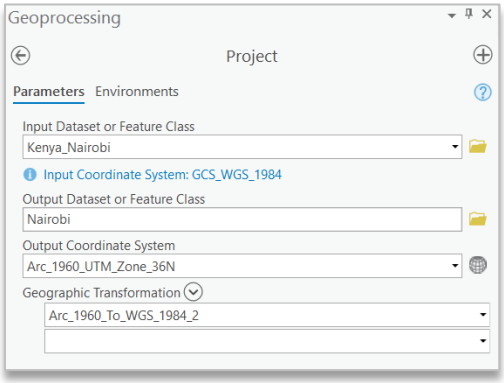
3. Activate the **NK Elephant Habitat** map then from the **Analysis** tab, choose **Tools** then type in "**project"** in the **Find Tools** box.



   → Click on **Project** to open the tool and then drag **Kenya_Nairobi** from the Contents pane into the *Input Dataset or Feature Class* box.

   → The *Output Dataset or Feature Class* should be called **Nairobi** and stored in the default geodatabase (… ArcGISPro_EnvAnalysis\Kenya**NK_Data.gdb**).

   → The output coordinate system should already be set to **Arc_1960_UTM_Zone_36N** because we set this under the **Environments** in the previous exercise. Similarly the *Geographic Transformation* should be set to **Arc_1960_To_WGS_1984_2.**



   → Click on **Run**.

4. Next we will add the **kenya_outside_boundary.shp** file to the **Contents** pane.

   → Add the **kenya_outside_boundary.shp** file to the **NK Elephant Habitat** map from **…ArcGISPro_EnvAnalysis\Kenya\BaseData** folder. *Note, the steps to do so were discussed above.*

   → Open the **Project** geoprocessing tool (it should be open in the geoprocessing pane) and add **kenya_outside_boundary.shp** to the input dataset and the output as **Outside_boundary** in …ArcGISPro_EnvAnalysis\Kenya**NK_Data.gdb**.

   → Keep the defaults for default coordinate system and transformations. Click **Run**.

   → Remove **Kenya_Nairobi** and **kenya_outside_boundary** layers from the **Contents** pane and turn-off visibility for **Nairobi** and **Outside_boundary** *(by unchecking the box so they don't draw).*

   → From the **Map** tab and **Navigate** group, click on **Full Extent** button.

5. Our next step will be to create a feature class from the table of problem elephant sightings.

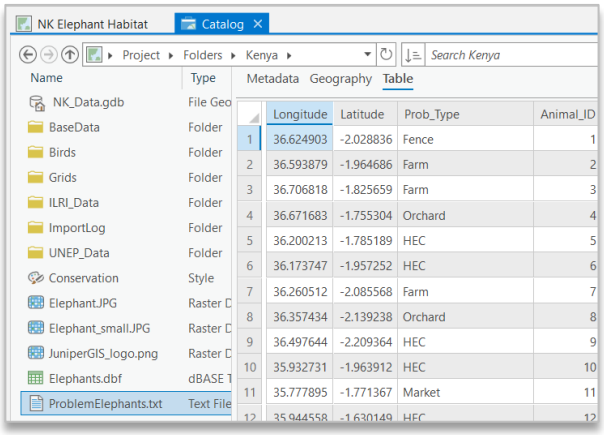
   → Open the **NK Elephant Habitat** map if needed, and then open the **Catalog pane**.

   → Navigate to the **Folders\Kenya** folder.

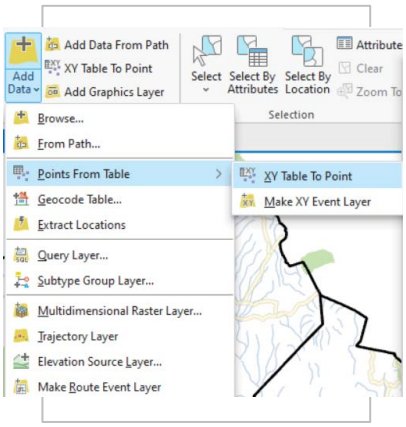
   → Right-click on **ProblemElephants.txt** and choose **View Metadata**.

   → This will open up the metadata view and click on **Table** tab to view table records.

   → You will see that the table contains fields for Latitude and Longitude, and a field describing the type of problem, such as HEC (Human Elephant Conflict), Farm, Fence, etc. *Remember, this data is completely made up for this exercise, but is the type of format that you would be working with if you had collected this in the field or from other observations.*



6. We will now import these records into our default geodatabase. Activate the **NK Elephant Habitat** map then from the **Map** tab on the ribbon, click on the drop-down option below **Add Data** choose **Points From Table** and click on **XY Table to Point.** This will open up the **XY Table To Point** geoprocessing tool.

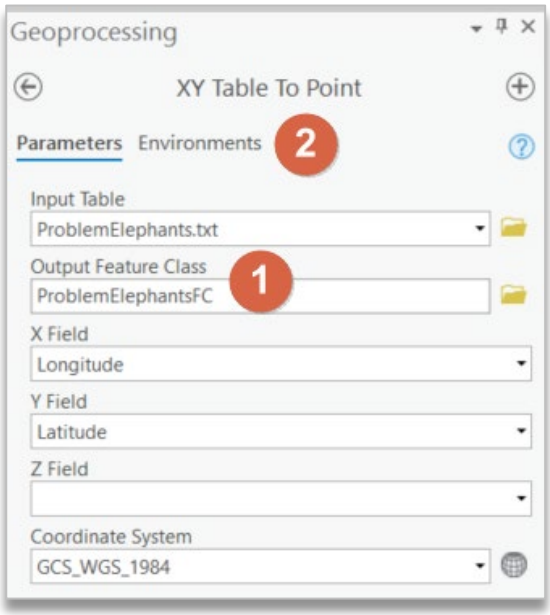


   → For the input file, browse to the **ProblemElephants.txt** file.

   → Name the output feature class **ProblemElephantsFC (1)** in the **NK_Data.gdb**. *Note: Because we set the default geodatabase to NK_Data.gdb, this will be the default and no need to always check, but good practice to check every now and again.*

   → In the next dialog box, verify that the X Field: is **Longitude** and the Y Field: is **Latitude**.

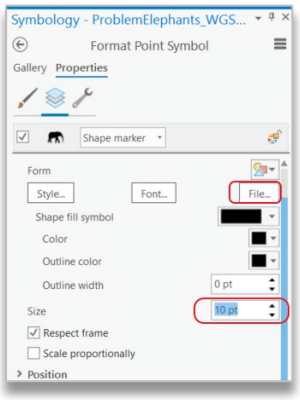
   → The **Coordinate System** describes the input coordinate system of the XY table and this should already be set to **GCS_WGS_1984**. If not, then select this option from available list.



   → Click on the **Environments** tab on the **XY Table To Point** geoprocessing tool (**2**). You will notice that the output coordinate system has been set to Arc_1960_UTM_Zone_36N to match that of the project settings. We will keep this as is.

   → Next click **Run**.

7. Once **ProblemElephantsFC** has been added as a layer, we will want to change the symbology to make them stand out. As Pro does not include a symbol of elephant under the symbology gallery, we will load a free one that we downloaded off the web from Openclipart.org (https://openclipart.org/detail/855/elephant-silhouet).



   → Right-click on **ProblemElephantsFC** under the Contents pane and click on **Symbology**.

   → Under the **Primary symbology** tab, ensure that **Single Symbol** is selected. Click on default symbol that has been applied to open up the **Format Point Symbol** dialog box.

   → Then click on **Properties** primary tab **>Layers** graphic tab and then under **Appearance** and **Insert shape from**, click on **File** and browse to **…\ArcGISPro_EnvAnalysis\Kenya** and open **molumen-elephant-silhouet.svg**.

   → Change the Size to 10 pt.

   → Click **Apply**.

8. **Save ArcGIS Pro**; your map should look similar to the one below.

Exercise Summary: In this exercise we worked some with the Catalog pane, learning how to preview metadata, project shapefiles, and create a feature class from a table. In the last step, you saw how you could add in a custom symbol into ArcGIS Pro. In the next chapter we will learn more about symbology.

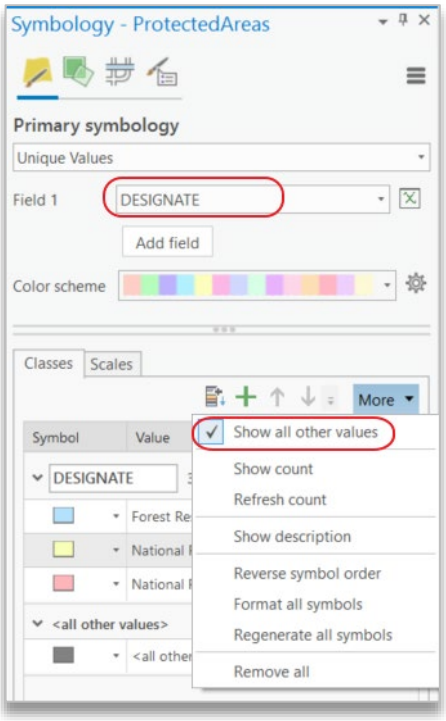
Lab Exercise 4: Follow these directions, and then upload your exported layout (PDF) to Canvas.

- Modify your map to include the **Outside_boundary** of Kenya (change symbol to **black outline**) so that it is clear where the **Narok Kajiado** region of Kenya is located in the country.
- Zoom to the extent of the Kenya boundary (**Outside_boundary**).
- Change the Symbol of the capital city, **Nairobi**, to a **red star (Star 3)** and turn that layer on.
- Right click on the **Nairobi** layer and choose **Label**. This will add the label "Nairobi City" to the map.
- Turn on just the **ProblemElephantsFC, Nairobi**, **Outside_boundary**, and **Narok_Kajiado** layers.
- Create a new layout and call it Lab4. It should be **8.5 X 11 Portrait**, and at a scale of around **1:5,500,000**.
- Add an appropriate **title**, **your name**, a **scale bar**, a **legend**, and a **north arrow**.

Exercise 5: Symbolizing Features

At the moment we do not have particularly interesting or complex data to symbolize, but this exercise will demonstrate the basics of working with symbology in ArcGIS Pro. As we progress in our analysis, we will have a chance to try some other symbolizing options.

1. If needed, open the **KenyaPro** project and the **NK Elephant Habitat** map if this is not open. Zoom to the Full Extent to make sure you are zoomed to the Narok Kajiado study area.



2. We will start with the Protected Areas first, which has 3 categories.

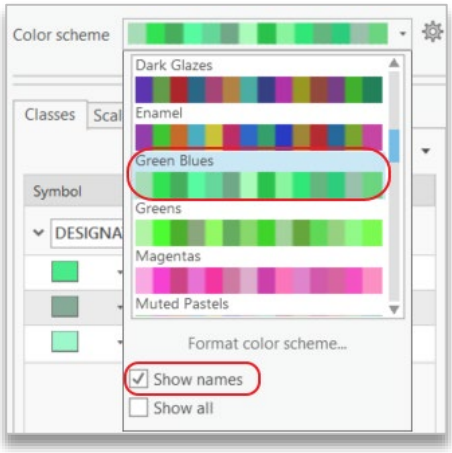
   → Turn on the **Protected Areas** layer.

   → Right-click on the **Protected Areas** layer and choose **Symbology**.

   → Under Primary symbology choose **Unique Values**.

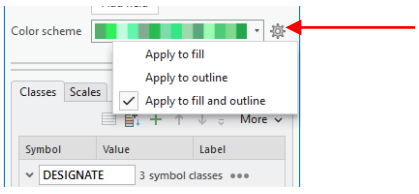
   → Select **DESIGNATE** as Field 1 for the unique values.

   → Under *More* drop-down, uncheck **Show all other values.** (Do not skip this! You will need to do this step frequently.)



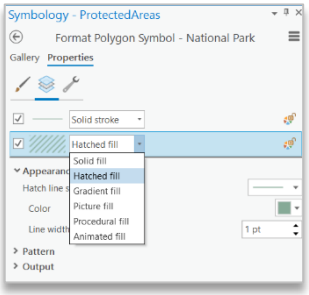
   → Under **Color scheme** drop-down, click in **Show names** then select the **Green Blues** color scheme.

   → The color scheme has been applied to the polygon fill but not the outline. To add it to the outline, click on the **Color scheme options** button to the right of the drop-down and select **Apply to fill and outline.**



Note: the default color scheme provided should be OK but you can easily click on one of the individual color to change them. Next we can change the symbology for each protected area so that we can see through them and the underlying features.

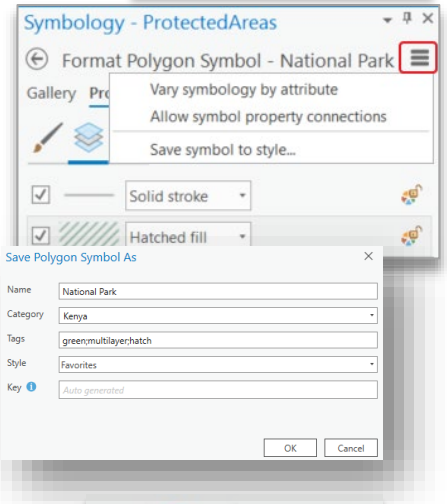
→ In the **Contents** pane, under the **ProtectedAreas** layer, click the symbol for the **National Park** designation. When the **Symbology** pane opens, the **Gallery** tab may be activated. Click on **Properties** tab, if not already there.



→ Click on the **Layers** graphic secondary tab then change *Solid fill* to *Hatched fill* using the drop-down options.

→ Click **Apply** below.

→ Then from the hamburger **menu** button in the top right of the **Symbology** pane, select **Save symbol to style ….**

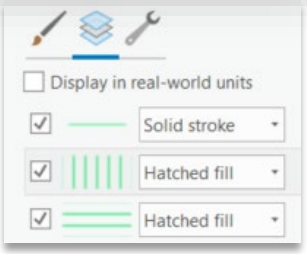


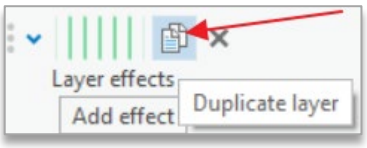
→ Type in **National Park** as the name and **Kenya** as the Category. If you want, add a few tags, separated by a comma, to make the symbol more searchable. The style will be saved to **Favorites**. Click **OK**.

→ Then click on **Forest Reserve**. The **Properties** tab should be already be activated from the previous step so just change the *Solid fill* to *Hatched fill*, but we will make some more changes to it.

  → Expand the **Pattern** options and change the **Angle** to **0°** with **6 pt Separation.**

  → Then select the **Structure** graphic secondary tab, then under **Layers** you will see two options, **Stroke symbol layer** (*Note: hover your mouse over it to see the name*) and **Fill symbol layer**. Click the **Duplicate layer** icon to duplicate the **Fill symbol** layer. A copy will appear below the last **Fill symbol layer**.



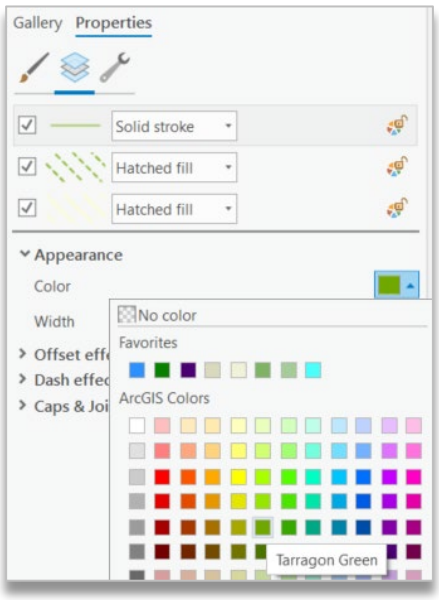


  → Click back to **Layers** tab, then under the duplicated *Hatched fill* layer, change the **Angle** to **90°.**

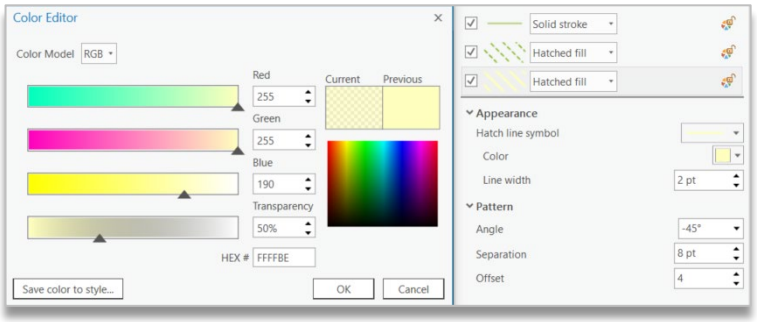
  → Click **Apply.**

→ **Save** this symbol as **Forest Reserve** in the **Kenya** category *(the same way as you saved the National park symbol)*.

→ Last, click the **National Reserve** designation symbol, change the *Solid fill* to *Hatched fill*. We will make a few more changes.

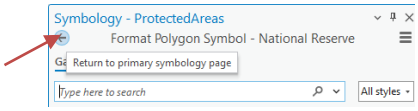


- → Change the **Hatch line symbol** to **Stroke with dashes**.
- → Change the **Color** to **Tarragon Green** (also for Solid Stoke, if it is a different color)**.**
- → Change the **Angle** from 45° to -45°.
- → Change the **Separation** to 8 pt.
- → Duplicate the *Hatched fill* (*Note: use **Duplicate layer** under the **Structure** tab*)
- → Click the **Layer** secondary tab, under the lower most *Hatched fill* layer, then from the *Color* drop-down change the color to **Yucca Yellow**, then again click on the *Color* drop-down but now select the **Color Properties** option and change transparency to 50%.



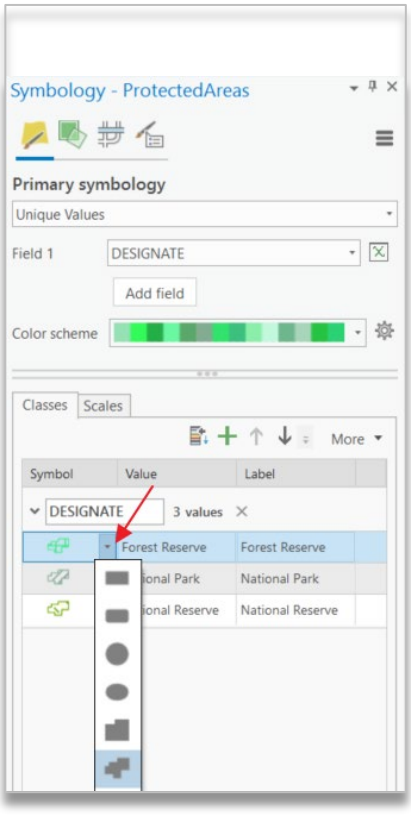
- → Change **Line width** to 2 and **Offset** to 4.
- → Click **Apply**.
- → **Save** this symbol as **National Reserve** in the **Kenya** category.

→ At the top of the **Symbology** pane, click on the **Gallery** tab. You will see your new symbols at the top under **Favorites**. You can also search by **Kenya**, which will bring up your new symbols.



→ To change the shape of the legend patch, from the **Primary symbology** tab, you will need to click on the **Return to primary symbology page** back button at top of pane, and then click on the very small drop-down option next to each protected area symbol and change it to **Boundary**.

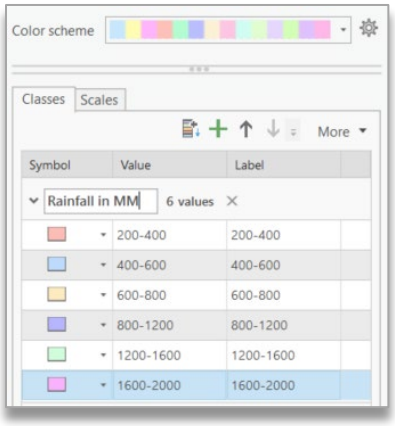
→ Repeat changing the shape to **Boundary** for each of the protected area designation classes.



3. Rainfall will be a consideration when we try to determine the best conservation areas, so we will improve the symbology for that layer.

   → **Turn on** the **Rainfall** layer; it might cover the **Protected Areas** symbols and maybe some of the other data. When we are done, we will make it semi-transparent.

   → Right-click the **Rainfall** Layer and under **Primary** symbology select **Unique Values**. *Note: rainfall is in fact numerical and we should be able to use graduated colors symbology but the attribute table includes ranges such as "200 – 400" hence we need to treat the rainfall values as narrative text.*

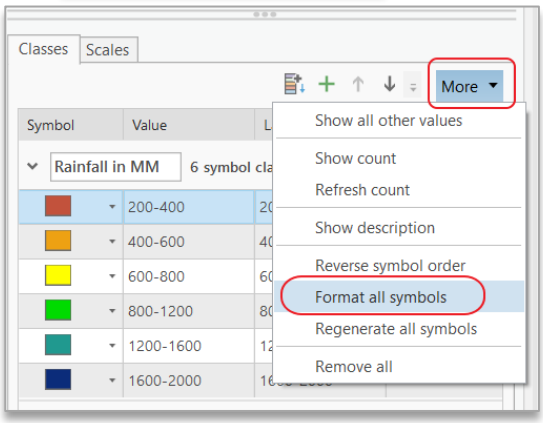


   → Choose **TYPE** as the **Field 1**; Under **More** drop-down uncheck **Show all other values**; then click on **Add all values** symbol to populate all the unique values.

   → Change the order of the **TYPE** so that **200-400** is at the top and the rest are in order from low rainfall to high rainfall. *You can click on the symbol and either drag each class up or down or use the up and down arrows.*

   → Then under the field heading in the **Symbology** pane (see graphic), change **TYPE** to **Rainfall in MM**. Under the **Value** column, click on the top most value (200-400), then holding down the shift key, click on the bottom-most value (1600-2000), to select all of them.

   → Now click on the **Color scheme** drop-down menu, and select **Show names** and **Show all**, then you will see the text description of the color schemes.



      → Choose the **Precipitation** color scheme (the color schemes are ordered alphabetically).

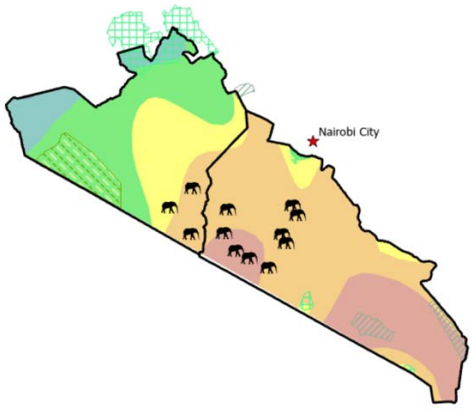
      → The rainfall polygons have gray outlines which we need to remove. Click on the **More** drop-down list and then select **Format all symbols**.

      → Click on the **Properties** pane and under **Outline color**, select **No color**.

   → Click on **Apply**. Now the symbology should look better.

→ The last step is to create some transparency so we can see through the rainfall to other features. Click on **Rainfall** under the **Contents** pane to activate the layer (*if not already activated).* Then from the **Feature Layer** tab, set the transparency to **50%.**

→ Under the Contents pane, drag the **Rainfall** layer to the bottom.



4. If you want, experiment with some symbology for the other layers, then **Save** ArcGIS Pro.

Exercise Summary: In this exercise you reviewed some basic functionality for symbols, saw how you could search for symbols, which saves a lot of time, learned a little about customizing and saving symbols. In the next chapter we will work on labeling.

Lab Exercise 5: Follow these directions, and then upload your exported layout (PDF) to Canvas.

1. Create symbology for the **Roads_WFP** layer based on the **RDLNTYPETX** field. Pick symbols that are typically used for roads (such as Major and Minor roads in the Gallery). As you did with **Rainfall**, change **RDLNTYPETX** to **Type of Road** in the Primary Symbology pane. Don't forget to click off "**Show all other values.**"
2. Turn on and select an appropriate symbol for **Major_Towns**. *(You may want to search for "Building.")*
3. Turn on just the following layers: **ProblemElephantsFC, Nairobi, Major_Towns, Roads_WFP, ProtectedAreas, Narok_Kajiado,** and **Rainfall**.
4. Zoom to **1:1,500,000** and then insert a new layout. Name it **Lab5**. It should be in Landscape mode, 8.5 X 11 in size.
5. Add an appropriate title, your name, a scale bar, a legend, and a north arrow.

Exercise 6: Creating Labels and Annotation

In this exercise, we will "label" only the protected areas, but with Labels and Annotation, so you can see how each of these works. In this exercise we will label features and then also look at some different label fitting strategies.

Part One: Labeling Features

1. First, we will create labels for the Protected Areas, using a stacked label showing the name and the designation type.

   → Open **KenyaPro.aprx** and go to the **NK Elephant Habitat** map.

   → Turn off visibility of the **Rainfall** layer, then right-click on the **ProtectedAreas** layer and open the **Attribute Table.** Notice the **AREANAME** field. This field contains the values that will be used to label the protected areas. Close the attribute table.

ProtectedAreas

Field: Add Calculate | Selection: Select By Attributes Zoom To Switch Clear Delete Copy

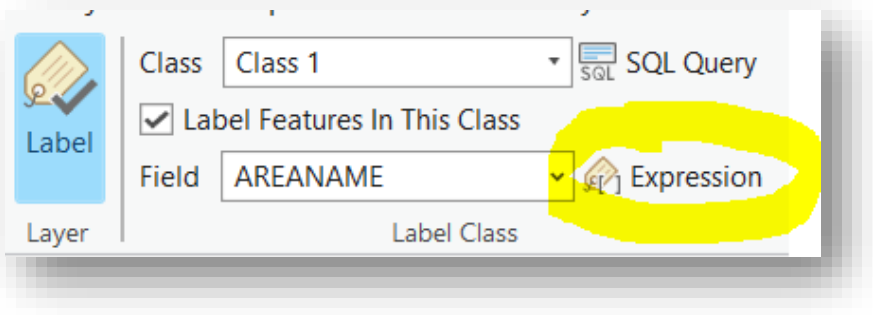
	OBJECTID *	Shape *	AREANAME	YEAR_	IUCNCAT	LON	LAT	DESIGNATE	IUCNUM	Shape_Length	Shape_Area
1	1	Polygon	Eastern Mau	1941	VIII	35.9	-0.4833	Forest Reserve	8	181227.079105	659370260.51949
2	2	Polygon	South-western Mau	1932	VIII	35.65	-0.4833	Forest Reserve	8	169172.908059	830816946.48334
3	3	Polygon	Ol-pusimoru	1957	VIII	35.7167	-0.6667	Forest Reserve	8	92590.617482	356886629.17113
4	4	Polygon	Transmara	1941	VIII	35.5167	-0.6833	Forest Reserve	8	81087.855788	376122386.90157
5	5	Polygon	Hell's Gate	1984	II	36.0833	-1.4167	National Park	2	45493.873059	119161197.04351

   → Right-click on the **ProtectedAreas** layer and click on **Zoom to Layer**. Labeling works better when your view scale is set to the scale where you usually view the labels.

   → From the **Contents** pane, the **ProtectedArea** layer should be activated. Then from the contextual **Labeling** tab, click on **Label** under the **Layer** group (a subgroup of the labeling tab) to label features.

   → The **ProtectedAreas** will be labeled with the first string field that has the word "name" in its field name. In your map this will be the **AREANAME** field.

However the name does not tell us much about the designation so we will join two fields together using Arcade.



   → Click the **Expression** button to the right of AREANAME dropdown.

      → The **Label Class** pane will open and at the top you will notice that the default programming language has been set to **Arcade**. We will keep this as Arcade allows you to use these across the other ArcGIS applications.

→ In the Expression dialog, $feature.AREANAME should already be in the expression area. If not, clear anything in the expression area and then double-click on the AREANAME field to move it into the expression area.

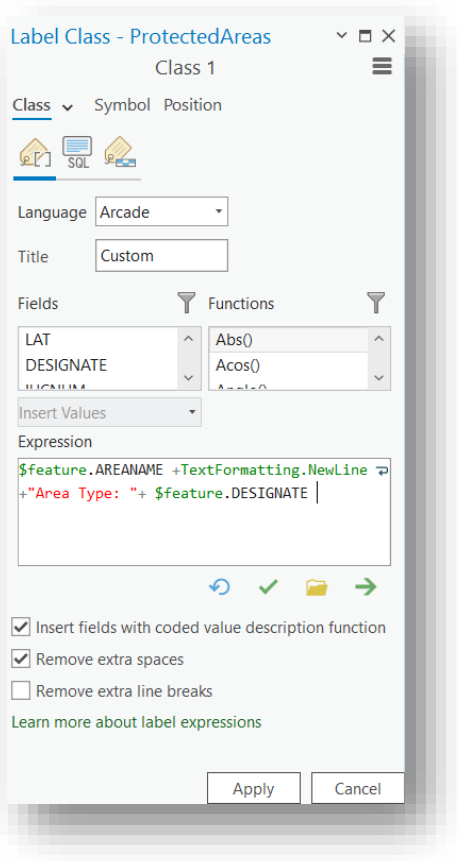
→ In the dialog box, after `$feature.AREANAME`, type + " "+ to add a space and then double click on **DESIGNATE** under **Fields**.

→ Below the Expression box, click on the green check mark to verify the expression. If expression is valid, click **Apply**.

→ It would be good to move the designation to a new line and to add some introductory text. Therefore delete the two double quotation marks and type **`TextFormatting.NewLine`** in their place.

→ After the second +, type **`"Area Type: "`** and add another +.

