Exercise 2

Displaying Geospatial Data

Objective – Explore and Understand How to Display Geospatial Data

2.1 Introduction

In this exercise, you'll learn how to complete a well-designed map showing the relationship between species habitat and federal land ownership, as well as how to symbolize GIS data