→ Notice the space before the last double-quote mark. Your expression should look like this.




```
$feature.AREANAME+TextFormatting.NewLine +"Area Type: "+
$feature.DESIGNATE
```

→ Click on the **Verify** button to check that the expression works. Click on **Apply**.

Note 1: If you receive an error, check that you did not paste any text in (best to type it) and that the quotation marks are vertically aligned.

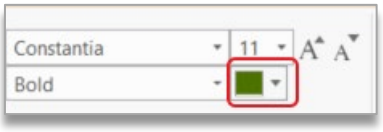
Note 2: ArcGIS Pro uses the Maplex labeling engine with the default setting to stack labels. So do not be surprised when labels are placed on three lines instead of the two we created.

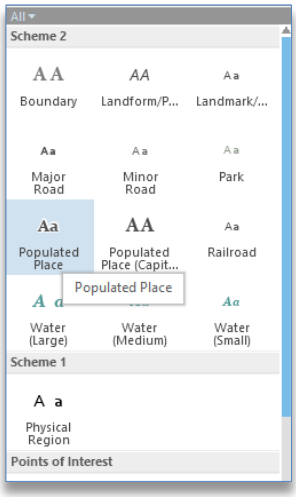
→ Next we will change the color of the symbols.

→ In the **Text Symbol** group, click the **Text Symbol Style** drop-down menu. Under **Scheme 2**, click the **Populated Place** style.

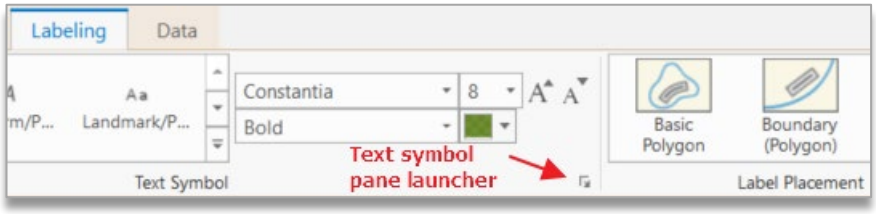
→ Next we will then change the color of the symbology text. Under the **Text Symbol** group, click on the **Text Symbol Color** picker, and select the **Spruce Green** color. Change the size to **8** and the label should already be in **bold**.

→ Let us change the transparency of the symbol halo. We will do so in the **Label Class** pane.

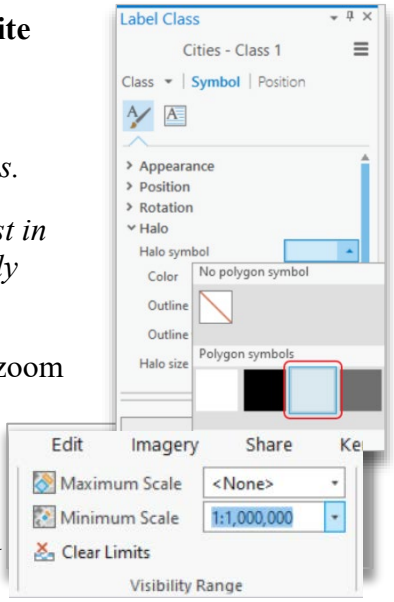




→ If the **Label Class** pane is not already open, click on the small **Text Symbol** pane launcher button in the lower right-hand side corner of the **Text Symbol** group to open it.



→ Ensure that the **Symbol** primary tab and **General** secondary graphic tab functionality is activated. Then expand the **Halo symbol** drop down and under **Halo**, select **White fill 50% transparency**, and click **Apply**.



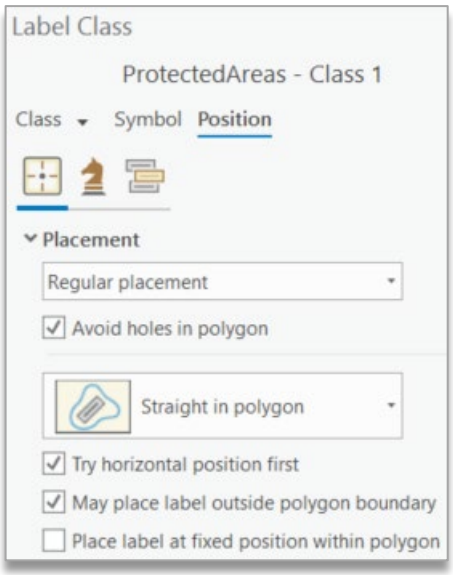
Note 1: In ArcGIS Pro, the various sub-menus in a pane are also frequently referred to as tabs. Not to be confused with the ribbon tabs.

Note 2: Setting the transparency to symbols and their halos can assist in balancing their appearance, making them visible yet not too strikingly apparent.

→ Labels may be more helpful at some scales than others. As you zoom in, labels for regional features become less important and labels for local features become more important.

→ On the **Labeling** tab, in the **Visibility Range** group, click the input box next **Minimum Scale** select 1 000 000 (1 million) and then hit enter.

→ Try zooming in and out a couple times to see how the labels change in size and placement. *Remember, labels are dynamic in that they change size and location as you move around the map*.



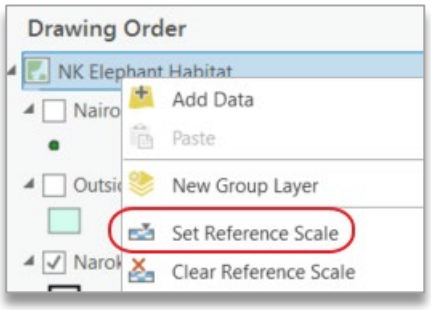
→ Next we will change the position of the labels so that they try and stay within the protected area polygons. Under the **Label Class** pane, click on the **Position** tab and then the **Position** graphic subtab.

  → Under the **Placement** dropdown, select **Straight in polygon option** (*instead of the default **Horizontal in polygon***) and then click on **Try horizontal first** option. Keep all other defaults.

  → The labels will adjust accordingly.

  → **Save** your changes.

2. We will want to convert our dynamic labels to annotation so that we can move some of them.



   → Change the map scale to **1:1 000 000** from the scale dropdown at the bottom of the map.

   → Then right-click on the **NK Elephant Habitat** Map and select **Set Reference Scale.**

   → Try zooming in to a scale of 1:500 000 using the scale dropdown. You will notice that all the symbology is now bigger, which is another effect of setting the reference scale and can cause problems.

Part two: Annotation

1. We will make three quick changes to our labels before we create annotation. We probably do not need to have the phrase "Area Type" in the label since this is obvious and it makes the labels somewhat cumbersome.

   → Right-click on the **ProtectedAreas** layer and select **Labeling Properties…**. This opens the **Label Class** pane. Click in the **Expression** dialog box and delete the `"Area Type: "+`. Click **Verify** to make sure it works then click **Apply**.

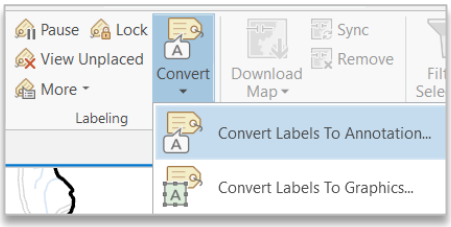
   → We also need to clear the Labeling *Visibility Range* before creating annotation. From the **Labeling** tab, under the *Visibility Range* group, click on *Clear Limits* to remove any visibility restrictions.

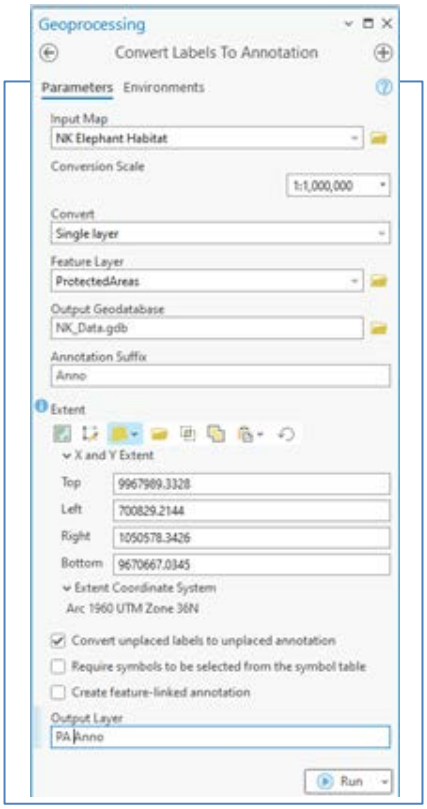
   → Lastly, right-click to open Map properties and then *Clear Reference Scale*

   → The labels for the protected areas probably look pretty good, but we may want to make some adjustments in placement. Click the **Select** tool from the **Map** tab on the ribbon and try to select a label. Nothing happens – at least to the labels – so we will have to convert these to annotation. **Clear** any selections.

*Note: In **ArcGIS Pro** you can create annotation for all the active labels on the map or all labels for only one layer.*

   → From the **Map** tab, under the **Labeling** group, click on the drop-down below **Convert** and select **Convert Labels To Annotation** button to open up the **Convert Labels To Annotation** geoprocessing tool.





→ The *Input Map* is NK Elephant Habitat

→ The *Conversion Scale* should be set to 1:1 000 000.

→ Under *Convert* select Single layer.

→ Under *Feature Layer* select ProtectedAreas.

→ For *Output Geodatabase,* click on the browse button and then select the default NK_Data.gdb.

→ Change the *Extent* to that of ProtectedAreas.

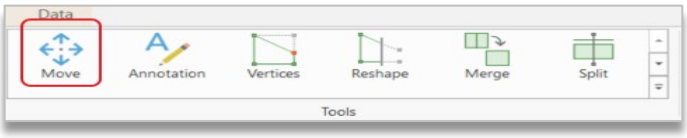
→ Click on *Convert unplaced labels to unplaced annotation*.

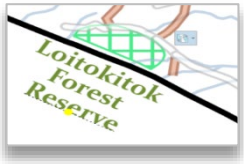
→ Change the *Output Layer* to **PA Anno**

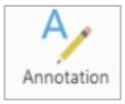
→ Keep the rest of the defaults and click on **Run**.

→ Zoom into the southeast. The annotation for **Loitokitok Forest Reserve** is bigger than the reserve itself. Click on the **Edit** tab, then select the **Move** tool from the **Tools gallery**.

→ **The Modify Features** pane opens and the select feature tool is automatically activated. Select that annotation and then move the text element by clicking and dragging on the yellow dot that appears near the base of the name. Also rotate the label to be parallel with the country boundary. Double-click or push F2 to end.





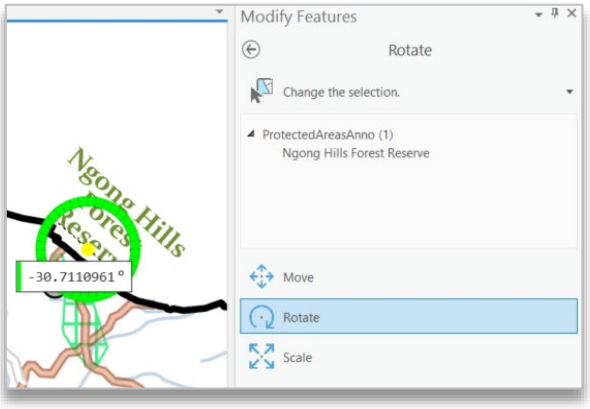


→ Next we will try and put the annotation text on 2 lines instead of 3. With the annotation still selected, click on **Annotation** tool under the **Tools gallery**.

*Note: for some reason Pro seems to select the Vertices tool some of the time so just make sure that the **Annotation** tool is activated under the **Tools gallery**.*

→ Click in at the end of the word **Forest** and then hit the spacebar and then delete to add a space and then the word **Reserve** at the end of **Forest**.

→ In the north –central part of Narok Kajiado, there is another small reserve where the name obscures the boundary. This is the **NgongHills Forest Reserve.**



→ Repeat the above process to move the annotation off the reserve. But this time you also need to use the rotate tool once you have moved the annotation. The **Rotate** tool is also an option on the **Modify Features** pane.

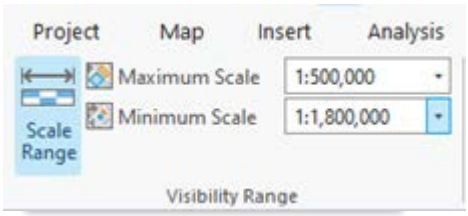
→ Click on **F2** when you finish rotating annotation.

→ Put the annotation on two lines by bringing the word Reserve just after Forest as in previous step for **Loitokitok Forest Reserve**.

→ When finished editing, click the **Save** button under the **Manage Edits** group.

2. Next we will set properties for the annotation. For example, it would be good to set a display scale for the annotation so that it only appears when we zoom into a scale of between 1: 500,000 and 1: 1,800,000.

→ From the **Contents** pane, click on **ProtectedAreasAnno** to activate it, and then from the **AnnotationLayer** tab, under *Visibility Range*, change the values to:



→ Maximum Scale: 500 000

→ Minimum Scale: 1 800 000

(*Note: if the values do not exist under the available options then just type in the value you want*).

→ Zoom in and out to test how this works.

3. Since we now have annotation and not labels, we can clear the reference scale so this will not be causing problems with symbology

→ Right-click on the **NK Elephant Habitat** map and select **Clear Reference Scale**.

→ Save **ArcGIS Pro**. *(It is very important to save at this point!)*

Part three: Fitting strategies

1. Now we will try some fitting strategies. *With this map we could probably label the Protected Areas well enough as is, but this will give you a little practice with Fitting strategies. In order to make some labeling problems that we can "fix" with Fitting Strategies, we will make the labels larger and uglier. Depending on your screen size and resolution, you might get different results than in the exercise.*

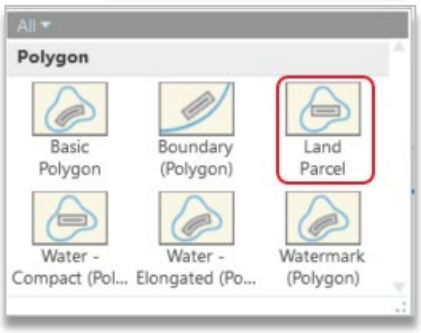
   → **Zoom To Layer** for **ProtectedAreas** layer.

   → Ensure than **PA Anno** is unchecked.

   → Right-click on **ProtectedAreas** layer in **Contents** pane and select **Label** to turn on labeling.

   → From the ribbon's **Labeling** tab and text symbol group, change the font size to **10.**

   → To reset any label changes, from the **Label Placement** style gallery, select **Land Parcel**. There should be only one or two polygons now labeled.

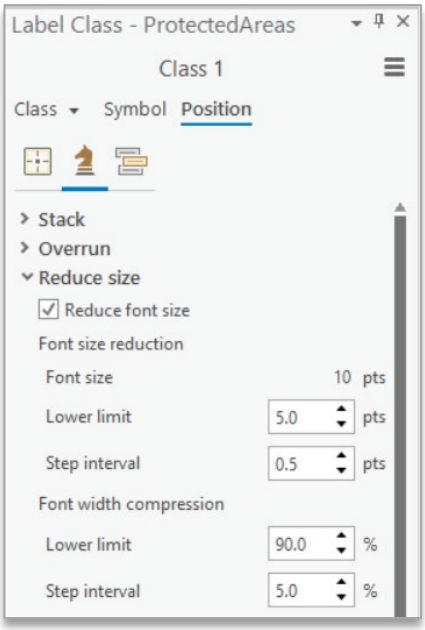


   → Right-click on the **ProtectedAreas** layer in **Contents** pane and select **Labeling Properties** to open us the **Label Class** pane.

2. Let us try a label fitting strategy that reduces font size as required.

   → From the **Label Class** pane, click on the **Position** primary tab, then click on the **Fitting strategy** graphic subtab 

   → Expand the **Reduce size** group and click on the option to **Reduce font size**.



      → Change the lower limit of the font size to 5.0 pts if this option is not automatically selected.

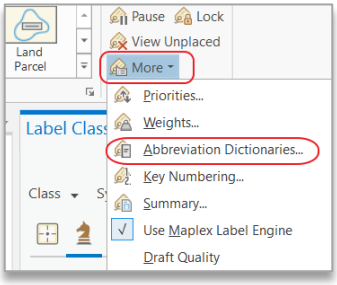
      → The Step interval should be set to 0.5 pts. *Note: this is the amount by which the font size may be progressively reduced to place a label.*

      → Also set the **Font width compression** to 90% (lower limit) and 5.0 (step interval).

      → Zoom in and out of map to assess effect of reducing font size.

      → We will try a different Fitting strategy next so uncheck **Reduce font size**.

3. Next we will try abbreviating some of the longer well-known names.



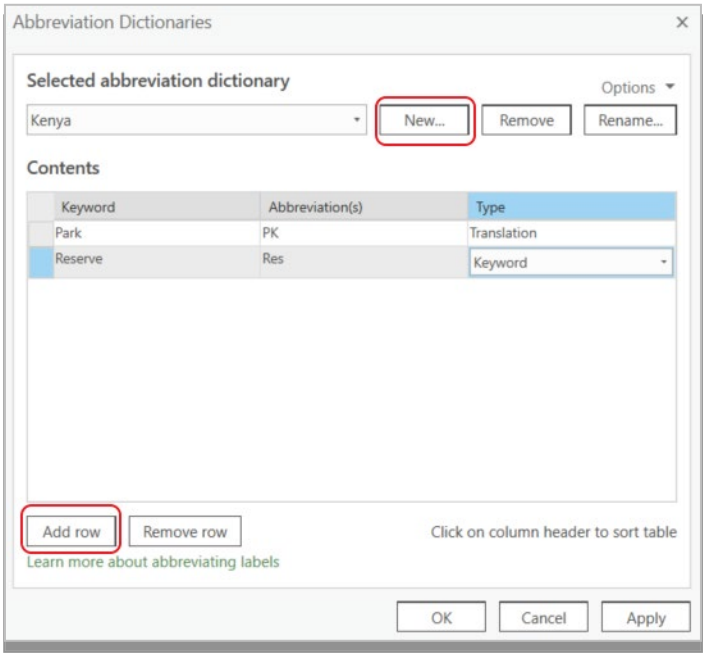
→ On the ribbon's **Labeling** tab, in the **Map** group, click **More > Abbreviation Dictionaries**. This opens the **Abbreviation Dictionaries** dialog box.

→ Click **New** and call the new abbreviated dictionary **Kenya** and click **OK.** We have now made a blank dictionary.

→ Then click on **Add row** at the bottom of the dialog box.

→ Under *Keyword* type **Park** and abbreviation as **PK**. Keep the *Type* to **Translation**.

→ Then click on **Add row** again and add **Reserve** as *Keyword* and **Res** as *Abbreviation*. Under *Type* change it to **Keyword**. *Note: By choosing **Translation** for the first row, we are telling ArcGIS Pro to always use PK whenever a label contains Park. By using **Keyword** in the second row, we are telling ArcGIS Pro to use that abbreviation if needed to fit the label.*



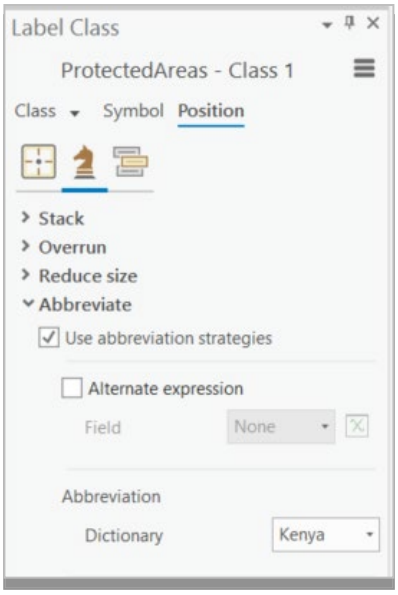
→ If you want to save this dictionary in as a separate file, you can click on **Options**, but for now just click **OK.**

→ Then from the **Label Class** pane, open the Fitting strategy sub-tab, open *Abbreviate* and then click on **Use abbreviation strategies**.

→ Under the **Abbreviation Dictionary**, select the **Kenya** as the Abbreviation strategy. The labeling on the map should automatically update.

→ How do your labels work now? *Do try zooming in and out and panning around the map. I found that the Keyword type (Res) was not always triggered when I expected it to.*

→ You can keep **Use abbreviation strategies** checked for the last step.



Part four: Working a bit more with Arcade expressions

Arcade is an expression language that can be used across the ArcGIS Platform. It is not equivalent to python but it is a new Esri format that not only labels features but can also apply geometry functions as well. It can be used to create new labels based on geometry functions without requiring a specific field in the attribute table.

1. Next we will change the font color of a protected area based on its size.

→ Right click on **ProtectedAreas** and select **Zoom To Layer** for **ProtectedAreas** layer.

→ Turn **ProtectedAreas** labels on if they are not already turned on.

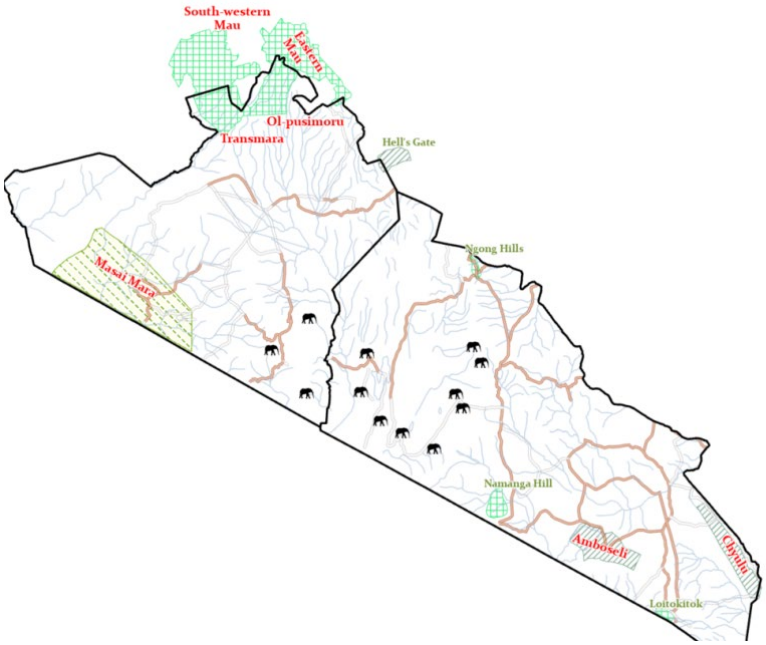
→ From the **Labelling** pane, and the **Label Placement** group, click on **Basic Polygon** to change some of the labelling properties.

→ From the **Label** pane and the **Label Class** group, click on the **Expression** button to open the **Label Class** pane with the **Label expression** sub-tab active.

→ Under the **Expression** dialog box, write (or copy across):

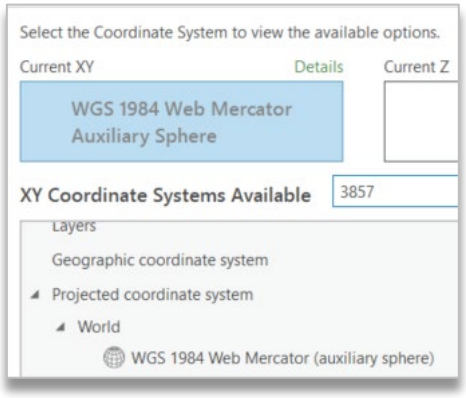
```
if ($feature.Shape_Area >= 250000000)
{
return "<CLR red ='255'><FNT size = '12'>" + $feature.AREANAME +
"</FNT></CLR>"
}
else {
     return $feature.AREANAME

   }
```



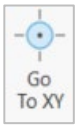
→ We just used some Arcade code to only label the larger protected areas in red, otherwise the default label style was applied.

2. Hypothetically, the problem elephants escaped from Masai Mara National Reserve and we would like to show the distance they have travelled from the reserve. We could run the **Near** geoprocessing tool and copy the values back into our **ProblemElephantsFC**, but we can also do this using the geometry function of ArcGIS Arcade.

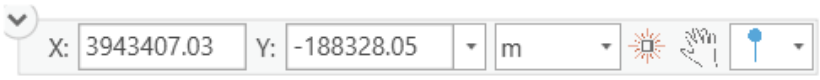


→ Geometry functions currently only work in **WGS 1984 Web Mercator Auxiliary Sphere** projection so open up the **Map** (**NK Elephant Habitat**) properties and change the projection to the above. You can also search for 3857 in the projection search window. Be sure to click **Apply/OK**.

→ The Mara River flows into Masai Mara in the east and this is a good place for our hypothetical elephants to have broken out. The coordinate for this point, in Web Mercator, is X = 3943407.03, Y = -188328.05.



→ From the **Map** tab, click on **Go To XY** to open up the search bar at the bottom of the map.



→ First change the input value to meters (**m**) as we are working in a projected coordinate system, and then add the coordinates and push **Enter**. The map will zoom to the location of our reserve exit point.

→ To the right of the **Go To XY** dialog box, click on **Mark Location** drop-down and select the plain pushpin. The location of the place where the elephants have broken out are added to the map.

→ Click on **ProblemElephantsFC** and then from the **Labeling** tab, click on the **Label** button to add labels.

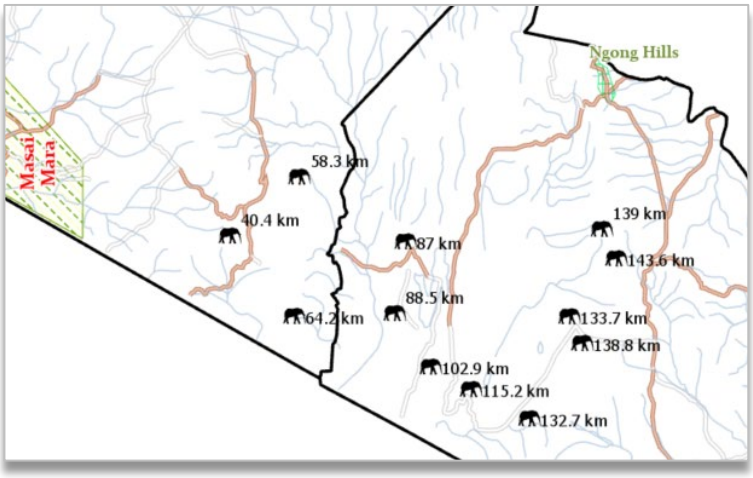
→ Then from the **Expressions** button from the **Labeling** tab on the ribbon to open up the **Expression** dialog window.

→ In this dialog box, type (or copy) the following text:

```
var from = Point({"x": 3943407.03, "y": -188328.05,
"spatialReference":{"wkid":3857}});
var from = Point(from);
var to = Geometry($feature);
var dist = Distance(to, from, 'kilometers');
return round(dist,1)+" km";
```

→ Click **Apply**.

Note 1: What this expression does is create a point called ***from*** *for the coordinates where the elephants escaped, and sets the spatial reference. It then creates a point for all the features in this feature class called* ***to****. It then calculates the distance between the* ***from*** *point to all the* ***to*** *points in kilometers and rounds them off to one decimal place. This dataset does not exist in a table but is calculated on the fly as needed.*



Lab Exercise 6: Follow these directions, and then upload your exported layout (PDF) to Canvas.

1. Zoom to the extent of **1:1,500,000.**
2. Be sure the following layers are turned on: **ProblemElephantsFC, Nairobi, Roads_WFP, ProtectedAreas** (with labels so the distances are showing), and **Narok_Kajiado.** Be sure that all protected areas and problem elephants are showing, along with their labels.
3. Create a Layout (Landscape, 8.5 X 11) and name it **Lab6.**
4. Add an appropriate title, your name, a scale bar, a legend, and a north arrow.

→ Once you are done with your Lab6 layout, go back to the Map (**NK Elephant Habitat**) open the Map properties and change the map projection back to Arc_1960 UTM_Zone_36N. You will find this projection under Favorites group. *(It is VERY important that you complete this step!)*

→ Turn off **ProblemElephantsFC** labels and **Save** the map.

Exercise Summary: In this chapter you learned how to create complex labels and then how to work with Standard Annotation. You also explored the effect of various labeling fitting strategies and how to add advanced Arcade expressions to labeling. In the next chapter we will learn a few selection techniques and also how to bring data in correctly with project on the fly and then how to correctly save that data to the correct projection.

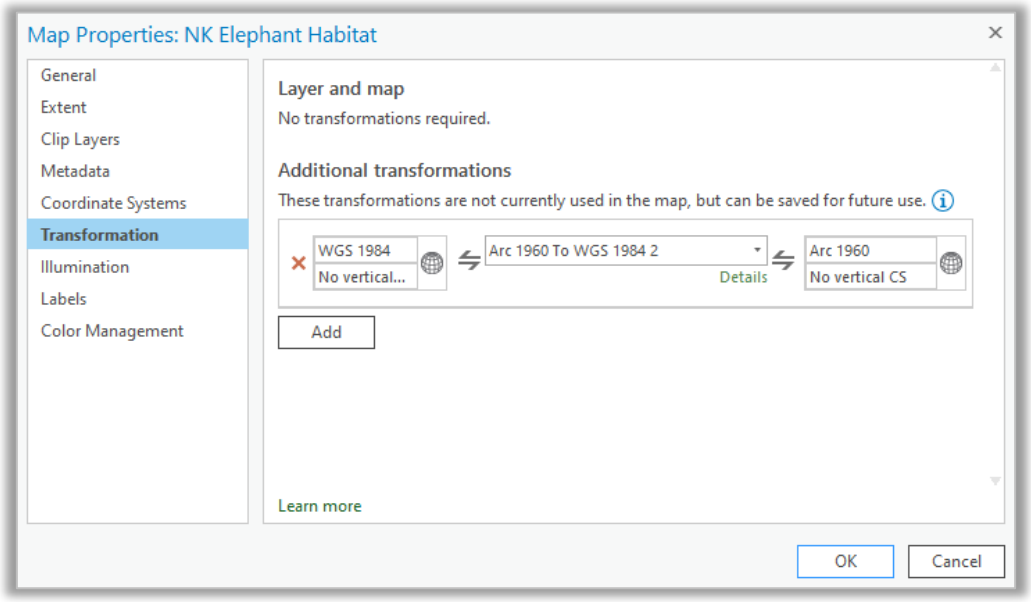
Exercise 7: Selecting Features for Analysis

For this course, we have already selected and clipped most of the data to meet the needs of our project. But we need to bring in two more pieces of data – **Land Use** from UNEP and **water points** from ILRI. Both are in different projections and we can use the transformation settings to correctly project the data on the fly. Then we will select for features within our study area and export them to the **NK_Data** Geodatabase.

1. Open the **KenyaPro.aprx** project if it is not open. The first step will be to bring in the Water Points data from ILRI. This is in Geographic Coordinates in the WGS84 Datum while we are using the GCS_ARC_1960 datum. ArcGIS Pro will select the correct transformation during the add data process so that the data lines up correctly when it is "projected on the fly".

   → For starters, let us first open the **Map properties** and check the map transformation. The transformation should be set to Arc 1960 To WGS 1984_2 as we had provided this setting under **Environments** in an earlier Exercise and then later added a WGS1984 point layer that we projected into Arc 1960 UTM Zone 36N.

   → If the transformation has not been set, please do so.

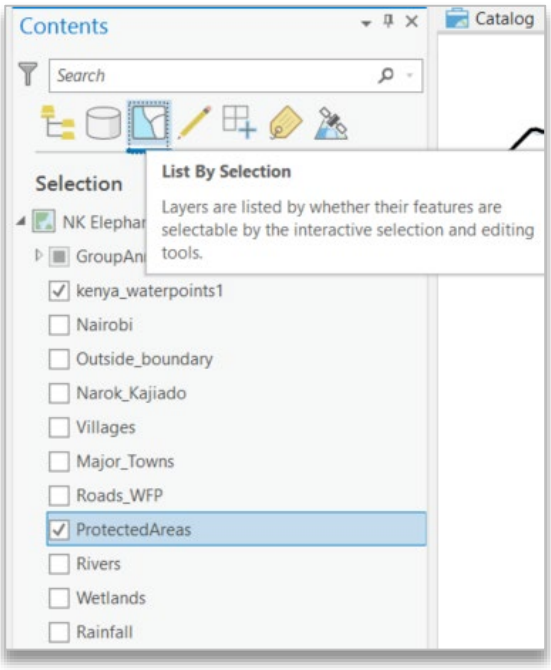


Note: if the transformation is different to the above, then check whether you may have a basemap added to your map. The larger extent of the basemap results in a different transformation being selected. Also, it doesn't matter which side a datum is listed on (e.g., it can be Arc1960 on the left and WGS 1984 on the right instead of what is in the image above).

→ Click **OK** to close the **Map** properties dialog box.

→ Click the **Add Data** button, navigate to **Folders\Kenya\ILRI_Data**, and select the **kenya_waterpoints1** shapefile.

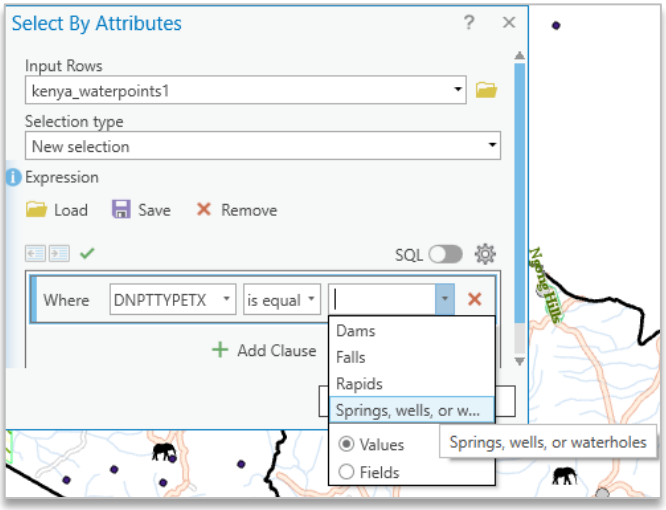
2. While doing selections, it is useful to be able to check the number of features selected, so you can verify your progress.



→ Activate the **List By Selection** tab in the **Contents** pane. For now it will just list the layers, but when any features are selected, it will also show the number of features selected. *Don't worry if the graphic does not look the same as yours in terms of selectable layers.*

3. Next, we will make some selections on the Water Points data. If you look at the table, you will see that there are different types of water points, but we are only interested in springs, wells and waterholes. (*It would be nice to be able to just select waterholes, but in the real world, data are not always categorized as you would like.*)

→ Activate **kenya_waterpoints1** under **Contents' Selection** pane and then click on the **Select By Attributes** tool from the ribbon's **Map** tab to open geoprocessing tool.

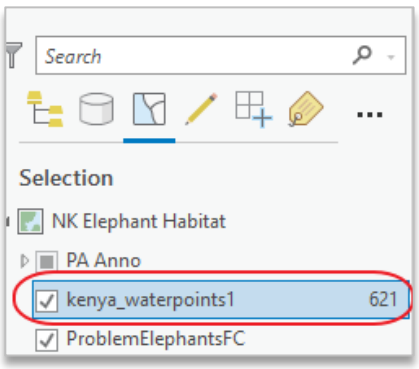


→ Make sure that the selection type is set to **New selection**.

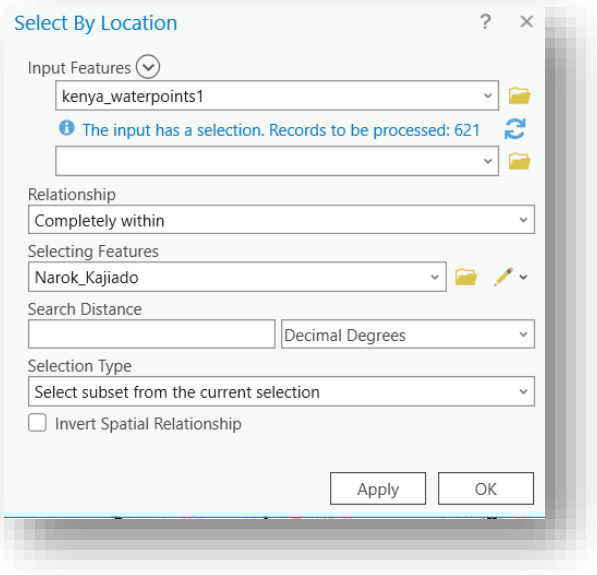
→ **Where DNPTTYPETX is equal to Springs, wells, or waterholes**.

→ Click on **OK** to apply query and close pane.

→ You should have **621** selected.



→ Then click on **Select By Location**.



→ Choose **Kenya_waterpoints1** as the *Input Features*.

→ Choose the **Completely within** *Relationship* type.

→ Choose **Narok_Kajiado** as the *Selecting Features*.

→ Make sure the Selection type is **Select subset from the current selection**. We want to select only from those that are springs, etc.

→ Click on **OK**.

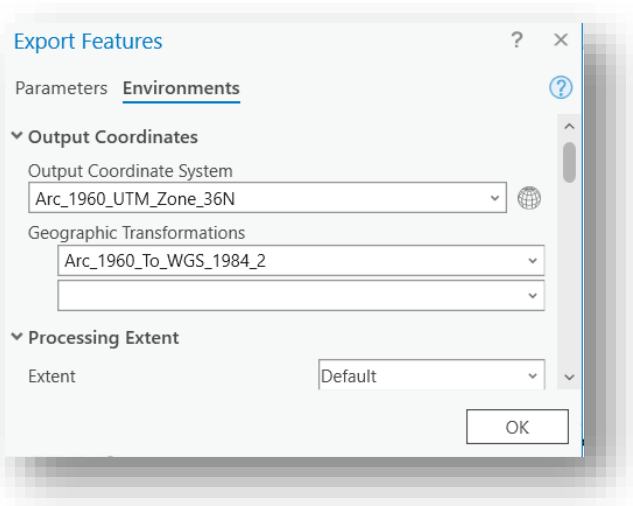
→ You should have **41** features.

4. Now we can export the selected water point data to our geodatabase.

→ From the **Contents** pane, right-click on **kenya_waterpoints1** and select **Data>Export Features**.

→ Save the output feature class as **WaterPoints** in the **NK_Data.gdb**.

→ Before clicking on **Run**, first click on the **Environments** tab of the **Export Features** geoprocessing tool to check the output coordinate system and transformation.



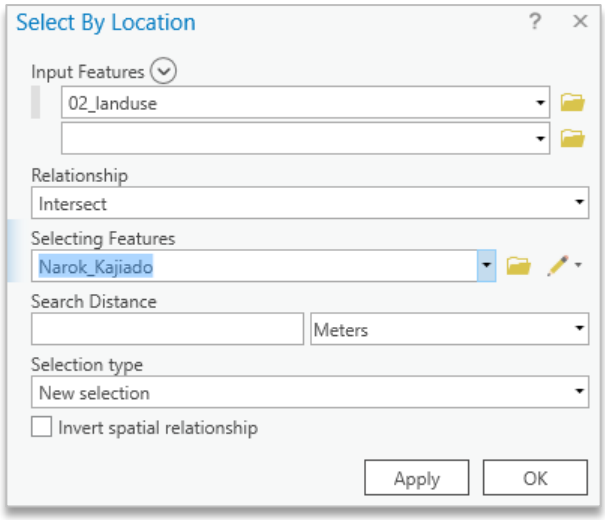
→ Because we set our **Environment** setting in an earlier exercise, the output coordinate system should be set to **Arc_1960_UTM_Zone_36N** and the *Geographic Transformation* to **Arc_1960_To_WGS_1984_2.** If as above, click on **OK** to create feature class.

→ Click on **List By Drawing Order** and then **Remove** the **kenya_waterpoints1** layer.

5. The last data we need is Land Use, which we will take from the UNEP data. UNEP has a custom projection based on Transverse Mercator with units in meters, but the datum is the same as the ILRI data, so you can use the same transformation we used earlier.

   → Use **Add Data** and select the **02_Landuse** shapefile from the **…ArcGISPro_EnvAnalysis\Kenya\UNEP_Data** folder.

   → Click on **Select By Location** to open tool.

   → *Input Features* is **02_landuse**.

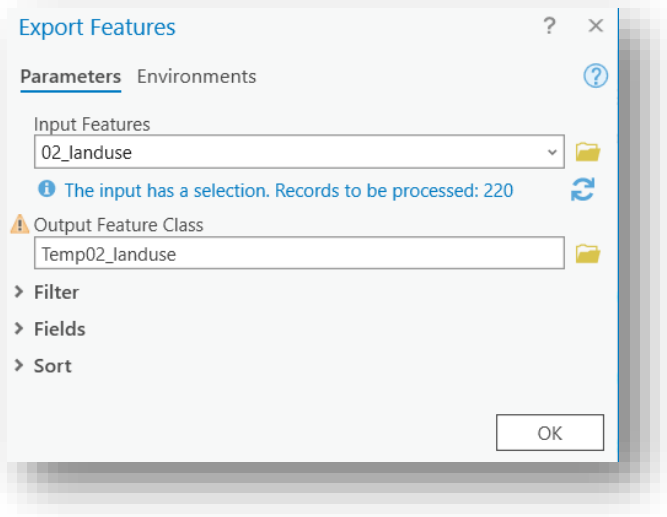
   → *Relationship* is **Intersect.**

   → Choose **Narok_Kajiado** as *Selecting Features.*

   → *Selection type* is **New selection**

   → Then click **OK**. You should have **220** features selected, which will include a lot of area outside our study area – we will fix that in the next step.

   → Right click on the **02_Landuse** layer and use **Data>Export Features** to export the selected features from the **02_Landuse** layer into the default geodatabase.

   → As this is a temporary feature class, call it something like **Temp02_landuse.**

   → Check **Environments** tab to ensure that the Arc_1960_UTM_Zone_36N projection is listed.

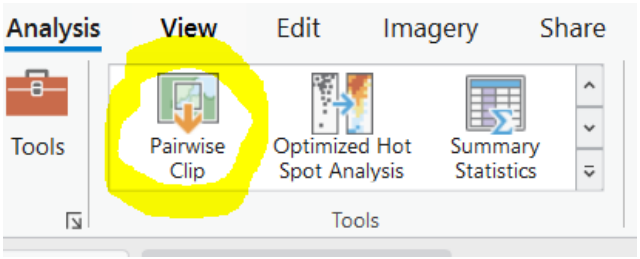
   → Click **OK** and then **Remove** the **02_Landuse** layer after the export operation is completed.

   → **Save** the project.

6. We now need to clip the Land Use features to match our boundary. *We could have done this originally instead of using **Select By Location**. But by making this a two-step process, then both inputs to the clip tool were in the same coordinate system, which is good practice and training. If we had used the clip tool directly, then one of the inputs would have been in geographic coordinates and the other in a projected coordinate system, which is then asking ArcGIS Pro to perform two sets of calculations – first to align the features, and then to calculate the clip. You probably would get the same results with either method, but doing it the way shown in the exercise is a better practice with less chance to introduce error.*

   → Switch back to **List by Drawing** order above the **Contents** pane.

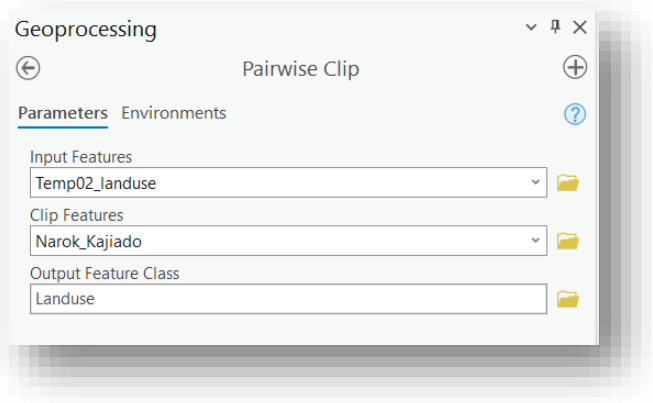
   → From the **Analysis** tab on the ribbon, click on the **Pairwise Clip** tool from the **Tools** gallery. *Note, the "Pairwise" tools are designed to work better on very large and complex datasets. It is now the default Clip tool. You may have to scroll down in the Tools list to see it.*



   → Drag **Temp02_landuse** into the *Input Features* box. *(your name may be different for the input feature).*

   → Use **Narok_Kajiado** as the clip feature.

   → Save this as **Landuse** in the **NK_Data** geodatabase



   → Click **Run**.

   → When the new **Landuse** layer is added to the map, **remove** the **Temp02_landuse** layer.

7. The map is pretty cluttered for now so we will organize it a bit.

   → Re-arrange the layers so that the order from top to bottom is**: PA Anno, Narok_Kajiado**, **ProblemElephantsFC**, **WaterPoints**, **Major_Towns**, **Villages, Nairobi, Rivers**, **Roads_WFP**, **Forest**, **Lakes**, **Protected Areas**, **Wetlands**, **Landuse**, **Rainfall**, and **Outside Boundary.**

   → Remove **Outside_boundary** layer.

   → Turn off all the layers except **Narok_Kajiado**, **Problem Elephants**, **Rivers**, **Roads_WFP**, and **Landuse**.

   → **Save** the project.

Lab Exercise 7: Follow these directions, and then upload your exported layout (PDF) to Canvas.

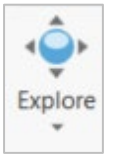
1. Symbolize the **Landuse** layer using Unique Values on **Land_use** category. Choose the color scheme **Verdant Tones**. Be sure to **click off** "Show all other values."
2. Label the Problem Elephants by their **Prob_Type**.
3. Change the color of **Waterbody** (in the **Landuse** legend) to **Cretan Blue.**
4. Zoom to the extent of **Narok_Kajiado**.
5. Create a Layout (Landscape, 8.5 X 11) and name it **Lab7**.
6. Add an appropriate title, your name, a scale bar, a legend, and a north arrow.

8. If you have time and want to try hyperlinks, do exercise **7a**. If not, **close ArcGIS Pro** for now. In the next chapters we will work with **Layer files** and **tables**.

Exercise summary: In this chapter you learned how to make selections by combining select by attributes and select by location. You also learned how to use "Project on the Fly" correctly by setting Transformations and then exporting the projected files into your geodatabase. This is actually a good method for doing projections, because it allows you to check the data you will project against existing data.

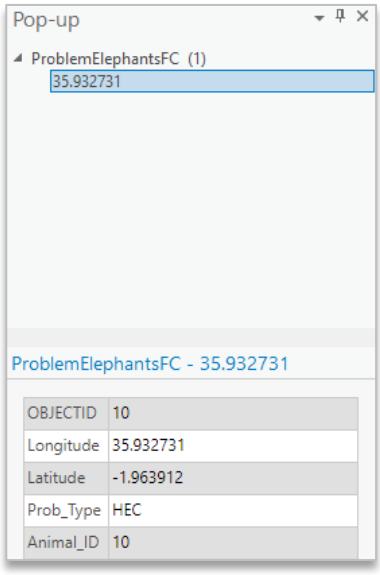
Exercise 7a: Hyperlinks (Optional)

1. Next, just for fun, we will add a hyperlink to one of the Problem Elephants so we can show a picture of the elephants causing problems. *(Actually, it is just a photo John Schaeffer took at Masai Mara!)*



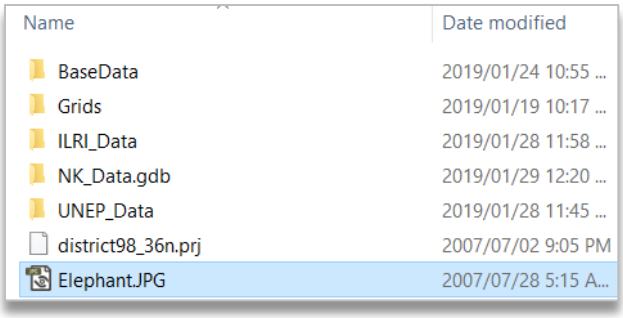
→ To zoom in and see the problem elephants, right-click on this layer and select **Zoom To Layer**.

→ Click off the problem elephant labels.



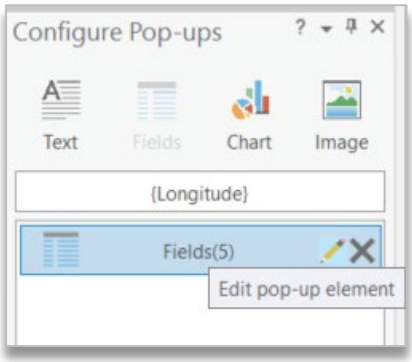
→ Click on the **ProblemElephantsFC** on the **Contents** pane and then select the **Explore** tool, and then click on any elephant. You might need to select the **Selected in Contents** option from the **Explore** tool's drop-down list, and then click on the elephant again.

→ In the Pop-up will show a limited set of information. We would like to pop-up to show a picture for all the elephants.



→ Use **Windows Explorer** to find the picture called **Elephant_small.jpg** in the **Kenya** folder. Hold down the **shift** key then right-click on that file and select **Copy as path**.

→ Then, from the **Contents** pane, right-click on the **ProblemElephantsFC** and select **Configure Pop-ups**.



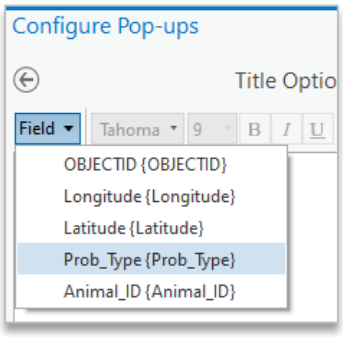
→ This opens up the **Configure Pop-ups** pane.

→ Hover your mouse pointer over the **Fields(5)** heading of the **Configure Pop-**ups pane, then click on the Yellow pencil icon on the right

→ Uncheck the *Only use visible fields and Arcade expressions.*

→ Then uncheck the tick-boxes for **OBJECTID, Longitude** and **Latitude**.

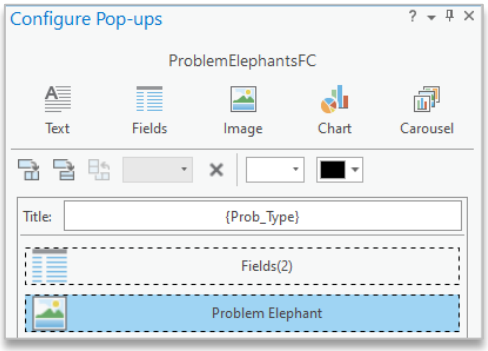
→ Click on the back button.



→ Then click in **Title** filed at the top of the pane, delete the {Longitude} text, then from the **Field** drop-down menu on the left, select **Prob_Type** as the new title for the pop-up. *(If it already has {Prob_Type} then leave it as is!)*

→ Click on the back button then click on the **Image** button at the top to add an image to the pop-up.

→ Then click on the **Edit pop-up element** tool to the right of the image.



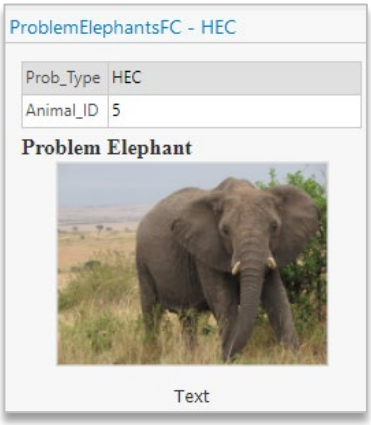
→ Under **Title** write **Problem Elephant**.

→ Under **Source URL**, right-click in the box and paste the folder path to the elephant image.

NB: Remove the quotation symbols from the image path " " otherwise the pop-up will not work.

→ Click on the back button.

→ From the map, click on any of the problem elephants and a pop-up with picture should show.



*Note that you could also quite easily provide an image for each elephant but then you would need to add a field to the attribute table with the path to each image. Then from the **Field** drop-down, you copy the field into the source URL space.*

2. **Save** and then close **ArcGIS Pro** for now. In the next chapter we will create "Layer Files" to use for our analysis.

Exercise 8: Creating Layer Files and Saving a Project Template

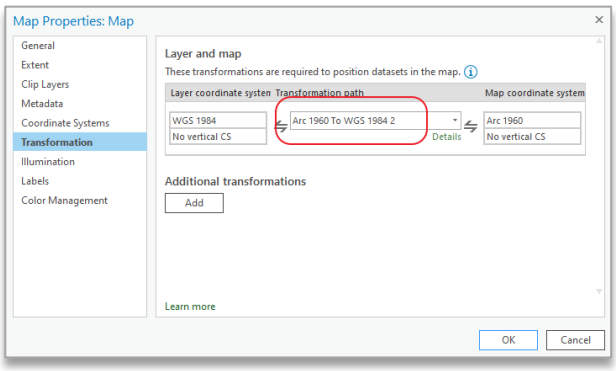
The process for creating several "layer files" from one data layer can seem confusing, because as you change properties and then the layer names, it looks like you are undoing your work. Just remember the basic steps: set the properties you want; save that as a layer file with an appropriate name in a logical location; and then make another set of changes to the layer's properties to reflect what you want the next layer file to represent, and save that set of properties.

In this exercise we will create "layer files" for some of the data we will need in the analysis. For example, we have a land use layer that has 12 categories, but we will want to group these into categories like preferred habitat, excluded lands, and water. By creating "layer files" instead of separate data files, we can keep the underlying land use data intact for any future editing needs, but make it easier to do our analysis.

1. Open **KenyaPro.aprx** project (if not already open) and then we will insert a new map so that we have an **empty map**. Since we are only going to use this as a temporary workspace, we will not set any properties for this map. We could create the layer files in the map we have been using, but this way we will not have any clutter from the other layers and can concentrate on the land use data.

   → Click on the **Insert** tab from the ribbon and then click on **New Map** under the **Project** group. A new map will added with the World Topographic basemap. We will keep the basemap this time.

   → From the **Map** tab, click on **Add Data** button, navigate to **Databases** folder and then double-click on **NK_Data.gdb** and select the **Landuse** feature class.



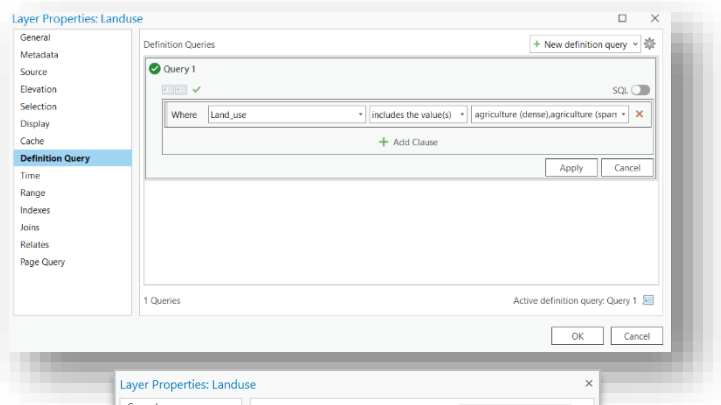
Note: If you activated project options to provide Transformation Warnings, you should see one appear now. Regardless of whether it shows or not, a default transformation was applied based on the zoom extent of the basemap, which may not be the most accurate. The correct transformation to use is Arc 1960 To WGS 1984_2. Please open map Properties and change the transformation to Arc 1960 To WGS 1984_2.

2. First we will set the **Display field** for the **Landuse** layer. This is useful for setting the default pop-title, for editing, etc.

   → Open Properties for the **Landuse** layer, under the **Display** tab, select the **Land_use** field under **Display Field**. *(It may already be selected.)*

3. We will now set up a few definition queries before changing symbology and exporting these queries as layer files. This workflow is quite different from what was available in ArcMap.

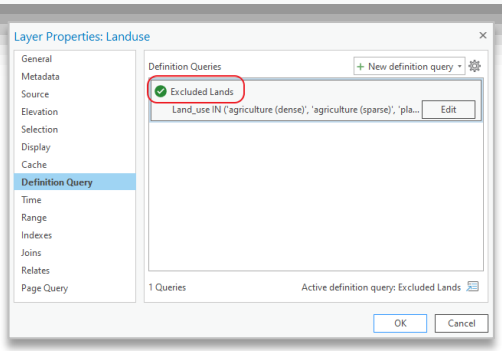
→ Click on the **Definition Query** tab, and then click on **New definition query**.



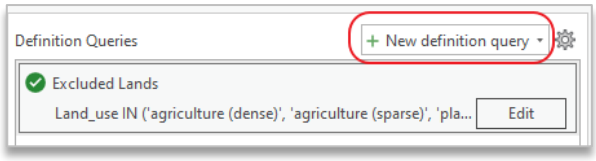
→ Create the query Where **`Land_use, includes the value(s) agriculture (dense), agriculture (sparse) and plantation`** by click on the relevant checkboxes (*These are lands we do not want the elephants near.)*

→ Click **Apply**.

→ Click on **Query 1** and change the text to **Excluded Lands**.

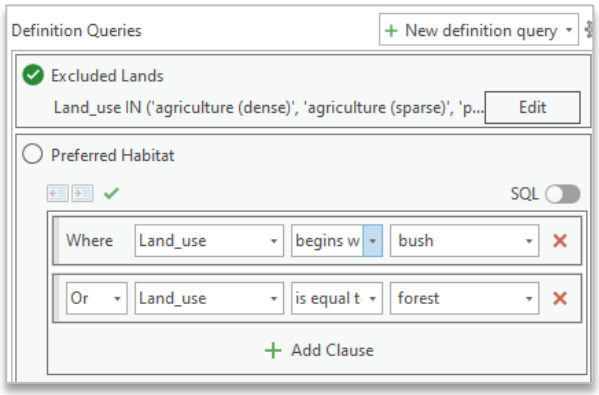


→ With the definition queries dialog box still open, click on **New definition query** at the top right (see graphic) to create a new definition query, independent of the last one you created.



→ We will use different clauses to show some of the functionality. Create query: **`Land_use, 'begins with,' 'bush'.`** *Do not include any of the '', they are to show you what to write only*. Click **Apply**.

→ We want to include an additional query option to this so click on the **Edit** button and choose to **Add Clause** and then write: **`Or, Land_use, is equal to, forest.`**

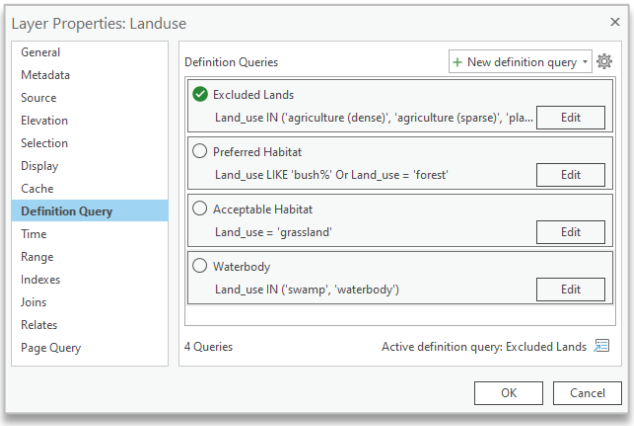


→ Click on **Apply**.

→ Again click on **Query 1** and change it to **Preferred Habitat** as these land uses represent the preferred habitat.

→ Next we need to create a query for the **Acceptable Habitat**. So again, click on the **New definition query** above.

→ For the query, write **`Land_use, is equal to, grassland`**. Click on **Apply**. *You may need to expand the dialogue window to see the Apply button.*



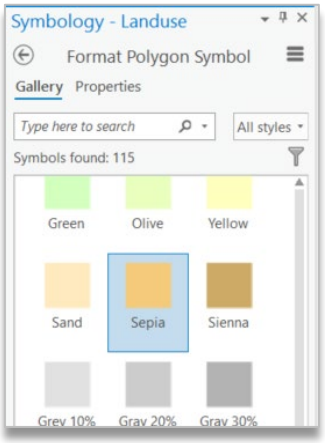
→ Click on **Query 1** and change name to **Acceptable Habitat**.

→ Lastly, complete the above process for the last query where **`Land_use, includes the values, "swamp" and "waterbody".`** Click **Apply**. Change name to **Water Body**. Click **OK**.

4. Now we will take a look at the various queries we created, change the symbology, then save each of these as layer files.

   → After clicking **OK** the map will update and show the results first query, **Excluded Lands**. We will check how many records were included in this query.

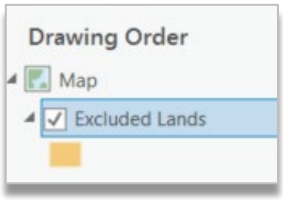
   → Under the **Contents** pane, right-click on the **Landuse** layer and click on **Attribute Table**. There should be **49** records in this query. Close the attribute table.



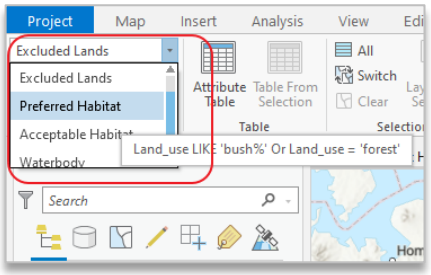
   → Open **Symbology** by clicking the symbol for **Landuse** and select the **Sepia** symbol from the **Gallery**. *You can also search for it.*

   → Click once on the **Landuse** layer name and then click again to get into text editing mode. Then change the layer name to **Excluded Lands**.

   → Right-click on the **Excluded Lands** layer, select **Sharing > Save as Layer File** and save this in the **Folders\Kenya** folder as **Excluded Lands.lyrx** (should be the default**).** *This will save all the properties you set for reuse in this or other maps*.



5. Now we will apply the various queries we created for the Landuse layer and save each of these as new layer files.



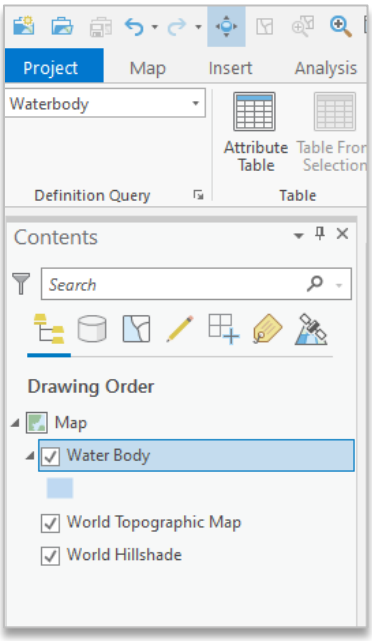
   → Click on the **Data** tab. On the far left of the ribbon, under the **Definition Query** group, Excluded Lands will be selected as the active query. This was based on the query we set, not the layer file we just created.

   → Click on the drop-down next to **Excluded Lands** and select **Preferred Habitat**. Notice how the map updates with the new query.

   → Under the **Contents** pane, change the name now from **Excluded Lands** to **Preferred Habitat**. There should be also be **60** records in this dataset (Hint, *you will need to open attribute table to check*).

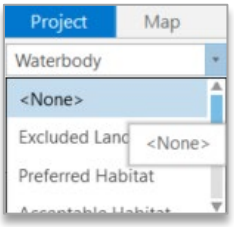
   → Change the symbol for the layer to **Park (scheme 1);** change the Layer transparency to 50% transparent (*click on **Feature Layer** tab and change transparency with slider);* and save this as a layer file named **Preferred Habitat** in the **Kenya** folder.

   → From **Data** tab, select the **Acceptable Habitat** query. There should be 22 records. Change symbol to **Land (scheme 1)**. Change to 0% transparency. Rename **Preferred Habitat** to **Acceptable Habitat** and then save as layer file **Acceptable Habitat**.



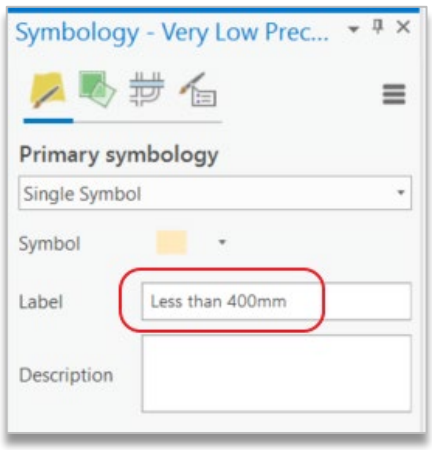
→ Repeat the procedure to create a **Water Body** layer file (**37** records) and the symbol is **Water (area)**. Save as a layer file called **Water Body**.

→ Then from the **Data** tab and **Definition Query** group, select **<none>** to remove the active definition query and all features will redraw. Remove the **Water Body** layer for now (*we will add it shortly but with the query in place*).



You now have created four different layer files based on 9 of the 12 different landuse types in the original landuse layer that group the categories as we might use them in the analysis. Of the three remaining landuse types, we will ignore town because this is very small and we already have a major towns layer; we have decided to leave out woodland because the area is small and that classification might be similar to an agricultural use; and we will not use barren land because that is not good habitat. For your own analysis, you will need to make similar decisions with your data if you use this method to re-categorize a data layer. But by doing this, it will be very easy to make classification changes and not have to create new data layers on disk.

4. Next we will work with the **Rainfall** data and create a "very dry" layer file. While we are ignoring the differences between wet and dry season, we might want to consider areas of very low rain as places not acceptable for an elephant conservation area. One source mentioned that while elephants can survive in fairly dry areas, we should mask out areas with less than 300mm of rain a year. Since our rainfall data has a break at 400mm, we will use that.



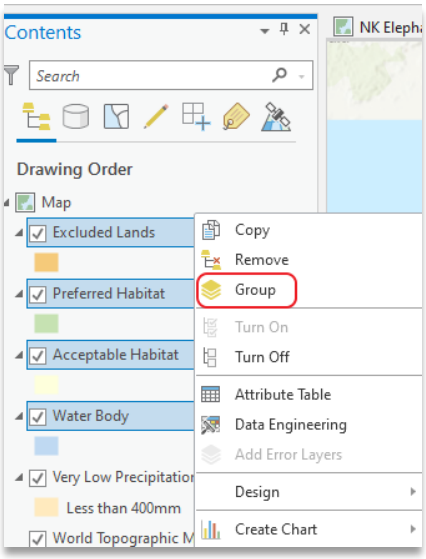
→ Click on **Add Data** and navigate to the **NK_Data.gdb** and add the **Rainfall** feature class to the map. Open the **Definition Query** and add a **New definition query** Where **`TYPE, is equal to,'200-400'`**.

→ Click **Apply** then **OK** and change name in **Contents** pane to **Very Low Precipitation** and change the symbology to **Sand** (Background).

→ Next, in the **Symbology** pane, at the top of the pane, click on the back button at the top to take you to the **Primary symbology** view. In the blank **Label** box, type **Less than 400mm**. When we add this layer to the map, this should display next to the symbol.

→ Save as layer file as **Very Low Precipitation** in Kenya folder.

5. Next we will add the rest of the new layer files to our map and create a group layer.



→ Add the **4** layer files you just created; they will be in the **Kenya** folder. (you will need to add **Acceptable Habitat, Excluded Lands**, **Preferred Habitat**, and **Water Body**)

→ Rearrange the order alphabetically *(the order is shown differently in the image to the right)* and then select the four layers derived from the Landuse layer by clicking on one of the layers, holding down the **Ctrl** key and then clicking the other 3 layers. Then right-click on one of the layers and select **Group**.

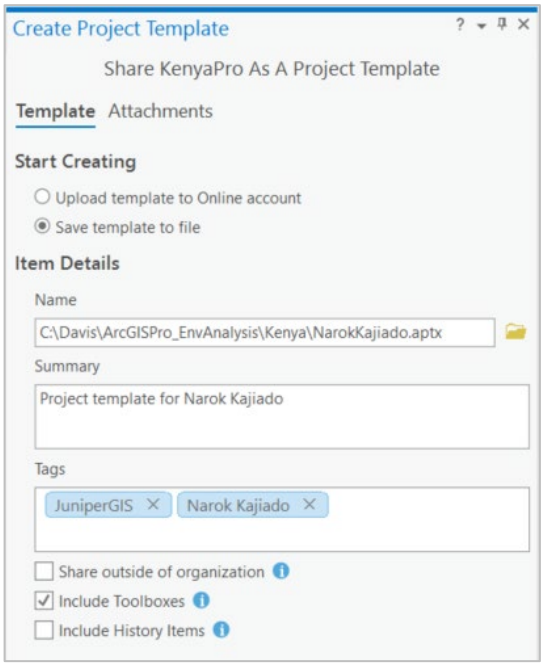
→ Then change the name of the group to **Landuse by Class**. Save this as a layer file in the **Kenya** folder.

→ **Close** the new **Map** view we created and open up the **NK Elephant Habitat** map.

6. Now that we have a good project set up, we should save it as a template for use in other maps we might want to create in this same area.

→ Right-click on **Narok_Kajiado** and **Zoom to Layer**.

→ From the **Share** tab and **Save As** group, click on **Project Template** to open up the **Create Project Template**.



→ Select option to **Save template to file**

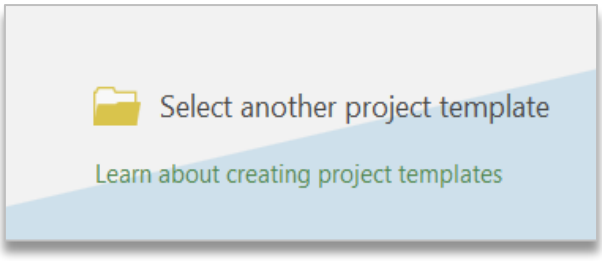
→ Browse to your …**ArcGISPro_EnvAnalysis\Kenya** folder and call the Project Template file **NarokKajiadoTem.aptx.**

→ Add **Project template for Narok Kajiado** to the *Summary* and **JuniperGIS** and **Narok Kajiado** as tags.

→ Uncheck **Include History Items**

→ Click on **Analyze** and then on **Create** if there are no problems identified. *(Ignore a warning about Annotation Layer.) Note that you will be prompted to save project. Click on* ***OK****.*

→ The next time you open ArcGIS Pro you will have the option to **Select another project template**. Browse to the default folder where template was placed and thereafter the template should always show under **Recent Templates**.



7. **Save** the **KenyaPro** project.

Exercise Summary: In this exercise you learned how to set up several definition queries and how to use layer files to divide data from one layer into different classes. This is a very efficient way to manage your more complex data sets. In the chapter on analysis, you will see how we can use these layer files to make our analysis more efficient. In the next chapter we will work with tables.

Lab Exercise 8: You will create a layer file for elephants that are of problem type HEC (Human Elephant Conflict). Below are some hints about the steps to follow. When you have finished, create a layout as you have in previous exercises, including all the map elements that you have added before. Upload the PDF of your layout to Canvas.

1. **Copy (**right-click on the layer and choose **Copy)** the **ProblemElephantsFC** layer in the **Contents** of the **NK Elephant Habitat** Map and **Paste** it**.** To **Paste** it you must right-click on the **NK Elephant Habitat** Map and choose **Paste.**
2. Rename the duplicate layer **HEC Elephants.**
3. Use a **Definition Query** to select just the HEC elephants. Change their color (using **Symbology**) to red, then save as a layer file (**HEC Elephants.lyrx**) in the **Kenya** folder.
4. In the **Contents** pane, change the name of **HEC Elephants** to **Human Elephant Conflict**.
5. Turn on the following layers: **Human Elephant Conflict, Narok_Kajiado, ProblemElephantsFC, Rivers, Roads_WFP,** and **ProtectedAreas. (Be sure to turn off labels for HEC Elephants and ProblemElephantsFC.)**
6. Create your layout (Landscape, 11 X 8.5).

Review Notes

Right-clicking > Context menu>Properties – many changes in ArcGIS Pro are done through properties. Layers, maps, symbols, etc. all have properties.

Context sensitive ribbon – the ribbon is a useful way to only provide you with options relevant to your dataset. But remember you have to first activate a layer or a frame to get the required ribbon options.

Panes – ArcGIS Pro uses panes for managing just about everything that ArcGIS Pro does. They are movable, dockable on different monitors, so use them to get the most out of Pro.

Checking selections – check visually on the screen to see if the selections make sense, but also use the **Selection** tab in the Contents pane or open the attribute table to see the number and type of selected features.

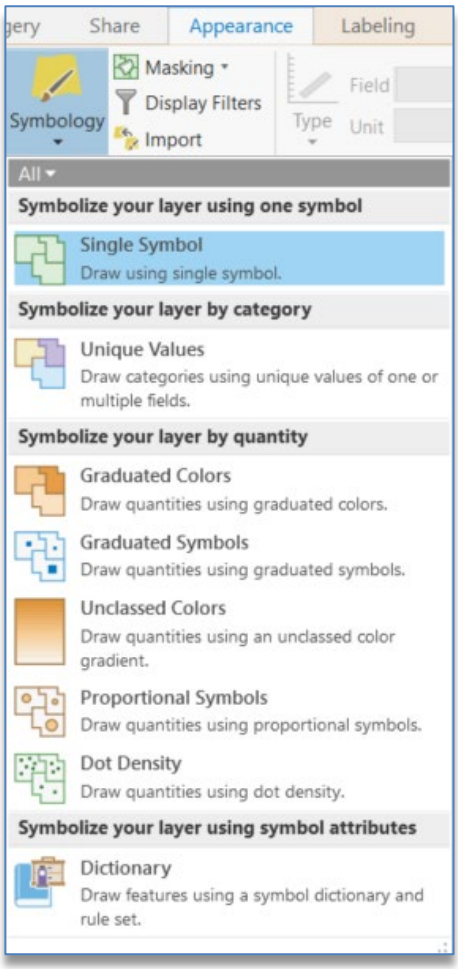
Exporting data – right-click the layer with the features you want to export, click on Data>Export Features; then specify the correct folder location and name for the output data.

Creating symbology – from the Appearance tab on the ribbon, click on Symbology

Symbolizing on numeric data – use quantities options.

Symbolizing on names or other text data – use category options.

You can also Import symbols from other layers, layer files (.lyr or .lyrx) files.



Changing symbols

Left-click on the symbol in contents pane for symbol properties

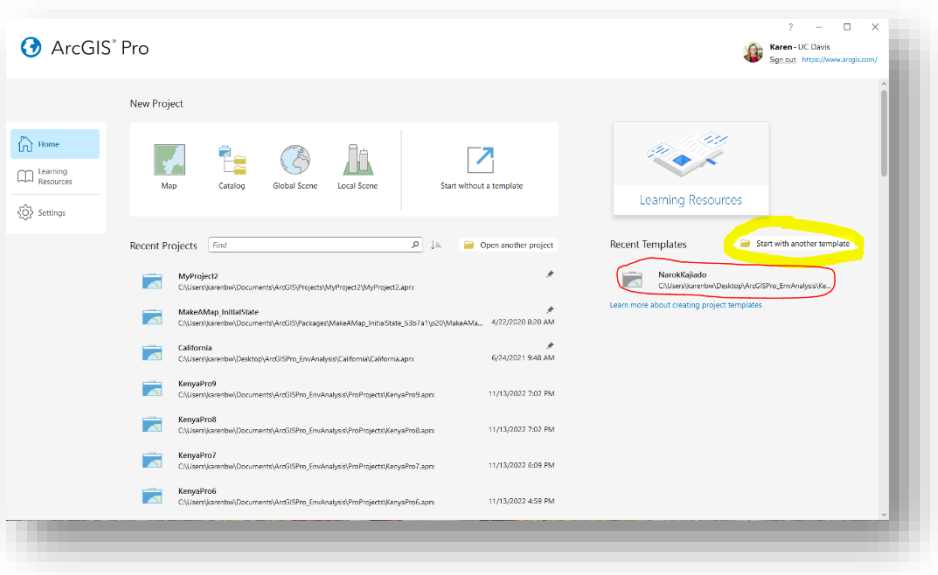
Right-click on the symbol in the contents pane to change the color.

Contents pane

Remember to use the added functionality of the various ***List By*** options. For example List By Selection, List By Editing, List by Snapping, etc.

Exercise 9: Working with Tables

In this exercise we will make some changes to the layer attribute tables to make them more user-friendly. For example, we have area in meters for our **Landuse** layer, but hectares are a more meaningful measurement when comparing land size. These types of operations are very common with GIS as data is rarely in the format we need to do the analysis we are trying to do.

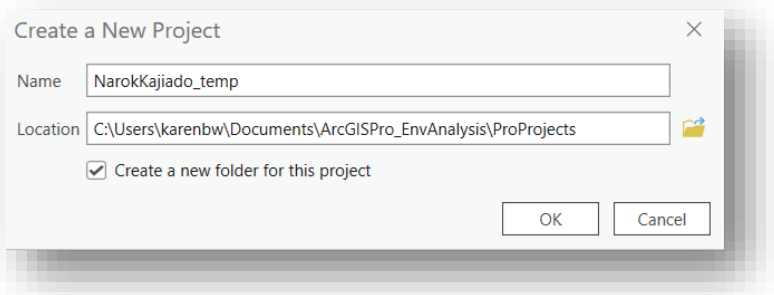


1. First we will see how to start a map from a template. This is just to demonstrate how one can use templates.

   → **Start ArcGIS Pro**, and in the opening dialog, click on **Start with another template**. (Alternatively, you could choose the correct template if it shows up under **Recent Templates**.)

   → In the next dialog, navigate to **…\ArcGISPro_EnvAnalysis\Kenya** and select **NarokKajaidoTem.aptx**. *(Next you may be asked for an unpacking location. Create a **Template** folder under your **Kenya** folder to save the data. If not, then skip this step.)*

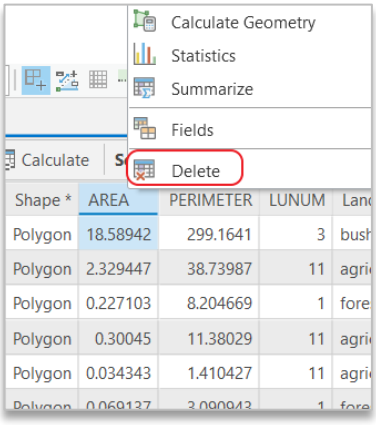
   → You will be asked for a new name. As this is for demonstration purposes, just call it **NarokKajiado_temp** and save it in …**ArcGISPro_EnvAnalysis\ProProjects.** You can keep the option to **Create a new folder for this project.**



   → Open and activate the **Catalog** pane. Notice how this project looks exactly as the **KenyaPro** project! It even references the same geodatabase although it created its own new one in the name of your new project.

   → Close the **NarokKajiado_temp** project and open the **KenyaPro** project.

2. First we will clean up the Landuse table and eliminate some extraneous fields. The original data had Area and Perimeter fields in decimal degrees, which is not useful, but when we created the Landuse layer in a geodatabase, ArcGIS added the Shape_Area and Shape_Length fields, which are in our current map units – meters.



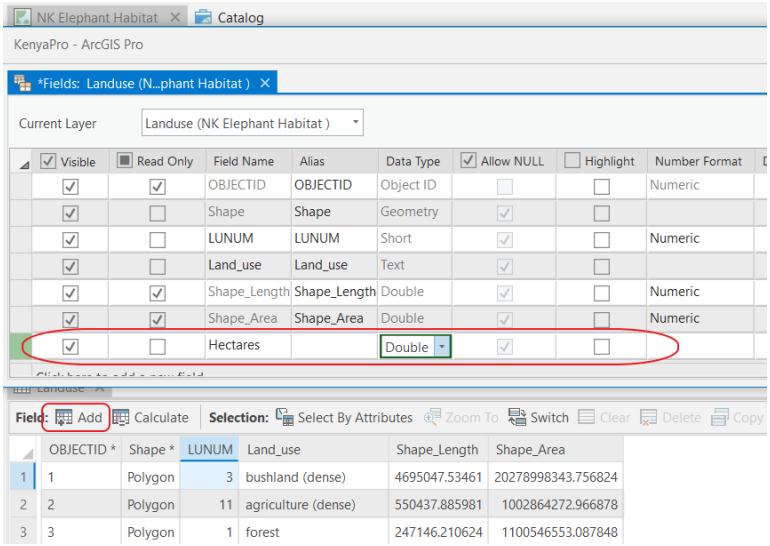
   → Turn on the **Landuse** layer. Then right-click the **Landuse** layer and select open **Attribute Table**.

   → Click on the **AREA** field, then right-click and select **Delete**. Click **yes** to ignore the warning.

   → Then also delete the **PERIMETER** field. Do not close the table window yet.

3. Next, we will add and calculate fields to show hectares for the **Landuse** layer. The table has a field for area in meters, but hectares are a more useful measurement.

   → Click the **Add (Field)** button at the top of the attribute table. This will open up the **Fields** pane.



   → Add a new field and call this field **Hectares**

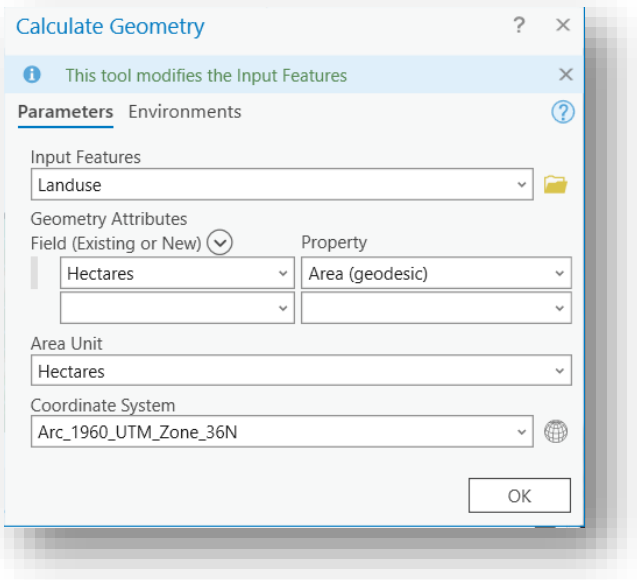
   → Make the Type: **Double**

   → Accept the rest of the defaults and click **Save** from the **Fields** tab on the ribbon.

   → Then close the **Fields: Landuse** tab to exit the **Design** view and return to table view.

→ **Right-click** the new **Hectares** field and select **Calculate Geometry**

→ The target field to update will be the **Hectares** field. Under **Property**, select **Area (geodesic)**. *Note that this calculates areas based on the ellipsoid, which means that the results of the operation do not change regardless of the input or output projections. Area results are more accurate, predictable and repeatable.*



→ Under **Area Unit**, select **Hectares**.

→ The default coordinate system should be **Arc_1960_UTM_Zone_36N.**

→ Click on **OK**. The values in the Hectares column should be updated.

*Note: In ArcGIS Pro 3.2 there may be a bug where you will get an **invalid datum transformation error**. This is a new bug. If this happens, it is because of geographic transformation set under the Environments tab. In this case just remove the transformation under the **Environments** tab of the **Calculate Geometry** window. It should work once the Transformation is removed.*

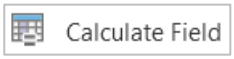
4. It would be good to see how changes in **Landuse** layer affect the layer files we created in Chapter 8.

   → Add the **Landuse by Class.lyrx**

5. Then open the tables for one of those layer files and you will notice that the **Hectares** field is there, and that the **AREA** and **PERIMETER** fields are gone.

5. Next we will calculate **Hectares** using another method.

   → Open the Attribute table for the **ProtectedAreas** layer and add a new field named **Hectares** with a **Double** data type. **Save** changes. Close **Fields** view.

   → **Right-click** the new **Hectares** field and select **Calculate Field**. 

   → As you would have selected **Hectares** before clicking **on Calculate Field**, the expression dialogue box will be active for **Hectares**.

   → Verify that the expression type is Python.

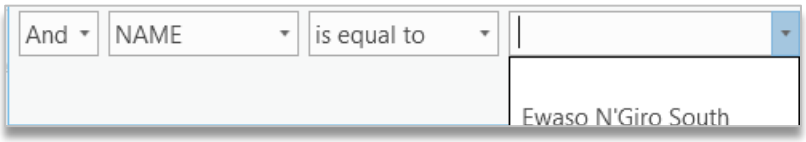
   → Click in the dialog box under **Hectares** = and type: **`!shape.area@hectares!`**

   → Click on **OK** and the attribute table should be updated with the hectares values. Close the attribute tables.

6. We also have some missing information in the Wetlands table that might cause problems if we want to label these.

→ Open the attribute table for the **Wetlands** layer.

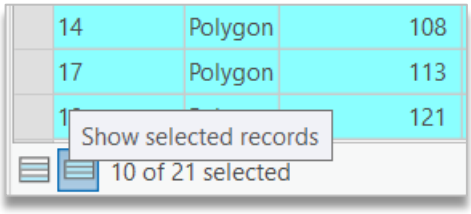
→ Click the **Select By Attributes** button from the **Table** view and create a query to find the records with no values for the **Name** field using the clause query: **NAME is equal to ' '** Click in blank row at top of table, which will automatically put in the select the blank rows. *(Do not type in any quotes!)*



→ Click **OK**.

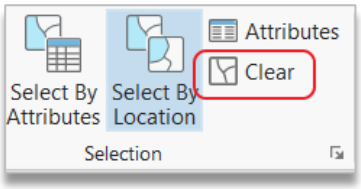
→ Then from the **Attribute** table, click on **Show selected records** tab at the bottom.

→ The attribute table should select that 10 of 21 records are selected. All of the selected records are freshwater marshes.



→ Then right-click the **Name** field, select **Calculate Field** and type **"Unnamed Marsh"** with the quotes, in the expression dialog box, and click **OK**; this will fill in the missing values.

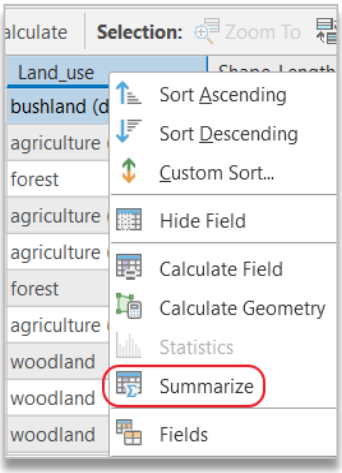
→ Now that you can see the values for the empty fields have been changed to "Unnamed Marsh", click on **Show all records** at the bottom of the table to make all records visible. Next click the **Clear** button to clear the selection set and then **close** the table. *It is always a good idea to clear your selection set when you are done with any operation that works on just part of the data – then when you do another operation, you will be sure to have all the data available.*



7. Now we will summarize the land use data to get a better idea of how many different types of land uses are in the study area and the hectares in each land use type.

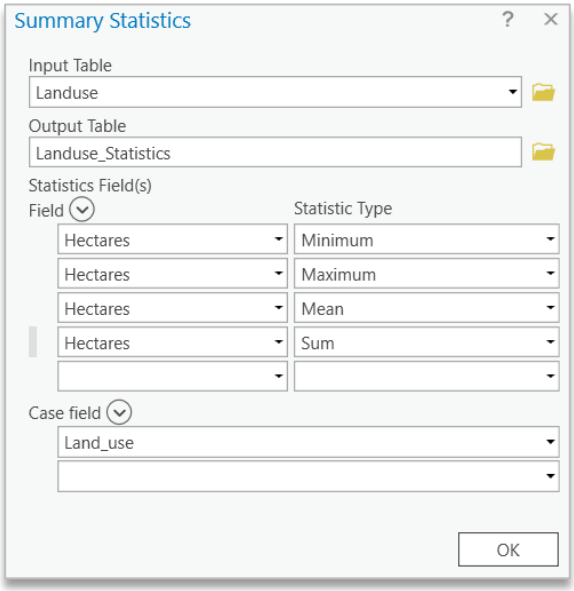
→ Open the attribute table for the **Landuse** layer. *(It may still be open, in which case no need to open it again.)*

→ Right-click again on the attribute field **Land_use** and select **Summarize.**



→ Keep the default name **Landuse_Statistics** in the **NK_Data.gdb**. *Note: relates work best if both the feature class and table are in the same geodatabase.*

→ For summary statistics, choose **Minimum**, **Maximum**, **Mean** and **Sum** for the **Hectares** field.

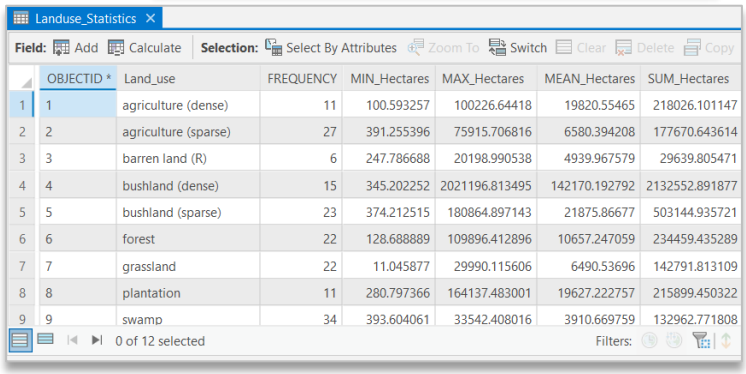


→ Verify that the field to summarize, which is called the Case field here, is **Land_use**.

→ Then click on **OK**.

→ **Close** the **Landuse** table for now.

→ At the bottom of the **Contents** pane, under **Standalone Tables**, open the new **Landuse_Statistics** table you just created (*right-click, Open*) and examine the fields and the data. Notice that there is a field named **FREQUENCY** that tells how many polygons of which type are in our study area.



→ At the bottom of the table, you will see the number of records.

Question 1: How many records are in the **Landuse_Statistics** table? _____

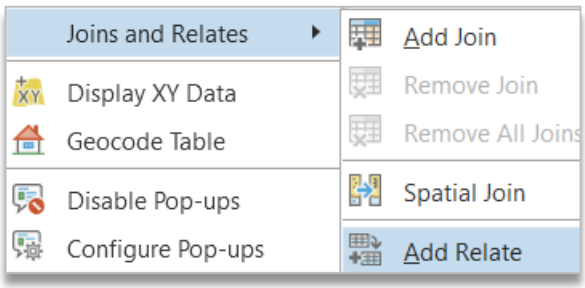
This is a good way of finding the number of classes you have in a particular table.

Question 2: What type of land use has the smallest average size? _____

Question 3: What type of land use has the largest total size? _____

→ Close the table for now.

8. Next we will try a **Relate**. Since we have list of the different land use types in our **Landuse_Statistics** table, we could make a connection to the **Landuse** layer and as we select a type of land use from the summary table, it will also be selected in the **Landuse** layer.



→ Right-click the **Landuse_Statistics** table in **Contents** and select **Joins and Relates>Add Relate**.

→ The **Add Relate** pane will automatically open.

  → Make **Land_use** the *Input Relate Field*

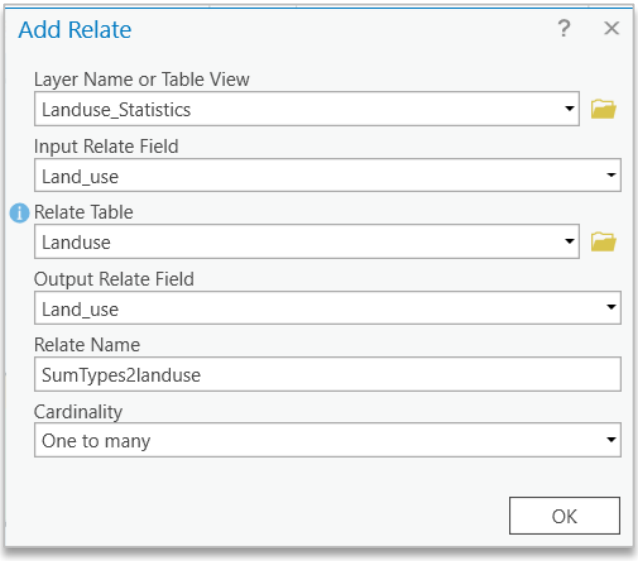
  → Make **Landuse** the Relate Table

  → Make **Land_use** the *Output Relate Field*

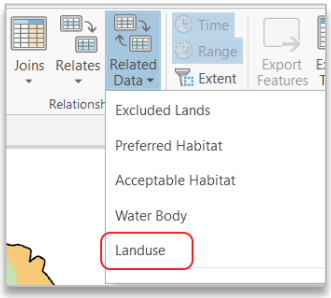
  → Name the relate **SumTypes2landuse**. *I use "2" instead of "to" in some names to make it more readable.*

  → Cardinality is *One to many*.

  → Click **OK** to finish the relate operation.

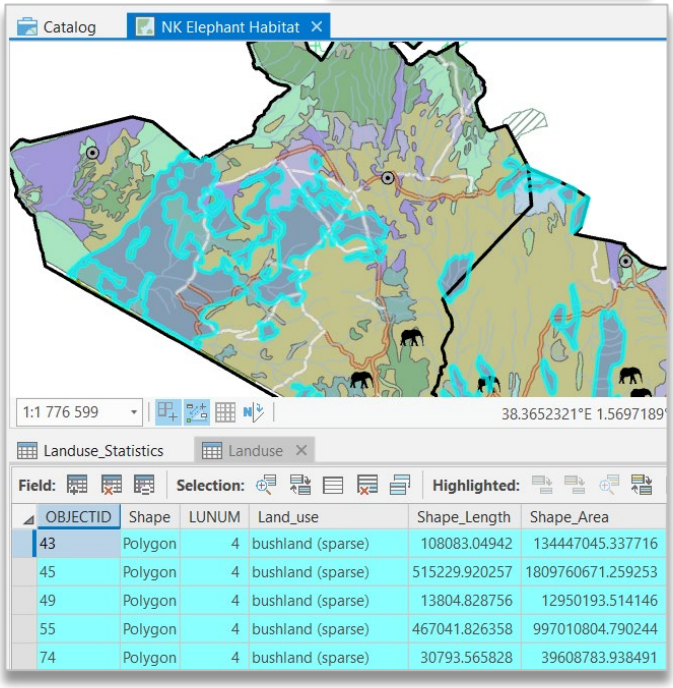


9. Now that we have created the relate, we can see how it works.



→ Open the **Landuse_Statistics** table, and select one of the records. *Hint: You must select a record first for this to work.*

→ Then from the **Standalone Table** tab on the ribbon, select the drop down by the **Related Data** button, and then select the **Landuse** relate. The attribute table for **Landuse** will open and the related records will be selected in the table and on screen.



Question 4: Try choosing both **agriculture (sparse)** and **agriculture (dense)** in the **Landuse_Statistics** table. How many polygons are selected in the **Landuse** table when you run the **Relate**? _____

→ At the top of the table window, you can choose which table you want to view. Try another selection. To make the new selection work, you need to activate the relate each time.

→ Try to activate the relate starting from the **Landuse** table. The feature you select from the **Landuse** layer will then select the related record in the **Landuse_Statistics** table.

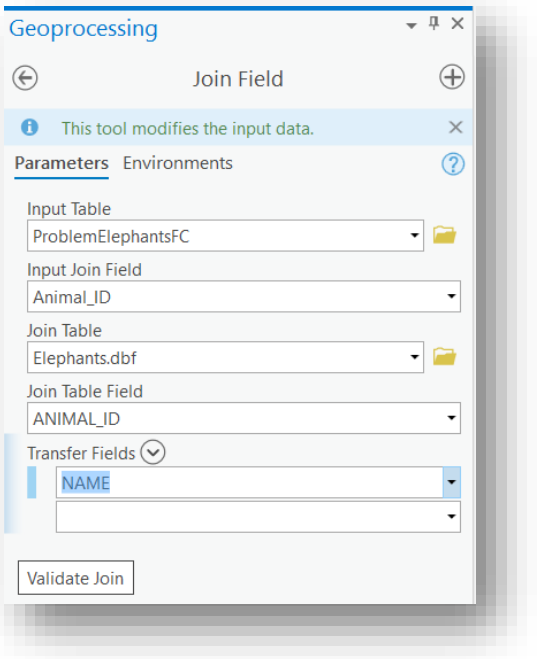
Question 5: Clear your selected sets for both tables, then select one record each of **woodland** and **forest** land_use types from the **Landuse** attribute table. Run the Relate. By right-clicking on the **Mean_Hectares** column in the Landuse_Statistics table, choose **Visualize Statistics**. What is the average (mean) of the Mean_Hectares for these two types? *(Hint: You will see the Mean for both the Dataset and the Selection in the right column. You want the value for Selection.)*

_____.

→ **Clear** the selected features and **close** all the tables.

10. One agency has been keeping track of these elephants and gave them names, stored in a dBase table named **Elephants**. We can link this table to our problem elephants so we can identify each elephant by name. We could just create a join and then have an active link, which is usually the best, but since we know the data will not change, we will add a field from the **Elephants.dbf** to the attribute table of the P**roblemElephantsFC** layer by using the **Join Field** geoprocessing tool.

→ From the **Geoprocessing** pane (from the **Analysis** tab), search for the **Join Field** geoprocessing tool.



- → Open the tool and drag the **ProblemElephantsFC** from the **Contents** pane into the *Input Table* box.
- → The *Input Join Field* is **Animal_ID**.
- → *Join Table* is **Elephants.dbf**. You will need to browse to the Kenya folder and select this table.
- → The *Output Join Field* is **Animal_ID**.
- → Keep **Transfer Method** as **Select Transfer Fields**
- → Then you need to select the fields that you would like to permanently join to the **ProblemElephantsFC** attribute table. Select **NAME**.
- → Click on **Run** and then open the **ProblemElephantsFC** attribute table and verify that the new field and values had been transferred to the **ProblemElephantsFC** layer.

*Note: an alternative and older approach would have been to first add a name text field to **ProblemElephantsFC, add** join to link up the two tables, and then use **Calculate Fields** to copy the names across from the one table to the other. The **Join Fields** tool simplifies this approach.*

11. **Clear** any selections and **Save** the **KenyaPro** project.

Exercise Summary: In this class you learned basic and a few advanced table operations, and how to access some of the table functionality direct from the table window. You learned how to generate summary data and you also learned how to create and use relates and joins. In the next chapter, we will learn how to work with Excel in ArcGIS.

Lab Exercise 9: Answer the 5 questions that were asked during this lab. Upload your answers in a Word, Text, or PDF format file to Canvas. Remember to include your name.

Exercise 10: Working with Excel and Displaying X/Y Data

In this exercise, we will explore and briefly analyze bird observation data for Kenya. The data set was downloaded and converted to Excel for use in this exercise. The only modifications made were to the headings for demonstration purposes.

The data set is publicly accessible data, licensed under Creative Commons (CC BY 4.0) and was downloaded from the Global Biodiversity Information Facility (www.gbif.org) and published by the Kenya Wildlife Service. The particular dataset is comprised of 11,444 bird observations recorded during 2017 and 2018. The particular reference to this dataset is *GBIF.org (11 February 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.ukz6l2*

1. Open Excel and browse to the **…\ArcGISPro_EnvAnalysis\Kenya\Birds** folder and open up the **GBIF_Kenya birds 11 February 2019.xlsx** file. We will need take a look at the data and make a few changes before opening in ArcGIS Pro.

   → The table contains a list of species and their location details. The date field begins with a number **1st event Date**. ArcGIS Pro will not be able to open any field that begins with number so rename this field to **Date**.

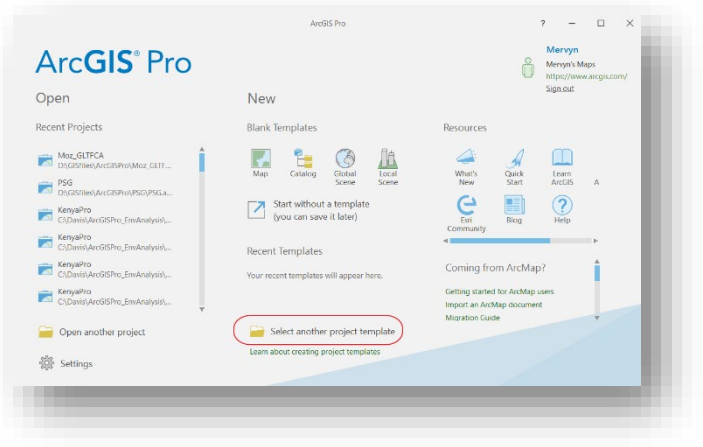
   → There are also spaces between some of the field headings and some fields are longer than 10 characters. This is only a problem if we plan to export the output to a shapefile, which we do plan on doing, so let us shorten and simply some of the headings. Change:

   - → **country Code** to **Country**
   - → **decimal Latitude** to **Latitude**
   - → **decimal Longitude** to **Longitude**
   - → **Basis Of Record** to **Record**
   - → **institution** to **Institute**

F	G	H	I	J	K	L	M	N	O	P
species	Country	Latitude	Longitude	Date	day	month	year	Record	Institute	license
Zosterops senegalensis	KE	-1.276301	34.960909	2017-09-10	10	9	2017	HUMAN_OBSERVATION	Nature Kenya	CC_BY_4_0
Zosterops senegalensis	KE	-1.415093	36.665195	2017-09-17	17	9	2017	HUMAN_OBSERVATION	Nature Kenya	CC_BY_4_0
Zosterops abyssinicus	KE	-2.633333	37.25	2017-06-01	1	6	2017	HUMAN_OBSERVATION	Nature Kenya	CC_BY_4_0
Geokichla piaggiae	KE	-1.166667	34.783333	2017-06-01	1	6	2017	HUMAN_OBSERVATION	Nature Kenya	CC_BY_4_0
Zosterops abyssinicus	KE	-1.622116	36.714937	2017-11-27	27	11	2017	HUMAN_OBSERVATION	Nature Kenya	CC_BY_4_0

   → Save your changes to **GBIF_Kenya birds 11 February 2019** and close **Excel**.

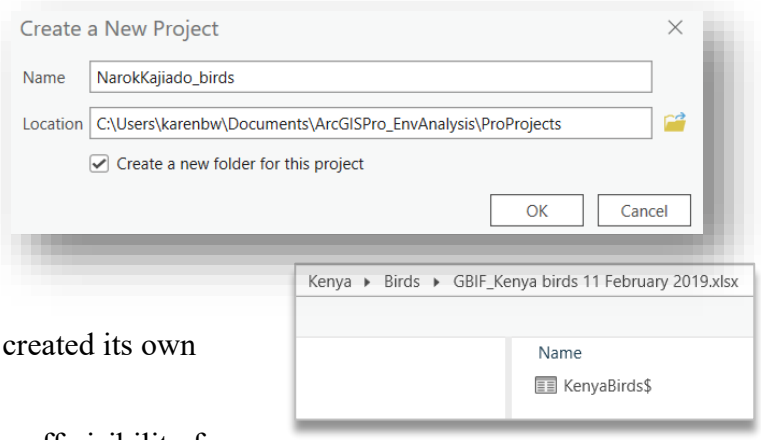
2. We will now open up a new project from the ArcGIS project template file we created in Exercise 8, then use this project to work with our bird data that we will import from Excel.



→ **Start ArcGIS Pro**, and in the opening dialog, then you should see **NarokKajiado_Tem** listed under recent templates. If not, then click on **Start with another template**.

→ In the next dialog, navigate to

C:\Davis\ArcGISPro_EnvAnalysis\Kenya and select **NarokKajaidoTem.aptx**



→ You will be asked for a new name. Call it **NarokKajiado_birds** and save it in …**ArcGISPro_EnvAnalysis**\ **ProProjects**.

→ Open and activate the **Catalog** pane. Notice how this project looks exactly as the **KenyaPro** project. It even references the same geodatabase although it created its own new one in the name of your new project.

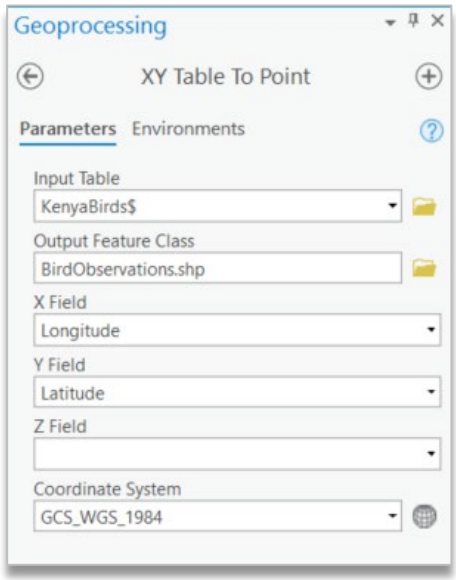
→ In the **NK Elephant Habitat Map** view, turn off visibility for all layers except for **Narok_Kajiadi, Rivers**, **Roads WFP**, and **Protected Areas.**

3. From the **Map** tab, click **Add Data** and navigate to the **GBIF_Kenya birds 11 February 2019.xlsx** file. Double-click on the file name and then select the spreadsheet **KenyaBirds$** and click **OK**.

→ The **KenyaBirds** table will be added to ArcGIS Pro as a **Standalone Table**.

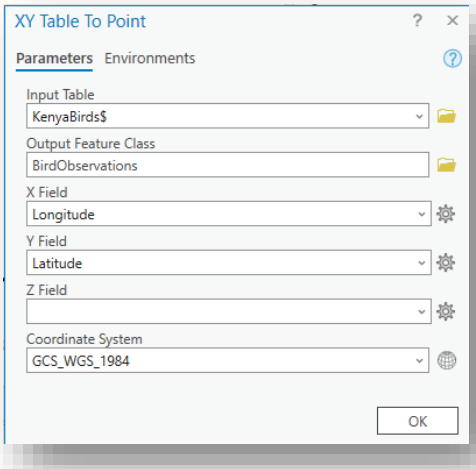
→ Open the **KenyaBirds$** table and check that data was correctly imported.

4. To be able to query and analyze this table, we need first need to create a point feature class from it.



Note: There are two broad methods to use to visualize the Excel table as points on a map; (1) ***Make XY Event Layer*** *or (2)* ***XY Table To Point/Display XY Data****. The first displays the coordinates but references the original dataset. It is a useful approach if edits may be made to the original Excel file as these will be reflected in the event layer every time ArcGIS Pro is reopened. However, it does not*

work well in all geoprocessing tools. The second option creates a feature class or shapefile of the Excel file but any later edits to the Excel file will not be brought across to ArcGIS Pro. We will use the second approach, as we want to use the file in further analyses.



→ Right-click on **KenyaBirds$** and select **Create Points from Table** and choose **XY Table to Point**.

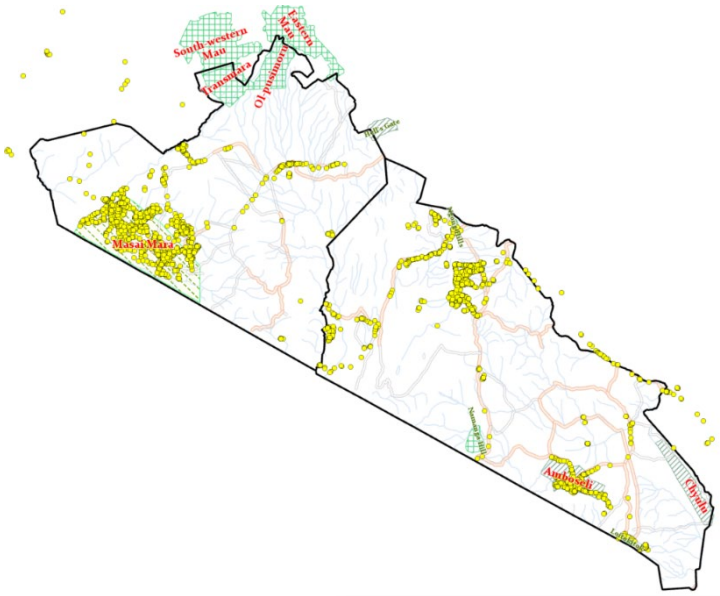
→ Call the *Output Feature Class* **BirdObservations** in the default new geodatabase (*a new geodatabase that was automatically created with the new project*).

→ ArcGIS Pro will automatically try and match up the latitude and longitude fields to the required *X Field* and *Y Field* from the field names. Confirm that **Longitude** is selected for the *X Field* and **Latitude** for the *Y Field*.

→ Keep the default coordinate system, which should be GCS_WGS_1984 and click on **OK.**

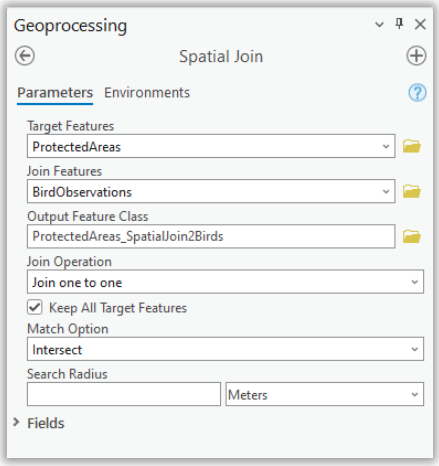
→ **BirdObservations** will be added to the **Contents** pane. Click on the actual symbol under **Contents** pane to change symbology to **Circle 3** with a size of **5** and the color **Solar Yellow**.

→ Remove the KenyaBirds$ table from the **Standalone Tables**.



5. We will now try and do a count of the number of bird species present in our protected areas.

→ From the **Geoprocessing** pane, search for and open the **Spatial Join** geoprocessing tool. *Note: one can also right-click on ProtectedAreas to create a spatial join but this approach opens a tool with limited functionality (one can no longer stipulate output name or join operation)*



→ From the **Contents** pane, click and drag **ProtectedAraes** into the *Target Features* field.

→ Under *Join Features*, click and drag in **BirdsObservations**.

→ Modify the output name to **ProtectedAreas_SpatialJoin2Birds**.

→ Relationship is **Join one to one** and match option is **intersect**.

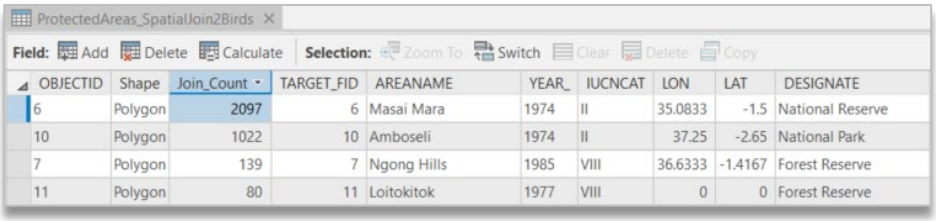
→ Click on **Run**.

Note: we have found that occasionally ArcGIS Pro does not include the protected area

attributes in the output results. To fix this, hit the back arrow on the GP tool to clear the tool parameters and then re-add them and then rerun the Spatial Join tool.

→ The resulting feature class is called **ProtectedAreas_SpatialJoin2Birds** which is in essence the **ProtectedAreas** layer with a count of the number of bird observations in each of the reserves.

→ Open the attribute table of **ProtectedAreas_SpatialJoin2Birds** and right-click on the **Join_Count** heading and choose **Sort Descending**.



OBJECTID	Shape	Join_Count	TARGET_FID	AREANAME	YEAR_	IUCNCAT	LON	LAT	DESIGNATE
6	Polygon	2097	6	Masai Mara	1974	II	35.0833	-1.5	National Reserve
10	Polygon	1022	10	Amboseli	1974	II	37.25	-2.65	National Park
7	Polygon	139	7	Ngong Hills	1985	VIII	36.6333	-1.4167	Forest Reserve
11	Polygon	80	11	Loitokitok	1977	VIII	0	0	Forest Reserve

→ Birds were identified in only four of the eleven protected areas, as only these reserves show a positive Join_Count. But is this a count of bird species occurring on each of these four reserves? No. It is the number of observations and probably more of an indication of sampling effort. It does not tell us how many bird species occur there. To do so will require a slightly different approach. Close the attribute table and turn off this layer.

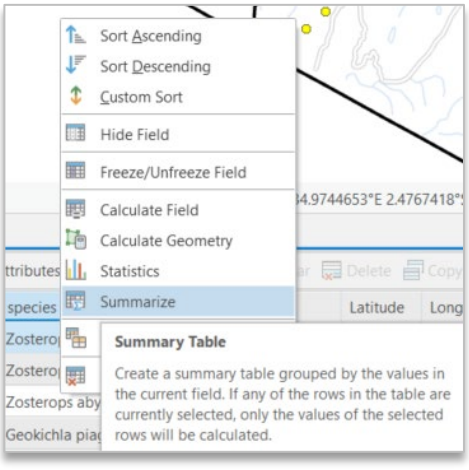
→ With the **Spatial Join** geoprocessing tool still open on the right, swap the input files by adding **BirdObservations** to the *Target Features* field and **ProtectedAreas** to the *Join Features* field.

→ Change the default output name and location as **BirdObservations_SpatialJoin**.

→ Relationship is **Join one to one** and match option is **Intersect**

→ Click on **Run**.

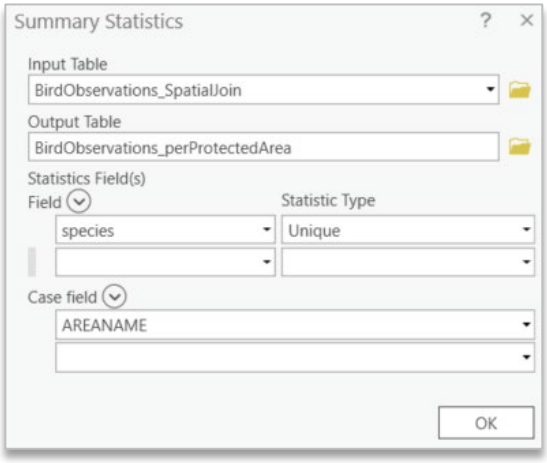
→ If you open the attribute table of the resulting file, you will notice that the protected area name (AREANAME) has been added to each bird observation. We now need to summarize this data to provide us with the number of unique bird species per reserve.



→ Right-click on Right-click on **AREANAME** field name and click on **Summarize** to open up the **Summary Statistics** tool.

→ The *Input Table* will be **BirdObservations_SpatialJoin** and change the output table **BirdObservations_perProtectedArea**.

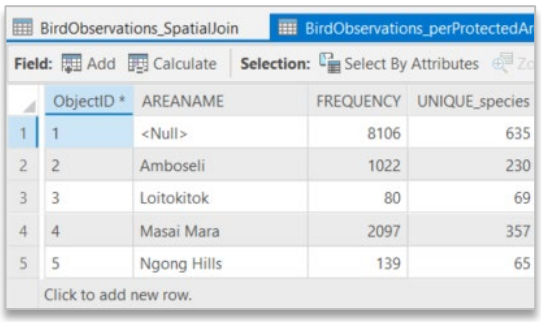
→ For *Field* and *Statistics Type* parameters, select **Species** and **Unique**. *This is a new option which simplifies the workflow considerably. Previously we had to do this in two steps to calculate unique values.*



→ Under *Case field*, **AREANAME** should be selected.

→ Click on **OK**. *Ignore the warning message as it is just telling us that we had nulls values in our table that were skipped.*

→ The summary table is added to the **Standalone Tables**. Open up the **BirdObservations_perProtectedArea** table and view the summary records. The first **FREQUENCY** column summarizes all the bird observations in each protected area, an indication of sampling effort while **UNIQUE_species** summarizes the number of bird species in each protected area.



  → Masai Mara has a bird list of 357 species.

  → Although Loitokitok has more birds in total than Ngong Hills, it promises to be much richer in bird species as the list is derived from only 80 observations instead of 139 of Ngong Hills.

→ **Save** and close the **NarokKajiado_birds** project.

Exercise Summary: In this exercise you learned how to prepare your Excel data before importing into ArcGIS Pro. You created a point feature class so that you could further use it in analyses. We used Spatial Joins and Summary Statistics to determine the number of bird species occurring in each protected area for which we had bird observations.

Lab Exercise 10: Answer these questions directly into Canvas.

1. **How many unique species of birds were observed outside of protected areas?_____**
2. **How many total observations were made outside of protected areas?_____**
3. **What is the average number of observations per unique species in Amboseli? _____** *(Hint: You can answer this using a calculator, or you can add a new field and use **Calculate Field** to find **frequency / unique species.**)*

Exercise 11: Performing Analysis in ArcGIS

We are ready to find areas where we might want to establish elephant conservation zones. After we have determined the likely areas, then we would use other tools and processes to further study the suitability of these areas. Remember that this class is not a study in elephant habitat analysis or modeling, but a way to demonstrate tools and procedures you can use in ArcGIS to effectively work with your own analysis situations and your own data.

Preparing for Analysis

While we have spent more time on some aspects of ArcGIS than you would normally spend, the process has been typical of a GIS project in that the majority of the time is spent getting the data in shape, and then the analysis goes relatively quickly. An important part of preparing for analysis is getting the data organized in terms of having the data files in a logical structure, adding or deleting fields as necessary, and above all making sure all the data is in the same projection or that we have set the "project on the fly" procedures correctly so all work will be in the correct projection.

Another part of organizing data for an analysis project is determining what data is best. It is very typical to start with as much data as you can gather, and then as you work with the data, narrow this down to the most appropriate data available. And in the real world, the most appropriate data may not always be the absolute best data. But we often need to work with what we have, and it is our duty as analysts, to always be clear on what our data is, what assumptions we make, and what procedures we use. Then as better data or procedures are available, we can improve on our analysis.

Analysis Assumptions

Here are some of the assumptions and clarifications we want to state about this project. We will make one excuse, which is that John had about two weeks to find data, learn about Kenya and elephants, and write this course outline. So please excuse any shortcomings in our knowledge about Kenya and elephant habitat. *(Karen knows a bit more about elephant ecology, but she was not working with John at the time!)* Regardless of that, the procedures and tools are typical of those that you would use in any GIS project; and in each analysis situation, you would use your knowledge to choose the appropriate data and procedures to best perform your analysis.

For data, we looked at several sources, but decided that because of the time limits, it would be best to use one primary resource that had the most comprehensive data, which in this case was ILRI. Much of the data they have is from other sources and could also be found on other sites, but by using ILRI the formats and projections were standardized.

John originally downloaded all the data that he thought we might use, but found there is some overlap and inconsistencies in the data. For example, if you compare the Forests layer to the land use types in the Landuse layer, you will see that the Forests layer also includes some grassland and dense bush land. It may be that the Forests layer is more "correct" or more recent, but since we do not have a way to verify this at this time, we have decided to use the forest designation from the Landuse layer for the analysis in our exercise.

For similar reasons, we have decided to not use the Wetlands and Lakes layer in this project. Also, since we are looking at the whole of both districts, it is better to use the Landuse layer that fully covers our study area. These are the types of decisions you will face as a GIS analyst and/or wildlife biologist and it is important that you research the data and that you state your assumptions.

Analysis Procedure

Before we start the actual exercise, we will look at the process a bit. To answer our question, which is ***to find possible areas for elephant conservation zones***, we will start with the **Preferred Habitat** land use area and then subtract all the unwanted areas. This will require several operations. *In the exercise, we will also have you perform a few operations that are not critical to the analysis, but will show some useful tools. And we will also take a little break in the middle of the analysis to do some edits on the features to refine results.*

Step 1: Set appropriate Geoprocessing environment settings.

Step 2: Determine the preferred habitat areas using the Landuse layer.

Step 3: Subtract out the existing protected areas, since these are already conservation zones.

Step 4: Buffer the agricultural areas. We want to minimize contact between elephants and agriculture.

Step 5: Decide on which types of villages to include and combine these with major towns and buffer around these features. Ideally, we would eliminate all contact with any villages, but because villages are spread extensively through the area and are often temporary because of the pastoral nature of the Maasai, it is not feasible to eliminate all villages at this stage of the study.

Step 6: Buffer around roads, since we do not want to have these in conservation areas.

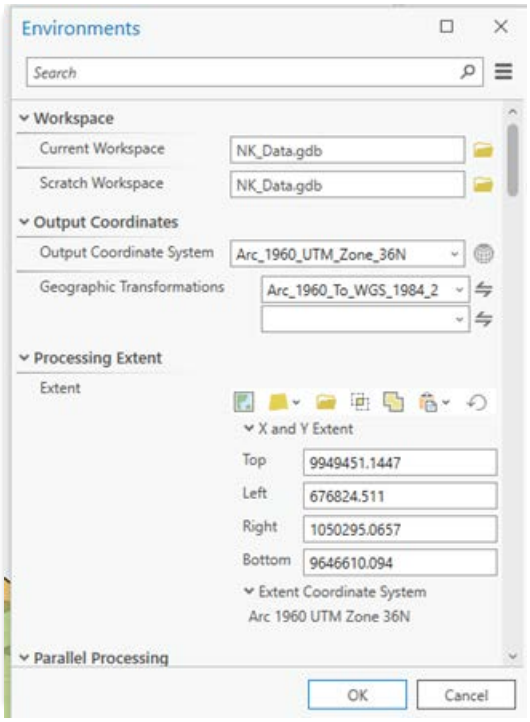
Step 7: Subtract the buffers from the preferred habitat areas.

Step 8: Summarize the results and calculate the hectares involved. From there we can use statistics to examine the data and display it in a chart, report, or layout.

Part A: Setting the Geoprocessing Environment

Most of this was done earlier, but it is good to double-check the settings before we run a lot of Geoprocessing tools. One of the most common problems with GP tools is having workspaces or coordinate systems set wrong in the environments.

1. **Open** the **KenyaPro** project and **NK Elephant Habitat** map, if needed.



   → From the **Analysis** tab, select **Environments**.

   → Verify that the **Current Workspace** and the **Scratch Workspace** are set to **NK_Data.gdb**.

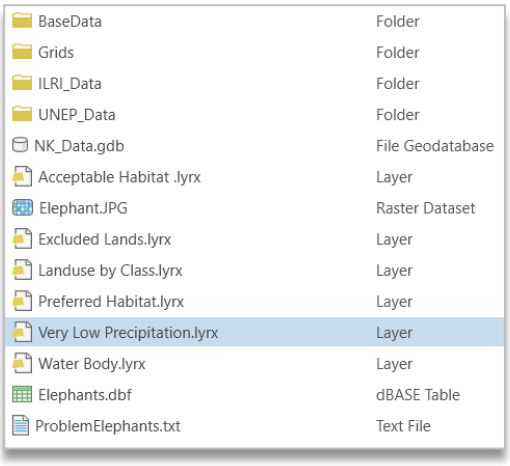
   → The **Output Coordinates** should be **Arc_1960_UTM_Zone_36N.** If not, just use the drop-down list to select the **"Narok_Kajiado"** feature class which shares the same coordinate system as the one we require.

   → Ensure that the **Geographic Transformations** is set to **Arc_1960_To_WGS_1984_2**.

   → Set the Extent to the Layer "**Narok_Kajiado.**"

   → Leave the rest of the settings as they are and click **OK** to accept the changes or **Cancel** if there were no changes.

Part B: Data Cleanup and Basic Analysis.



1. First we will do a little housekeeping and remove some unnecessary layers.

   → **Remove** the **Forests**, **Lakes** and **Wetlands** layers, since we have decided to use the data from the Landuse layer for these land classes.

   → Open the attribute table for the **WaterPoints** layer. If your scroll through the **DNPTTYPETX** field, it only shows "Springs, wells, or waterholes". We would not want Elephants close to springs or wells, and we might not even want elephants close to some waterholes because of the damage they could cause. But since we cannot distinguish the type of water feature, this data will not be useful in this stage of the analysis. **Close** the table and then **Remove** the **WaterPoints** layer.

   → If the **Landuse By Class** and **Very Low Precipitation** layers are not present, add them from the **Kenya** folder. Drag these below the **ProtectedAreas** layer in the **Contents** pane.

2. For fun, we will look at some of the spatial relationships between our problem elephants and villages, and then the spatial relationship with land use. Remember that the problem elephant locations are pure fiction.

   → **Turn** on the **ProblemElephantFC** layer if needed and drag them to the top of the **Contents** pane.

   → Remove the **Human Elephant Conflict** layer, as it will not be needed.

   → Then from the **Geoprocessing** pane find and open the **Spatial Join** tool.

      → Select **ProblemElephantsFC** as the *Target Features*.

      → Select **Villages** as the *Join Features* layer to join…

      → Save the output as **ProbElephants2Villages**.

      → *Join Operation* is **Join one to one**.

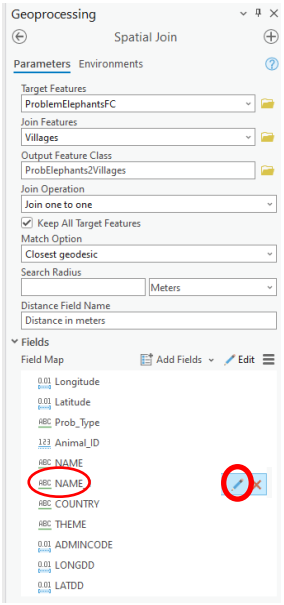
      → Keep the option to "**Keep All Target Features**"

      → Under *Match Option*, select **Closest geodesic** from drop-down list.

      → Under *Distance Field Name*, write "**Distance in meters**".

      → Under the output fields, click on the **Name_1**, which is the name of the village, then click on **Edit** to the right and under *Alias*, change name to "**Village Name**"

      → Click on **Run**.



→ Open the **ProbElephants2Villages** attribute table and notice the information that is now available. You now have the distance to each village in meters, the location of the Elephant, the type of problem and its name, and the name of the closest village.

ProbElephants2Villages

Field: Add Calculate Selection: Select By Attributes Zoom To Switch Clear Delete Copy

	OBJECTID *	Shape *	Join_Count	Distance_in_meters	TARGET_FID	Longitude	Latitude	Prob_Type	Animal_ID	NAME	Village Name	COUNTRY	THEME	Al
1	1	Point	1	2795.177135	1	36.624903	-2.028836	Fence	1	Abe	EMBALEKI	KE	STM	
2	2	Point	1	4061.463699	2	36.593879	-1.964686	Farm	2	Carlitos	KERITA	KE	SCH	
3	3	Point	1	4845.154034	3	36.706818	-1.825659	Farm	3	Anya	ELUAI	KE	AREA	
4	4	Point	1	2908.693803	4	36.671683	-1.755304	Orchard	4	Cecilia	OLOSIRUA	KE	HLLS	
5	5	Point	1	2275.288871	5	36.200213	-1.785189	HEC	5	Chaka	ILTUROT ONGATA	KE	PLN	
6	6	Point	1	3028.940324	6	36.173747	-1.957252	HEC	6	Gideon	OLORONGA	KE	HLL	
7	7	Point	1	2253.570292	7	36.260512	-2.085568	Farm	7	Luciana	LENDERUTHILLS	KE	HLLS	
8	8	Point	1	6422.519301	8	36.357434	-2.139238	Orchard	8	Diyan	KABONGO	KE	LBED	
9	9	Point	1	2288.105566	9	36.497644	-2.209364	HEC	9	Tiana	LENKIJABE	KE	HLL	
10	10	Point	1	1568.032624	10	35.932731	-1.963912	HEC	10	Mervyn	OLPUSARE	KE	STM	
11	11	Point	1	2520.66562	11	35.777895	-1.771367	Market	11	Joseph	EMBALUAI	KE	AREA	
12	12	Point	1	2728.035959	12	35.944558	-1.630149	HEC	12	Rebecca	OLOLNGOADA	KE	HLL	

Question 1: If the elephant locations had been real, how might you use this information?

_____

→ Try a spatial join between the **ProblemElephantsFC** layer and **Landuse**. (*Hint: the default Match Option of Intersect would be best.)*

→ Open the table and see what information you have.

Question 2: What is the most common land use type where the elephants were found?

_____

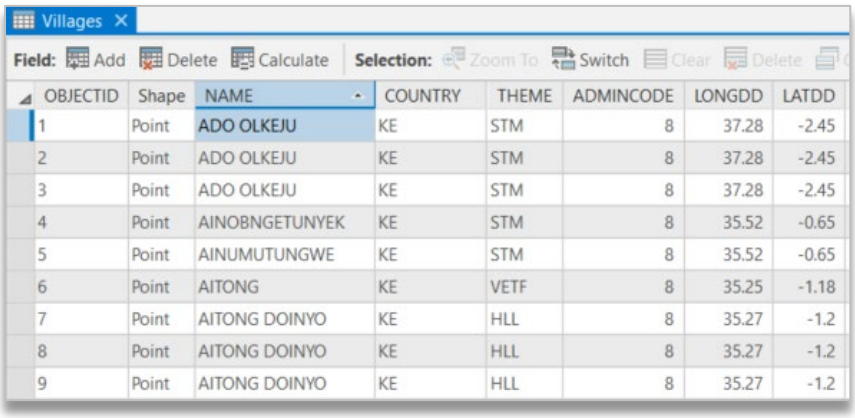
→ Turn off the elephant layers for now and close any attribute tables.

3. We also need to work with the **Villages** layer. While this is potentially an important piece of data, we do not have time in this class to sort out all the various types of villages and settlements contained in this layer, but we will do a little exploration and clean up of the data.

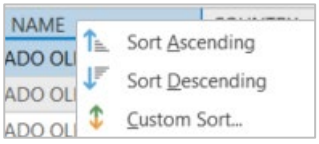
   → Turn on the **Villages** layer if needed.

   → Open the attribute table for the **Villages** layer.

   Question 3: How many records are in this table?_____ (*You might need to scroll down the table to force ArcGIS to read the full table; sometimes ArcGIS only opens the first 2000 records*.)

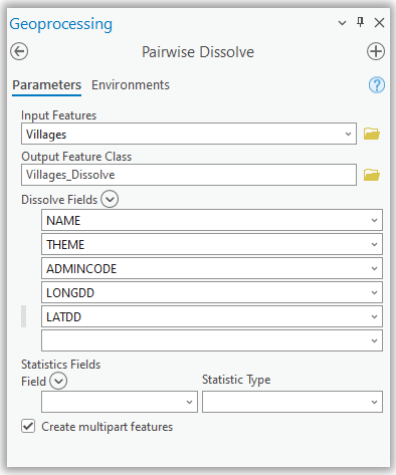


OBJECTID	Shape	NAME	COUNTRY	THEME	ADMINCODE	LONGDD	LATDD
1	Point	ADO OLKEJU	KE	STM	8	37.28	-2.45
2	Point	ADO OLKEJU	KE	STM	8	37.28	-2.45
3	Point	ADO OLKEJU	KE	STM	8	37.28	-2.45
4	Point	AINOBNGETUNYEK	KE	STM	8	35.52	-0.65
5	Point	AINUMUTUNGWE	KE	STM	8	35.52	-0.65
6	Point	AITONG	KE	VETF	8	35.25	-1.18
7	Point	AITONG DOINYO	KE	HLL	8	35.27	-1.2
8	Point	AITONG DOINYO	KE	HLL	8	35.27	-1.2
9	Point	AITONG DOINYO	KE	HLL	8	35.27	-1.2



   → Right-click on the **NAME** field and select **Sort Ascending**; notice that many names are repeated several times, usually with the same THEME, ADMINCODE, LONGDD and LATDD values. Look at the village of Bartinarau for example. *This is probably the result of combining multiple data sources without quality checking or having villages listed multiple times for other analysis purposes.* We should eliminate the extra entries to help keep our data clean. **Clear** any selections and **close** the table.

   → From the **Analysis** tab and tool gallery, select the **Pairwise Dissolve** tool. *Note, this tool is very similar to the standard dissolve tool, just more efficient and accurate on large datasets. For our dataset we could have used either.*



      → Select **Villages** as the input layer.

      → Change the name for the output feature class to **Villages_Dissolve**).

      → For *Dissolve Fields*, select **NAME**, **THEME**, **ADMINCODE**, **LONGDD**, and **LATDD**. The dissolve function will check that all of these values match before doing a dissolve and combining redundant records.

      → Check **Create multipart features** at the bottom of the dialog box. This will make one physical feature out of the matching records. Then click **Run**.

   → Open the table for the **Villages_Dissolve** layer.

   → **Question 4:** How many records are in this table?_____

→ Scroll down in the NAME field and check a few of the matching names to be sure that they have different themes, codes, or location.

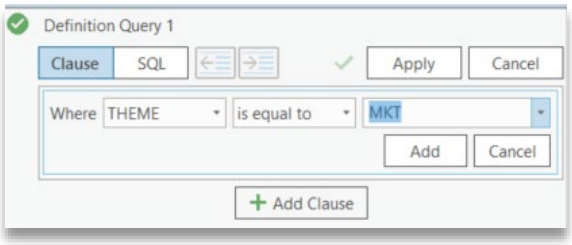
→ **Clear** any selections, **Close** all open tables, and **remove** the **Villages** layer. Make sure that you keep **Villages_Dissolve**.

Villages_PairwiseDissolve

Field: Add Calculate Selection: Select By Attributes Zoom To Switch Clear

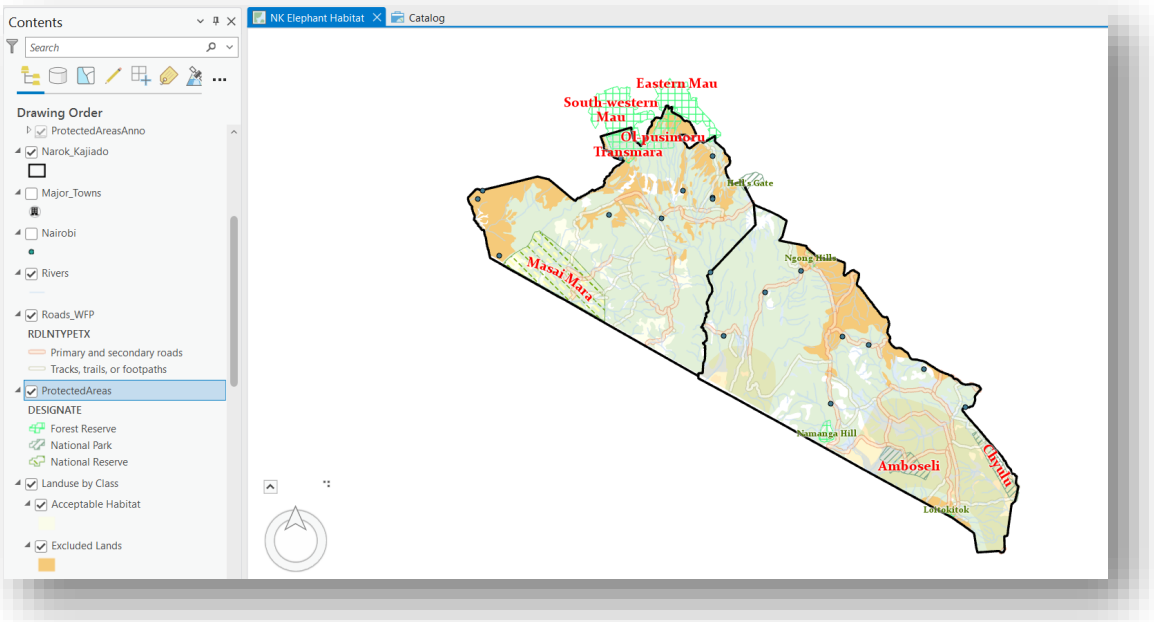
	OBJECTID *	Shape *	NAME	THEME	ADMINCODE	LONGDD	LATDD
1	1	Multipoint	ADO OLKEJU	STM	8	37.28	-2.45
2	2	Multipoint	AINOBNGETUNYEK	STM	8	35.52	-0.65
3	3	Multipoint	AINUMUTUNGWE	STM	8	35.52	-0.65
4	4	Multipoint	AITONG	VETF	8	35.25	-1.18
5	5	Multipoint	AITONG DOINYO	HLL	8	35.27	-1.2
6	6	Multipoint	AJIJIKNAIBORR	AREA	8	37.62	-2.88
7	7	Multipoint	ALADOAARE	STM	8	35.6	-1.53
8	8	Multipoint	ALANGARUA	PPL	8	36.12	-2.08
9	9	Multipoint	ALAROSH	STM	8	35.73	-1.6

4. We also want to focus on a just a few types of villages. There are 61 different types listed under the THEME field *(a quick way to find this out is summarize on that field)*, but the metadata on the web does not have an explanation of what these mean. After working with the data, we decided that we will just consider market towns for this stage of the analysis and we assume that the value MKT stands for Market Town.



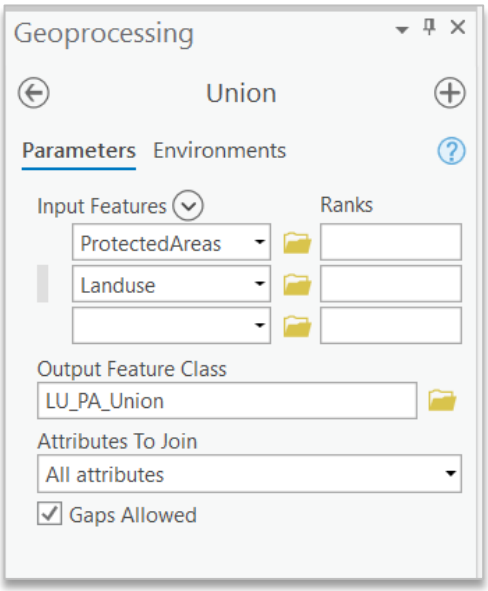
→ Using a definition query, create a layer file named **Market Towns** from the **Villages_Dissolve** layer, rename it before exporting layer file, then give it an interesting symbol, and save it in the **Kenya** folder.

*If you forgot how to make a layer file - Open the properties for the layer and create a definition query to select the market towns where the value for **THEME** field is equal to **MKT**; (you should have 19 market towns) change the name of the layer to **Market Towns**, and then right-click the layer and select **Sharing>Save as layer File**.*



Part C: Identifying Potential Elephant Conservation Areas.

1. The first step will be to subtract the Protected Areas from the Landuse layer. Since the Protected Areas are already conservation zones, they should not be included in our analysis. *If you have access to ArcGIS Pro Advanced, there is an Erase command, but since that is expensive, we will use a technique that can be done with ArcGIS Pro Basic.*



→ From the **Geoprocessing** pane, search for the **Union** tool (or select it from the tools gallery). Open the **Union** tool.

→ Select **ProtectedAreas** and **Landuse** as the Input Features.

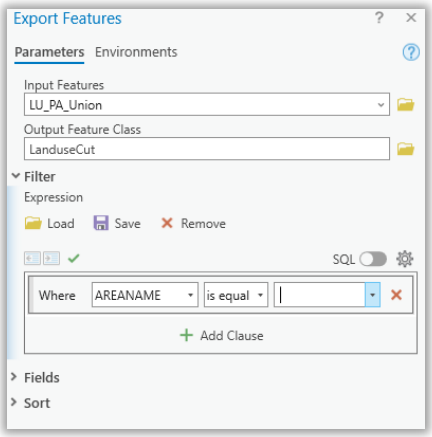
→ Save the Output Feature Class as **LU_PA_Union** in default geodatabase.

→ Verify that **Gaps Allowed** is checked.

→ Accept the rest of the defaults and click **Run**.

→ Open the table for the **LU_PA_Union** layer. Notice that some records have values for both AREANAME and Land_Use, and some have values in only one of those fields. Any record that has a value in the AREANAME field is inside a protected area, which is a polygon we do not want. *Pro will also automatically apply the symbology from the Protected Areas layer to this layer, which will only show those areas that are protected. Therefore, change the symbology to Single Symbol and accept the default color.*

→ Right-click on the **LU_PA_Union** layer and select **Data>Export Features** to export this as **LanduseCut** in the **NK_Data** geodatabase.



→ With tool still open, click on **Filter,** then New expression and add an expression where **AREANAME is equal to "blank space"**. *This will appear as the blank space at the top of the drop-down list. Just click on this blank area. This approach should select features that are not protected areas*

→ Click on **OK.**

→ **Remove** the **LU_PA_Union** layer and confirm that the protected areas are missing from the **LanduseCut** layer that we just created.

→ Turn off the **LanduseCut** layer and turn on the **Landuse by class** layers.

→ These layers still show land uses within the protected areas as they reference the Landuse feature class. But there is a very quick fix for that. We will change the layer file so that it references a different data source.

→ Right-click the **Acceptable Habitat** layer, and select **Properties>Source>Set Data Source**, click on **Set Data Source**, and then change the data source to the **LanduseCut** layer which is in the **NK_Data.gdb**. Now this layer file will keep all the properties that you set earlier, but apply them to the features in the **LanduseCut** layer. *Note, if you don't immediately see the **LanduseCut** layer that you just created, click on the refresh button for the **Change Data Source** window.*

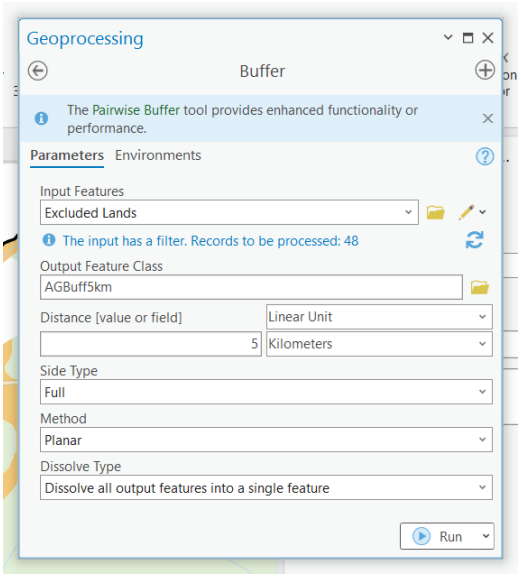
→ Click **OK.**

→ Repeat this operation for the 3 other layers in this group and verify that none of the features in these layers overlap with the **ProtectedAreas** layer by zooming into some of the protected areas, primarily the Masai Mara National Reserve.

→ ***BE SURE TO DO THIS FOR ALL 4 OF THE LAYERS!***

2. The next step is to buffer the agricultural areas.

→ Open the **Buffer** tool from the Geoprocessing menu.



→ Select **Excluded Lands** as the Input. *Here is a good example of how the layer files will help in doing analysis. If we had not created this layer file, we would have needed to first query on the Landuse layer for this.*

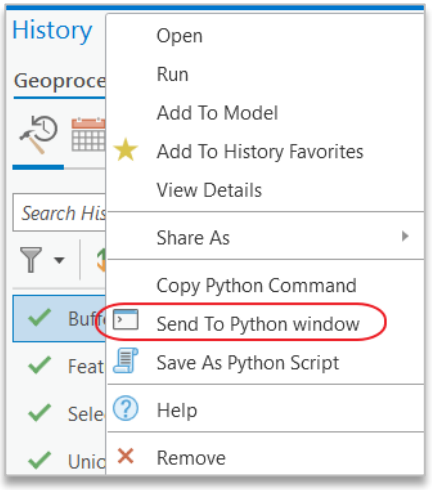
→ Save the Output as **AGBuff5km**.

→ Set the Distance to **5 Kilometers**.

→ Set the Dissolve Type to **Dissolve all output features into a single feature**

→ Accept the rest of the defaults and click **Run.**

→ However, after examining the results we are advised that that a 10 km buffer would be more appropriate. To teach you a new approach, from the **Analysis** tab and **Geoprocessing** group, click on **History**. From the **History** pane, right-click on **Buffer** and select **Send To Python Window.**



→ A python window will be opened at the bottom of the project with all the code used to run the previous step.

→ We will modify this text to create a buffer 10km side. You need to make the following changes to the python text:

→ Change `AGBuff5km` to `AGBuff10km`

→ `"5 Kilometers"` to `"10 Kilometers"`

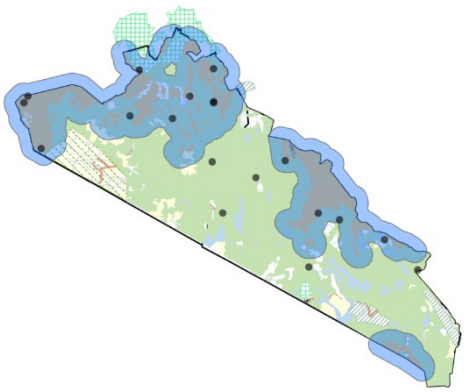
→ The Python code required to create a buffer of 10 kilometers is therefore: `arcpy.analysis.Buffer(r"Landuse by Class\Excluded Lands", r"C:\Davis\ArcGISPro_EnvAnalysis\Kenya\NK_Data.gdb\AGBuff10km", "10 Kilometers", "FULL", "ROUND", "ALL", None, "PLANAR")` *Note, if you are starting to learn python, then this code could be added to other code to create your own workflows or tools.*

→ Then click after the end of the bracket … `"0 Meters")` and hit **Enter**. *Be sure you click to the right of the closing bracket)* .

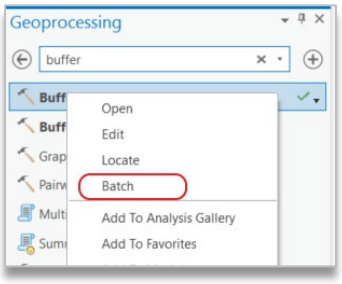
→ A larger 10 km buffer will be created.

→ Close the Python window and remove **AGBuff5km** from the contents pane.

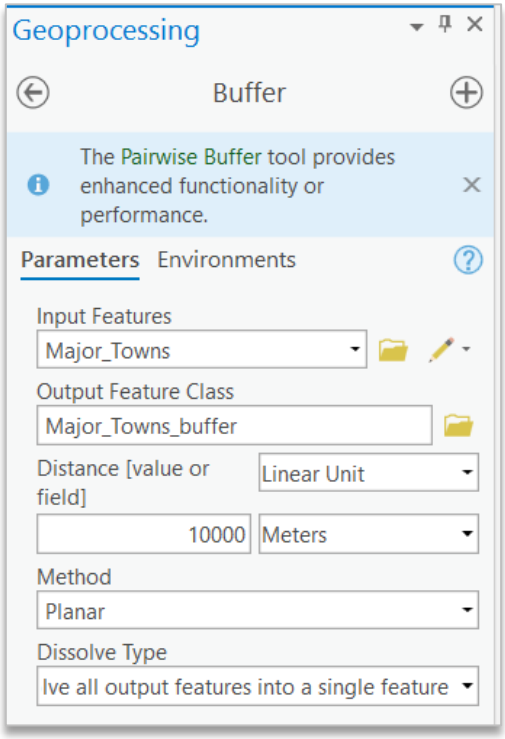
→ The agricultural lands buffer should look like the blue buffered area in the map below.



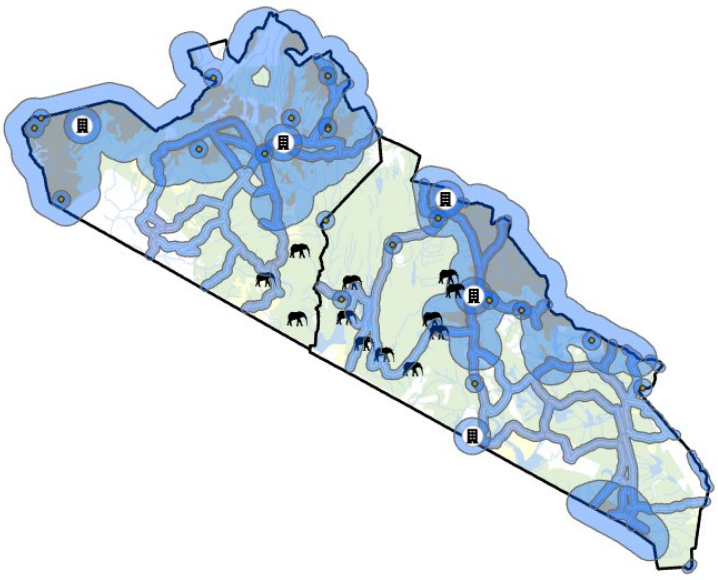
3. Next we will buffer the two layers for towns and the layers for roads. *ArcGIS Pro has a batch buffer menu option (context menu) but unfortunately it does not allow batch buffering of different input features with different buffer distances (unless values stored in field). We will therefore use the conventional method below.*



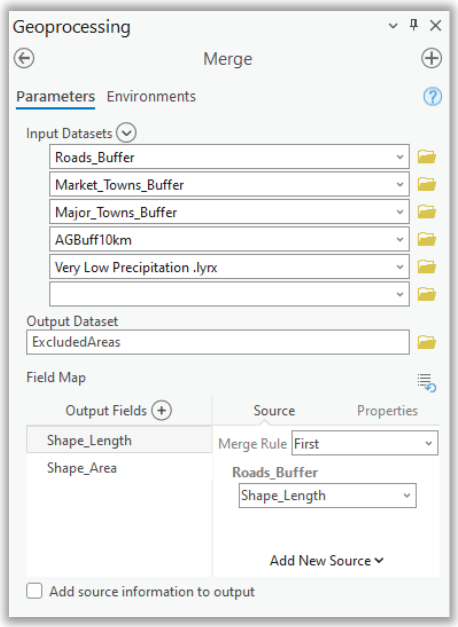
→ From the Geoprocessing pane search for **Buffer** and open the **Buffer** tool. *Note, it should already be open,*



- → Drag **Major_Towns** into the *Input Features* section.
- → For Output feature class, you can keep the name **Major_Towns_buffer.**
- → For *Distance*, enter **10000** and the units as **Meters**.
- → **Dissolve Type** should be **Dissolve all output features into a single feature**.
- → Keep the rest of the defaults and click on **Run** and the results will be added to the map.
- → Then with the **Buffer** tool still open, drag **Market Towns** into the *Input Features* box and change the name to **Market_Towns_Buffer**.
- → Change the buffer distance to **5000 meters** and click on **Run**.
- → Lastly, drag the **Roads_WFP** layer into the *Input Features* box and change the output name to **Roads_Buffer**.
- → Change the buffer distance to **2500 meters** and click on **Run**. All the buffers should look like the map below.



4. Now that we have the buffers, we can subtract that from the **Preferred Habitat** land use and get a good idea of what areas will be worth further study. First, we will merge the buffers together, along with the low precipitation layer, which also needs to be excluded, and then do a Union between that and the **Preferred Habitat** layer.



→ From the **Analysis** tool gallery, select **Merge** tool.

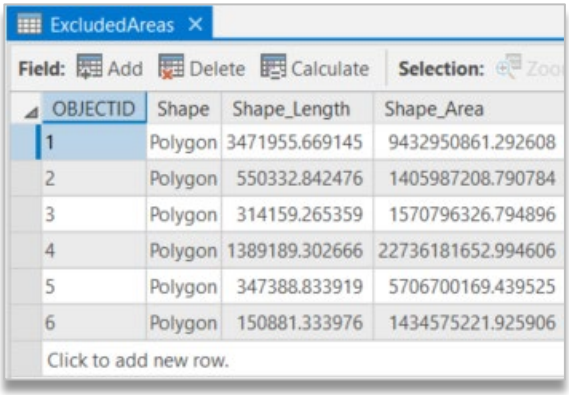
→ For input, drag the **Roads_Buffer, Market_Towns_Buffer, Major_Towns_Buffer, AgBuff10k** and **Very Low Precipitation** layers into the *Input Datasets* box.

→ Save the output as **ExcludedAreas**.

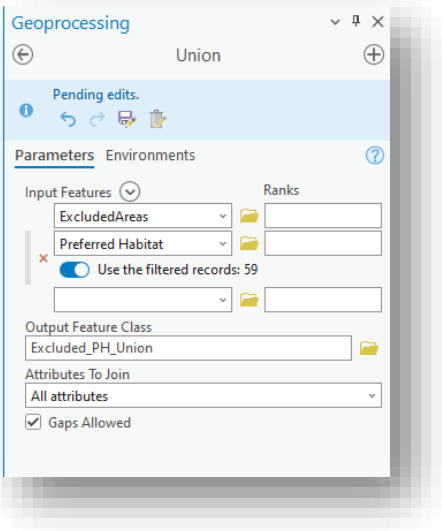
→ Accept the rest of the defaults and click **Run**.

→ Turn off the **Roads_buffer, Market_Towns_buffer, Major_Towns_buffer, Very Low Precipitation** and **AGBuff10km** layers.

→ Open the attribute table for the new layer and you should see that there are 6 records, one for each buffer and one for each of the 2 low precipitation polygons. If you have more, make a note of the count and let the instructor know.



5. We now want to remove the **ExcludedAreas** from the **Preferred Habitat** layer.



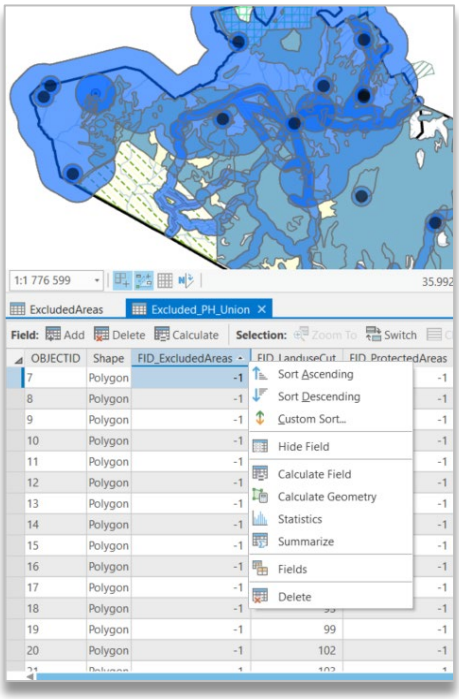
→ Search for and open the **Union** tool and union the **ExcludedAreas** layer with the **Preferred Habitat** layer.

→ Save the output as **Excluded_PH_Union** in the default geodatabase and accept the rest of the defaults.

→ Click on **Run**.

→ Turn off the **ExcludedAreas** layer.

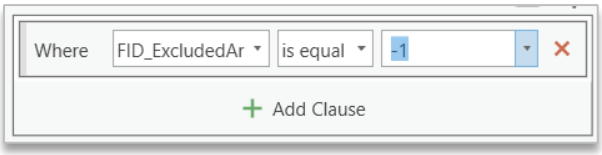
→ **Open** the table for the **Excluded_PH_Union** layer and use **Sort Ascending** and **Sort Descending** on the **FID_ExcludedAreas** field. You will see that values start at **–1** and go through **6**. *If there are more than 6 values, then you may have set the Dissolve Type to **No Dissolve** in the Buffer tool. This will not cause any problems for our analysis.*



→ Since there were **6** polygons in the **ExcludedAreas** layer, the records with the FID of –1 are polygons outside the buffered areas. Select a few of the records with the –1 FID and confirm that these are really outside the road, town and agriculture buffer areas. Now that we understand the results, we know we can query on all the records with the value of –1 now to get the area we want.

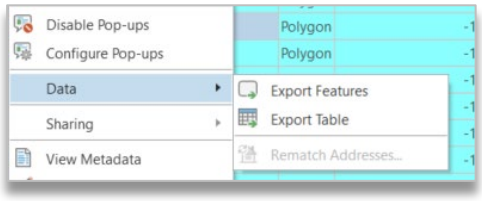
→ First click on the **Clear Selection** button to make sure all features are available.

→ Click on the **Select By Attributes** button from the Table view and create a query where **`FID_ExcludedAreas is equal to -1.`**



→ Click **Apply**.

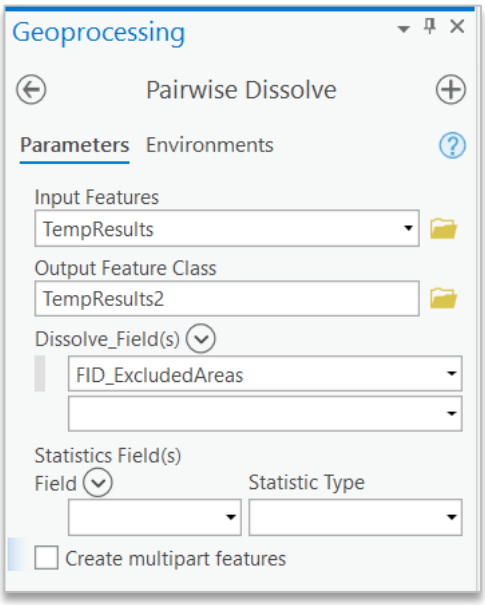
→ You should have **31** of **252** features selected.
If the selected features appear to be correct, right-click on the **Excluded_PH_Union** layer, export the features as **TempResults** (Temporary Results) to the default geodatabase, and it will be added to the map.



→ Turn off the **Excluded_PH_Union** and the buffer layers for now. Close all open attribute tables. We still need to do a little work first before we have our final study areas.

6. Next, we will consolidate the individual polygons into larger areas and then calculate the area for each new polygon.

→ Open the table for the **TempResults** layer and scroll through the **FID_ExcludedAreas** field. Notice that all the values are –1, which we would expect as we selected these. These values have no meaning now, but we need a field in the table where all polygons have the same value so we can dissolve any adjacent polygons. Close the table.



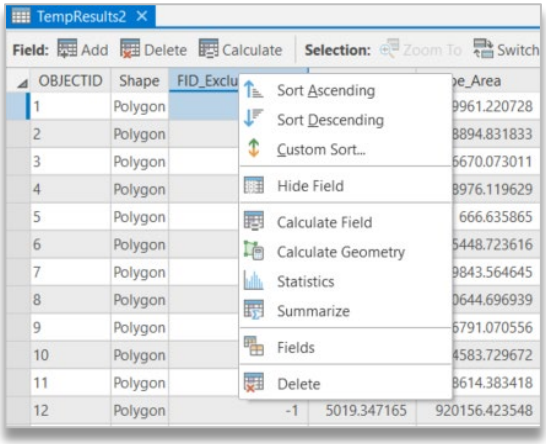
→ Open the **Pairwise Dissolve** tool.

→ Save the output as **TempResults2**

→ Dissolve the **TempResults** layer on the **FID_ExcludedAreas** field.

→ **Uncheck Create multipart features**. If you do not uncheck this, then we will end up with one giant multipart polygon. And then click **Run**.

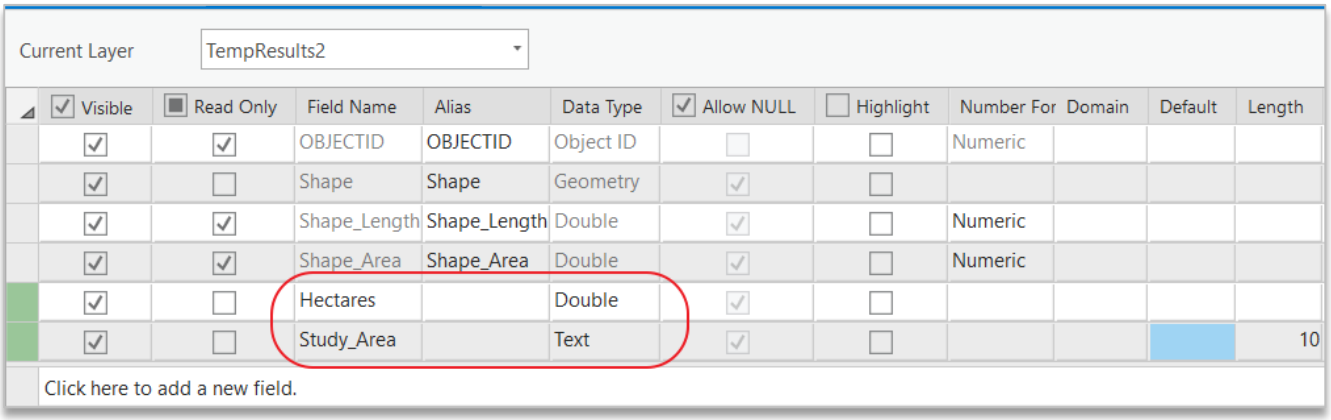
7. Open the attribute table for the **TempResults2** layer. This table is a lot cleaner and we no longer have all the fields from the various inputs. The table should have 49 records.



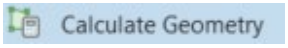
→ Right-click on the **FID_ExcludedAreas** field and **Delete** it since we no longer need this.

→ **Add a Field** named **Hectares** with a **Double** data type. (*Hint, right-click and **Design>Fields***)

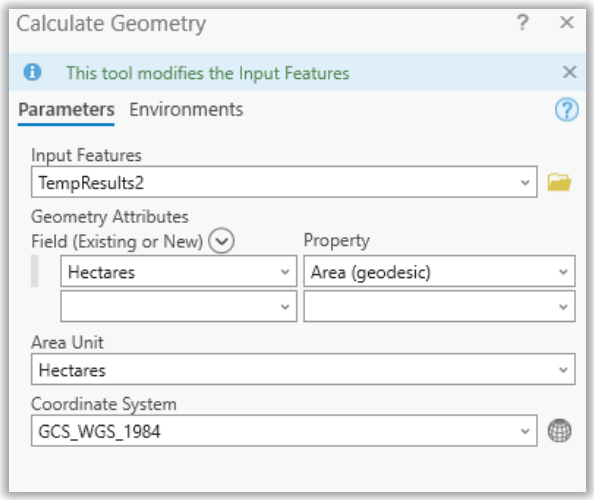
→ Add another field named **Study_Area** with a **Text** type and a length of **10**. We will use this field later to create names for each area.



→ From the **Fields** tab, **Save** the changes.

→ Close **Fields** pane and from the attribute table, right-click the **Hectares** field and use **Calculate Geometry** 

to find the area in hectares for each polygon.



→ Select **Area (geodesic)** under *Geometry Property* and keep the coordinate system.

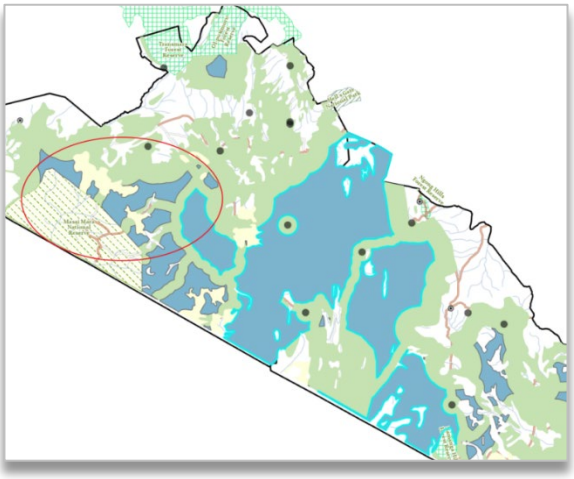
→ Under *Area Unit*, select **Hectares**.

→ Under Coordinate System, select WGS 1984.

→ Click on **OK**.

8. Now that we have area, what is the minimum area we should consider? The area needed will vary greatly depending on season, vegetation and herd type, but for the purpose of this study, we looked at the average size of protected areas throughout this region, which is 45 655 hectares.

→ Use **Select by Attributes** to query on the **TempResults2** layer to find polygons larger than **45,000** hectares. We only have 4 large polygons, but there is a polygon on the northern edge of the Masai Mara reserve. If you turn on the Acceptable Habitat layer, you will see that if we combined parts of these areas, this would also be a reasonable area to consider. If we had additional time to work on this, we may want to add in the Acceptable Habitat and combine some of these for a 5th large polygon.



→ Assign values of **1, 2, 3** and **4** to in the **Study_Area** field for the 4 largest polygons selected. Be sure to assign the number 1 to the largest polygon, number 2 to the second largest, and so on.

→ Export the 4 selected polygons in **TempResults2** to a feature class called **StudyAreas.**

→ **Clear the selected features** and **Save** the **KenyaPro** project.

Exercise Summary: In this chapter you worked with several different analysis tools to help you organize your data and to find potential conservation zones. You also worked through a fairly typical analysis flow where you identified non-useable areas, buffered them as needed, merged them, and then excluded those areas from the areas you had designated as preferred.

Remember, each analysis situation will require different tools in different sequences, but the general process of using the tools, examining the results at each step, and then going to the next step will be the same. In some situations you might find yourself going back a step or two because you find a tool or action is not helping you answer your question, but that also is part of learning and gaining experience with GIS Analysis. In the next chapter we will learn a little about customizing and then after that we will learn about editing and then

use some editing functions clean up our potential conservation zones.

Lab Exercise 11:

1. Answer the four questions from this exercise and upload to Canvas in a Word, Text or PDF file.
2. Create a final Layout showing (and labeling with the **Study_Area** numbers that you assigned based on size) the largest 4 Study Areas that should be evaluated further as candidates for the location of a new protected area. Be sure to make the best map possible, showing only the appropriate layers and making the map as clear as possible to the reader. Upload the layout as a PDF to Canvas.

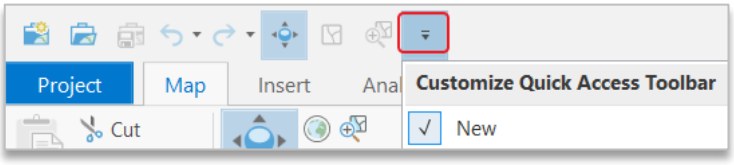
*(Note: You will upload **2** files for this assignment.)*

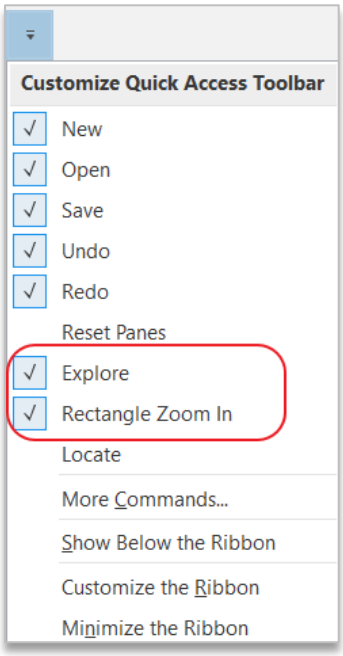
Exercise 12: Customizing Toolbars--Optional

In this exercise, we will just show a couple quick customizations.

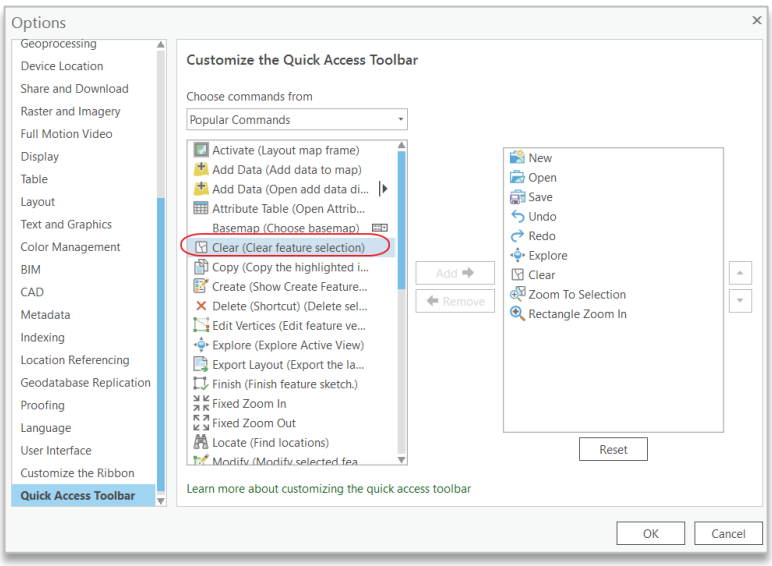
Part One: Customizing the Quick Access Toolbar and Ribbon

1. The Quick Access Toolbar, located above the ribbon, provides easy access to common commands. We will customize it to have some handy commands that we use often, instead of having to use tabs to locate them (if we happen to be on a different tab). One of the much requested tools that ArcGIS Pro does not provide by default, is the popular Rectangle Zoom that was part of ArcMap. It can now be added to the Quick Access Toolbar. We will then also add some others. *Note, the Explorer tool with shift key + left mouse drag functions like the Rectangle Zoom but we will add a new button to do this.*





- → Open the **KenyaPro.aprx** project and click on the **Customize Quick Access Toolbar** drop-down.
- → Then from the available options, check (tick) the options for **Explore** and **Rectangle Zoom In**.
- → Click on **Customize Quick Access Toolbar** drop-down to deactivate button.
- → Then click on the Rectangle Zoom and zoom in to an area of interest on the **NK Elephant Habitat** map.
- → We can also add the **Clear** selection button here. It can be a pain to have to always navigate to the **Map** tab to clear selections.
  - → Click on **Customize Quick Access Toolbar** drop-down and then on **More Commands**.
  - → This opens up a larger pane to customize the **Quick Access Toolbar**.
  - → Under *Choose commands from*, click on **Clear (Clear feature selection)** then click **Add** (between the two lists) to add the tool to the **Quick Access Toolbar**.
  - → Click **OK** to close pane and update the **Quick Access Toolbar.**

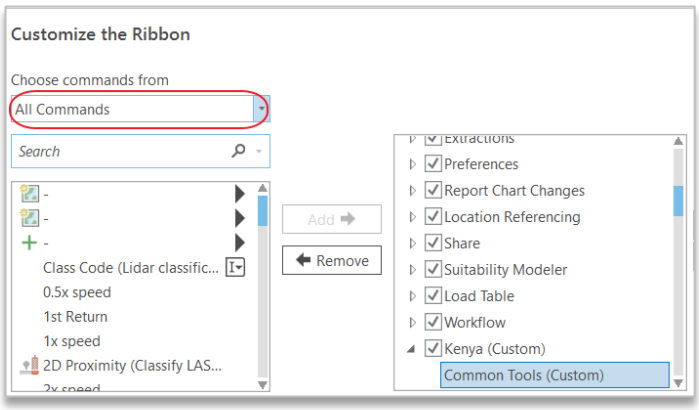


2. Next we will customize the ribbon and create a new tab called **Kenya** tools. This is not a complete list and the purpose is just to demonstrate some of the available functionality.

   → Go to **Project>Options>Customize the Ribbon** and on the list on the far right, click on **New Tab**, then click on **New Tab (Custom)** to activate and then choose **Rename**. Call it **Kenya** then click **OK**.

   → Then directly under the new **Kenya** item, click on **New Group** and then again on **Rename**. Call this **Common Tools** and click **OK**.

   → The next step is to add some of the tools to this new group from the list on the left. As we do not know where each tool is stored, we will search for them.



   → Change **Popular Commands** to **All Commands** which will then provide a search box. Then search for and add the following tools:

      → **Zoom to Selected**

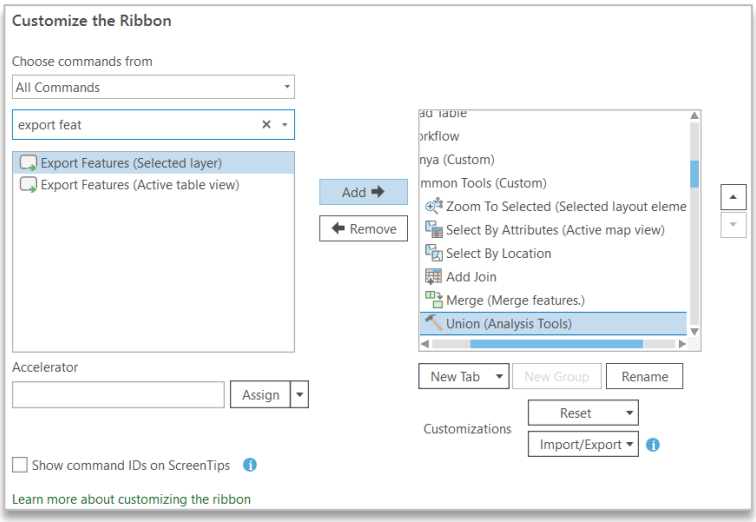
      → **Select By Attributes** (Active map view)

      → **Select By Location** (2nd option)

      → **Add Join** (the first option)

      → **Merge** (Merge features)

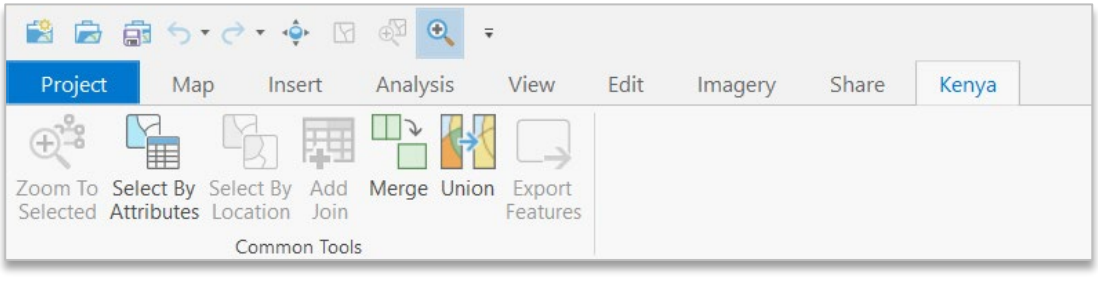
      → **Union**. You will notice that if you search for Union it will only show the Union (Layout) tool, which is not the one we want. Change the *Choose commands from* to **All Geoprocessing Tools** and then search for **Union** (Analysis Tools).



      → Change back to **All Commands** and search for **Export Features** (Selected layer).

      → Click on **OK** to close customization dialog box. Then click back button to return to map.

      → From the ribbon, just after **Share**, you should see a new tab called **Kenya**. Click on it and you will see the tools we selected are easily accessible here.



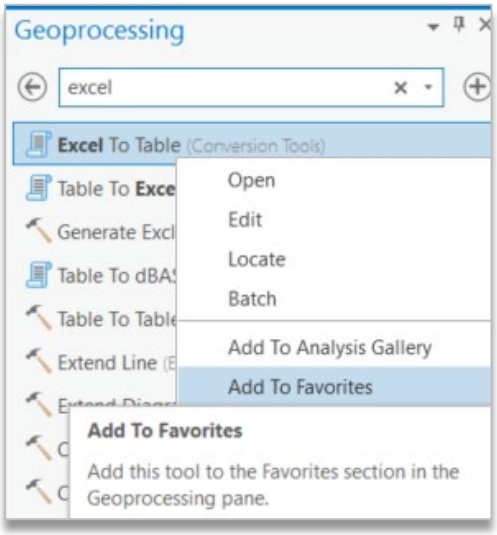
Part Two: Adding a geoprocessing tool to Favorites

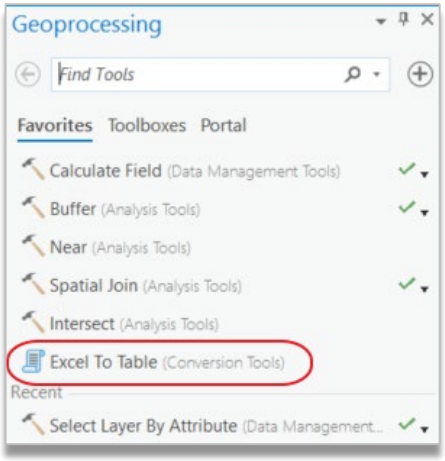
3. Lastly, we will add the **Excel To Table** geoprocessing tool to our geoprocessing favorites.

   → From the **Geoprocessing** pane, search for **Excel To Table** tool.

   → Right-click on the tool name, and click on **Add to My Favorites**.

   → It will now appear under the **Geoprocessing Favorites**.





Lab Exercise 12: There is no submission required for this Optional Exercise.

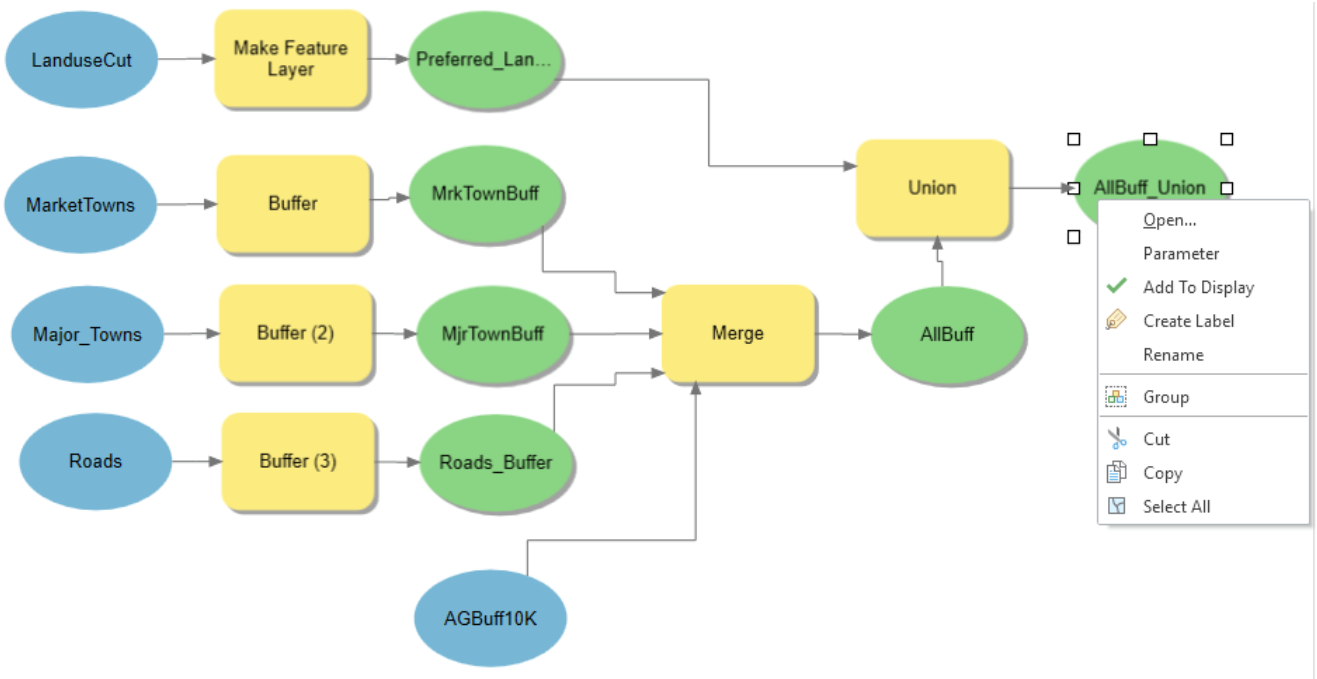
Exercise 13: Performing Analysis in ArcGIS using ModelBuilder

We can automate a lot of the work we have done thus far using ModelBuilder, which allows us to actually create a model of the process, by dragging data and tools into the ModelBuilder window. Then we can change parameters, change data inputs, and re-run the model with numerous variations. Besides the standard geoprocessing tools, or tools you or others create in a Toolbox, models can also use scripts, and other models as processes within a model.

When we completed our preliminary analysis, we found four potential areas ranging in size from 58,000 to just over 300,000 hectares. But what if we wanted to change some of the parameters? How would the results differ if we changed the buffer distance from market towns to 10km or maybe decreased the buffer around primary roads? We would have to go back several steps in the process and then repeat each operation to get to our results. By using ModelBuilder, we can more easily change the parameters and quickly see the results.

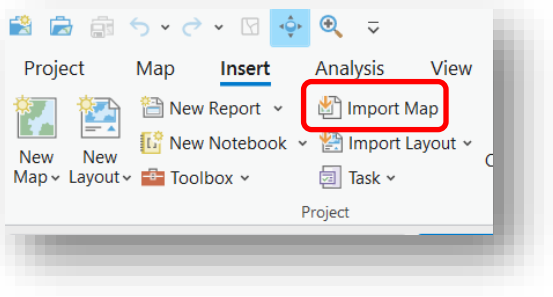
In this exercise we will not make a very complex model, but we will do enough to see how models work, and then if there are other factors to consider, you can add them to the model. Remember though that what we are doing here is still a binary study, where selected areas are good or bad, and that while we can add or subtract factors, we are not able to rank or weight the factors, at least not very efficiently. For more sophisticated site analysis where we can rank and weight factors, we would want to use Spatial Analyst.

We will start the model by first defining the preferred habitat based on land use classes, then bring in the exclusionary data such as roads and villages, create the buffers, and then extract the area remaining for our study areas.



Creating the Model

For this exercise, we will open an existing map that has been prepared for this exercise, and we will use another geodatabase – **NK_Model**, in the **ModelBuilder** folder. It is the same data we have been working with, but since you might have done some experimenting in previous exercises, it will be better to start fresh.



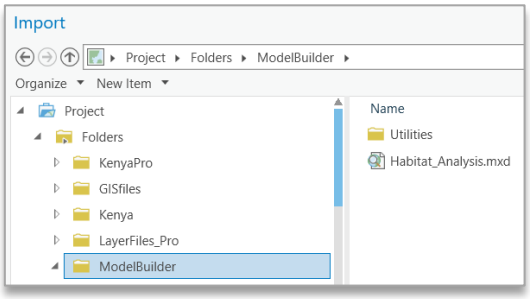
1. First we will start by importing a new map from ArcMap into our **KenyaPro project** and then set a few geoprocessing settings.

   → Open up the **KenyaPro** project if it is not already open.

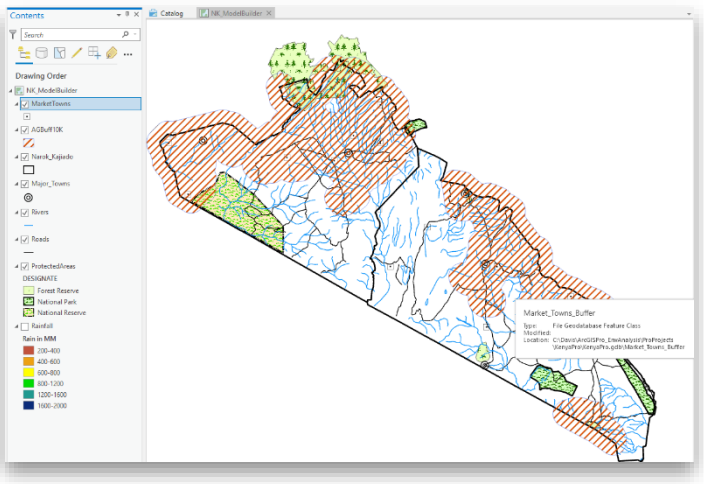
   → Close the **NK Elephant Habitat** map (you will be importing a map with the same name).

   → From the **Insert** tab, create a folder connection to **…\ArcGISPro_EnvAnalysis\ModelBuilder**.

   → Then from the **Insert** tab click on **Import Map** and browse to the **Habitat_Analysis.mxd** map in the **Folders \ModelBuilder** folder.



   → The map **NK Elephant Habitat(1)** will be added to the *project (it may have the **1** at the end since it's a duplicate name)*.

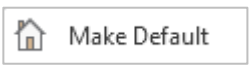


   → Open the map properties (right-click on **NK Elephant Habitat(1)**) and change the name to **NK_ModelBuilder**.

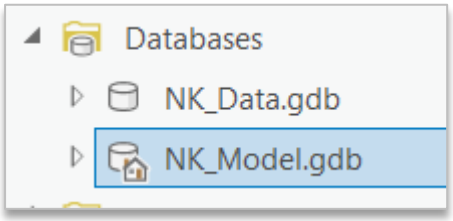
   → Turn off all layers except for **Narok_Kajiado** and **Roads**.

   → Next we need to add the **NK_Model.gdb** geodatabase to the KenyaPro project's geodatabases. This geodatabase contains a clean version of all the feature classes we need for our model.

   → From **Catalog** pane, right-click on **Databases** folder select **Add Database**. Then browse **Folders\ModelBuilder** folder and select the **NK_Model.gdb** to add it to the projects available geodatabases.

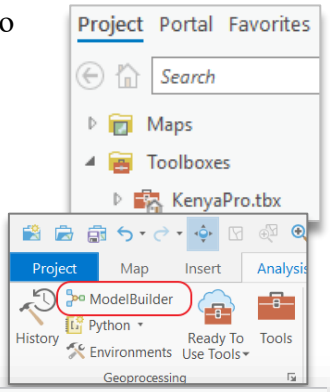


      → Then right-click on the **NK_Model.gdb** and select **Make Default**.

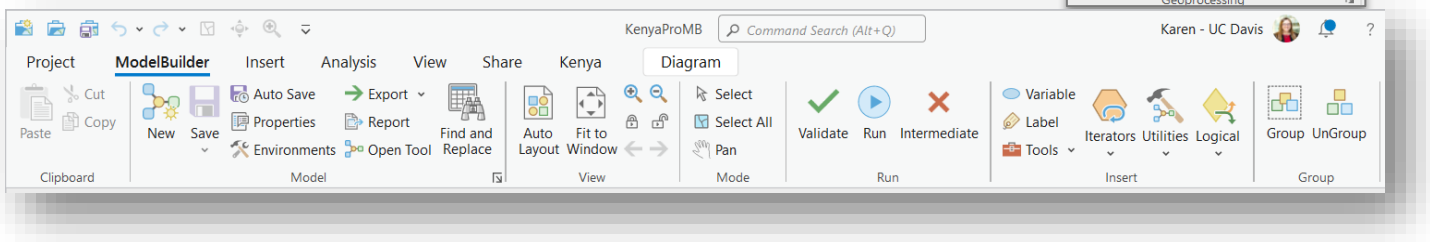


      → Expand this geodatabase to see the feature classes it contains.

2. A new **Toolbox** is created for you by default with each project ArcGIS Pro creates. The toolbox is named after the project name. We will create a model in the **KenyaPro** toolbox and set a few properties.



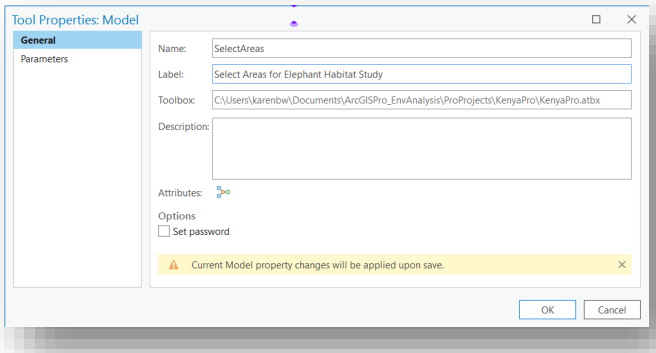
→ From the **Analysis** tab, click on the **ModelBuilder** button under the **Geoprocessing** group.



→ A blank model view will open and a new **ModelBuilder** tab will appear on the ribbon.

→ From the **ModelBuilder** tab and the **Model** group, click on the **Properties** option to set up the model properties.

→ Change the Name to **SelectAreas**. *Note: the name cannot have any spaces or underscores.*

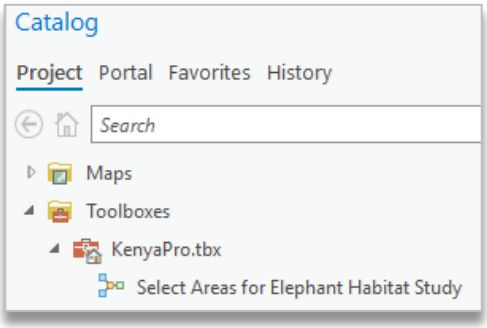


→ Change the Label to something useful like **Select Areas for Elephant Habitat Study**.

→ Click **OK.**

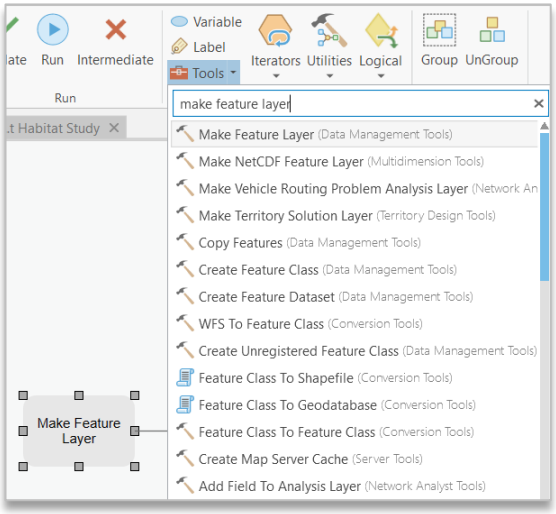
→ Then **Save** your model from the **Model** group. It is good practice to save your model often.

→ If you expand the **KenyaPro.tbx** under the **Catalog** pane, you will notice that a model called **Select Areas for Elephant Habitat Study** has been created here.



→ If you wanted to make this model available each time you create a new ArcGIS Pro project, then right-click on **Select Areas for Elephant Habitat Study** and select **Add to Favorites**. But no need to do so now.

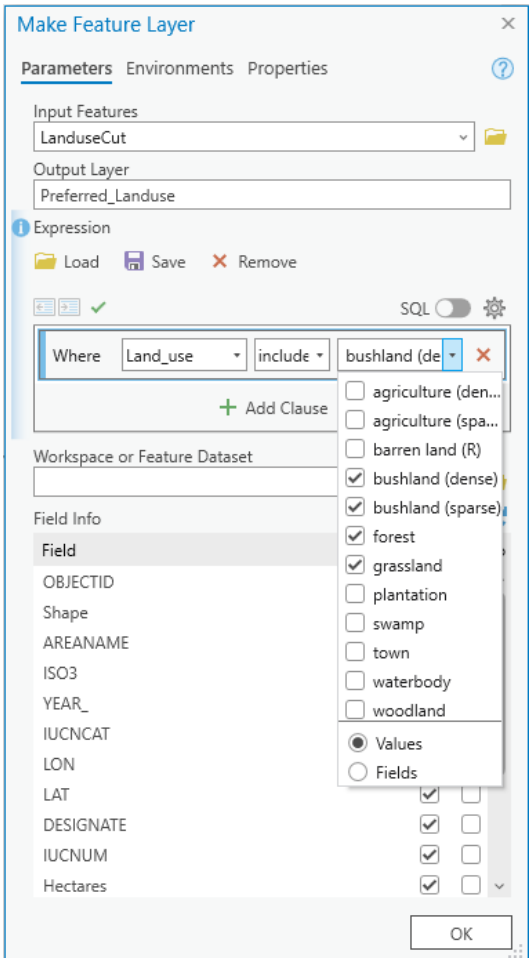
3. The first step will be to create a preferred habitat layer from the **LanduseCut** layer in the **NK_Model.gdb** geodatabase.



→ From the **Insert** group, click on **Tools** dropdown and then in the resulting search window that pops up, search for **Make Feature Layer**, then double-click on tool name to add to model view.

→ Right-click on the **Make Feature Layer** Tool to **Open…**.

→ Use the Browse button to navigate to the **NK_Model** geodatabase in the **Folders\ ModelBuilder** folder and select **LanduseCut** for the Input Features.

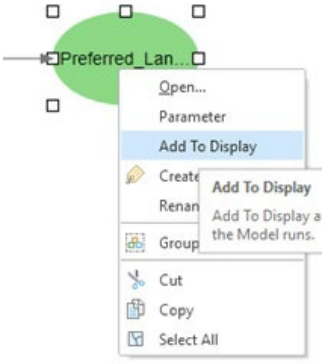


→ Change to Output Layer to **Preferred_Landuse**.

→ Then create the the query: **Land_use includes the values bushland (dense), bushland (sparse), forest,** and **grassland.** *With the query in the model, we can now easily change what we consider to be preferred land use. Note* ***grassland*** *are added here.*

→ Right-click on the **Preferred_Landuse** element and select **Add to Display**.

→ Then right-click the **Make Feature Layer** tool and select **Run**. Close the tool message dialog box.



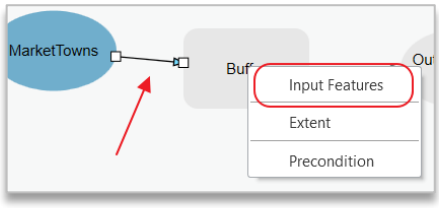
→ The new layer is now added to the **NK_ModelBuilder** map. Open the **NK_ModelBuilder** map and then if you open the attribute table for **Preferred_Landuse:Preferred_Landuse**, you can verify that the land-use types match the query.

→ Open the model view and then select **Model>Save** to save the changes we have made so far.

4. The next step in creating the model will be to create buffers around the areas we want to exclude.

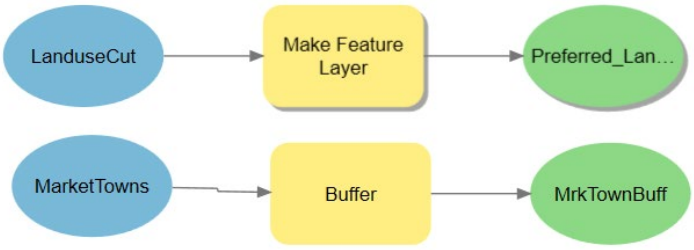
→ From the **Catalog** pane and **NK_Model.gdb**, drag the **Market Towns** layer into the model view and place it below the **LanduseCut** element.

→ Then from the **Modelbuilder** tab, choose the **Tools** search box from the **Insert** group, search for the **Buffer** tool and double click to add to the model view. Place this to the right of the **Market Towns** element. Then click and drag a line to connect up **Market Towns** with the **Buffer** tool. Then in the tool dialog box that will appear, select **Input Feature**. *Note: you may have to try this a few times to get the hang of how Pro does this.*



→ Double-click on the **Buffer** tool to open the dialog box. Notice that **Input Features** is already filled in.

→ Change the **Output Feature Class** to **MrkTownBuff** in the default geodatabase; change the distance to **5000 meters**; set the Dissolve Type to **Dissolve all output features into a single feature**; then click **OK**.

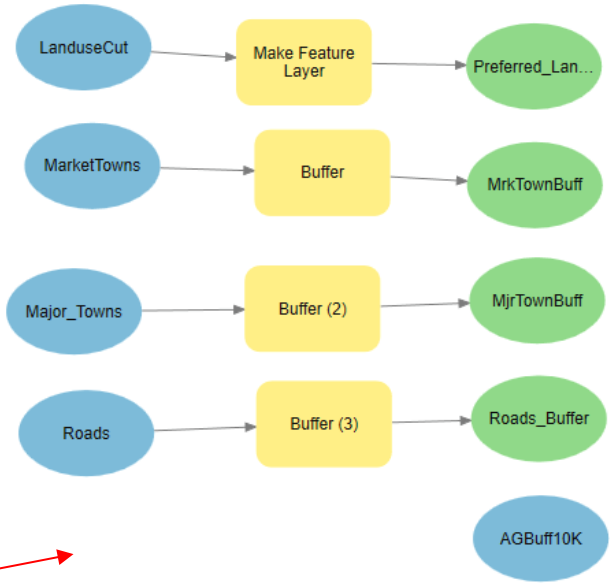


→ Your model should look similar to the illustration to the right.

→ Add another buffer process below the Market Town buffer for **Major_Towns** with the Output Feature class saved as **MjrTownBuff**; the distance set to **7500 meters**; and the Dissolve Type set to **Dissolve all output features into a single feature**.

→ Add a third buffer process for **Roads** with the **Output Feature Class** saved as **RoadsBuff**; the distance set to **2500** meters; the Side Type to full (not one side of the road), and the Dissolve Type set to **Dissolve all output features into a single feature**.

→ Next add the **AgBuff10k** layer to the model and place it below the last buffer output element. *We could have created another buffer process, but we will assume that the distance to agricultural lands will not change.*



→ The model should look something like this.

5. The next process is to merge the four buffers together.

   → From the **Geoprocessing** pane (just to show you a different way of adding tools), open the **Data Management Tools>General** Toolset and then drag the **Merge** tool into the model to the right of the buffer outputs.

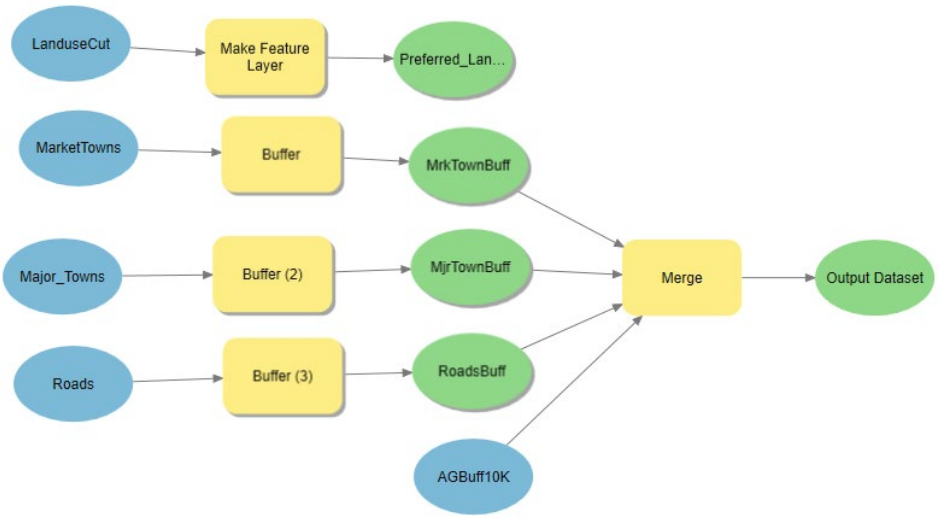
   → Note: you can use the zoom out button at the bottom of the model view to zoom out a little if needed.

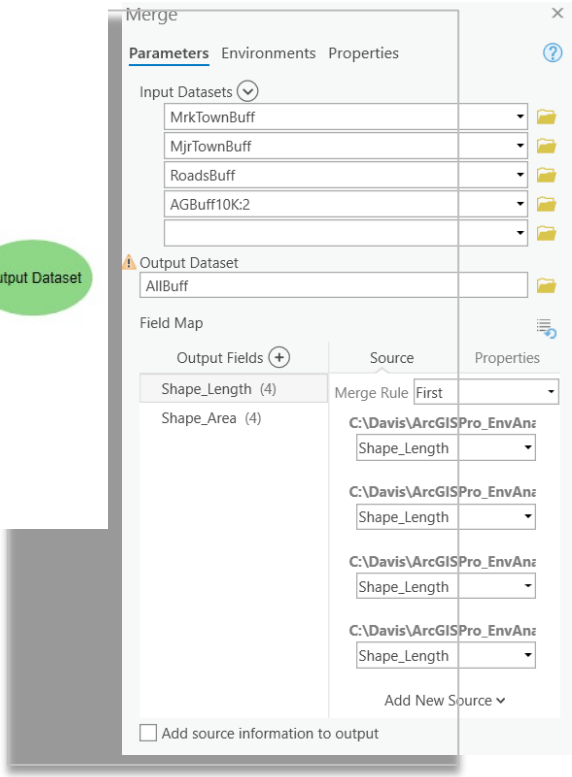
→ Create connections between each of the 4 buffer outputs (including the AGBuff10k layer), and the **Merge** tool. *(Select **Input Datasets** each time.)*

   → Open the **Merge** tool and change the output to **AllBuff**. Keep all other defaults and click **OK**.

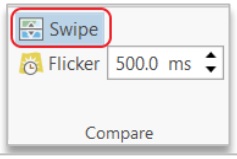
   → Right-click on the **AllBuff** element and select **Add to Display**.

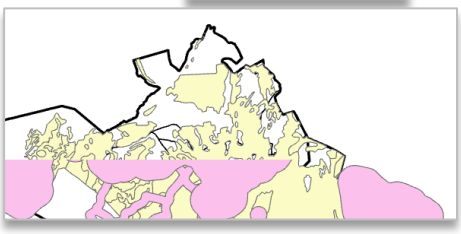
   → To check the model runs up until this point, right-click the **Merge** tool and select **Run**.





→ The **NK_ModelBuilder** map should now have the **AllBuff** layer (may be **AllBuff:AllBuff**) added so we can see how much area we are excluding. Click on **AllBuff** layer to select it, and then from the **Feature Layer** tab and **Compare** group, click on **Swipe**, then click on map and drag mouse down to visualize the effect of peeling away the **AllBuff** layer.



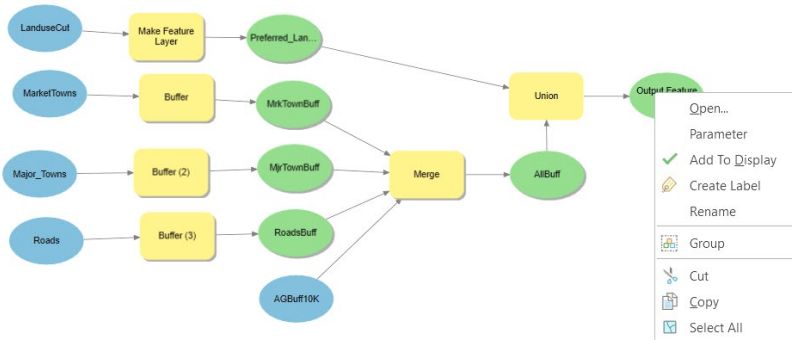


6. The next step will be to "subtract" the buffer areas from the preferred land use. We will do this with the **Union** tool and then a query.

→ Open up the **ModelBuilder** (**Select Areas for Elephant Habitat Study**) view and then from **Geoprocessing** pane, drag the **Union** tool (**Analysis Tools>Overlay,** or search for **Union**) into the Model and place it above the **AllBuff** element.

→ Connect the **AllBuff** and **Preferred_ Landuse** elements to the **Union** tool.

→ Right-click the Output for the **Union** tool; select **Open**, and save this as **AllBuff_Union**. *Note this name may already be populated even though in the model is labeled Output Feature Class.*



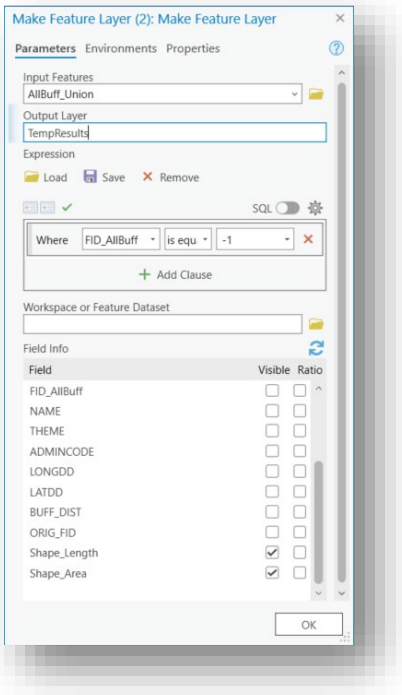
→ Then right-click on the element again and select **Add to Display**.

→ **Run** the **Union** tool.

→ Open the attribute table for the **AllBuff_Union** layer and notice that the **FID_AllBuff** field has values ranging from **–1** to **4**. Features with **FID_AllBuff** values from 1 to 4 are from the 4 excluded buffered areas, while **FID_AllBuff** values equal to **–1** are land use polygons not in the excluded buffer areas, which are the features we want to keep for our study areas.

→ Drag in the **Make Feature Layer** tool from the **Data Management Tools>Layers and Table Views** toolset into the model to the right of or below the **AllBuff_Union** element and then connect the **Output Feature Class** (or **AllBuff_Union)** element to the **Make Feature Layer** tool.

→ **Open** the **Make Feature Layer** tool and set the following parameters:



→ Change the Output layer to **TempResults**.

→ Create the query:

FID_AllBuff is equal to -1 *(there should be 49 records)*

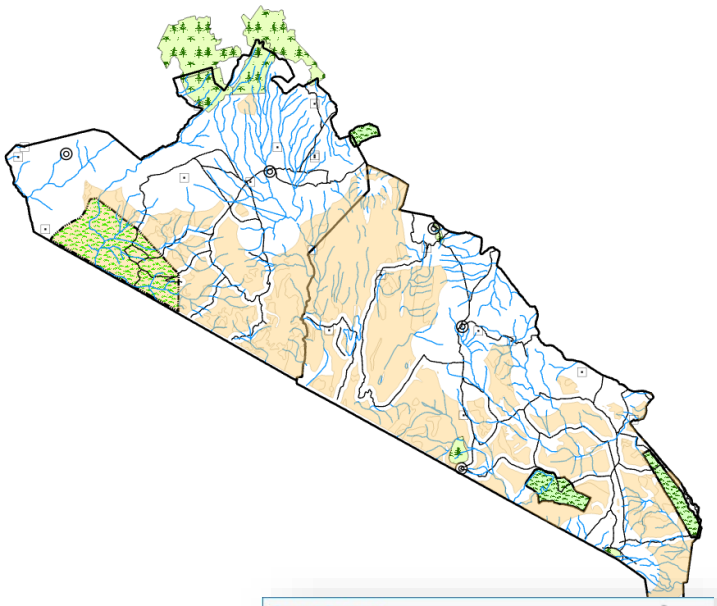
→ Uncheck **Visible** for all the fields except **Shape**, **Land_use**, **Shape_Area** and **Shape_Length** and click **OK**.

→ Right-click the **TempResults** element and check **Add to Display**.

→ **Run** the **Make Feature Layer (2)** tool.

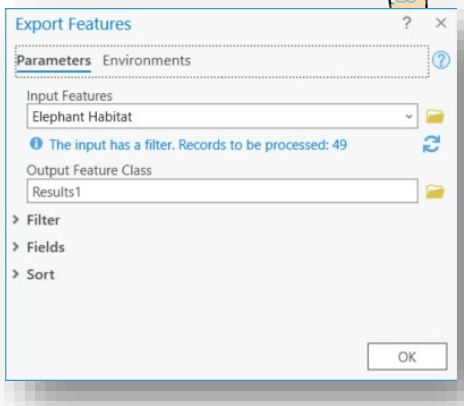
→ Then **Save** the model and open the **NK_ModelBuilder** map.

→ Turn off the **AllBuff_Union**, **AllBuff**, and **Preferred_Landuse** layers so you can better see the **TempResults** layer. Turn on the **ProtectedAreas** layer.



→ You should now have the **TempResults <u>layer</u>** in the map, and there should be differences from the results we had from the previous exercise because we changed some of the buffer distances and did not use the low precipitation areas as part of the analysis.

→ Symbolize the **TempResults** layer with a **Mango** (orange) fill and a **Raw Umber** (brownish) stroke outline, with 50% transparency. Then rename this layer to **Elephant Habitat** under the **Contents** pane and then save as a layer file called "**Elephant Habitat**" in the **ModelBuilder** folder. *(If you don't see this folder, you may need to add a folder connection to it first!)*



→ Then save the **TempResults** (**Elephant Habitat**) layer as **Results1** to the **NK_Model** geodatabase by right-clicking it and then selecting **Data>Export Features** and it should automatically be added back into the map. This will give us a permanent copy that will not change

when we try some other options in the model.

Lab Assignment 13: Create a map depicting the results (showing **Results1**) that contains all the elements of a final map product (Title, name, map, legend, scale bar, north arrow, etc.) Be sure that your map is clear and attractive, and that you apply all that you have learned in this class about communicating results in a layout. Upload the final map to Canvas.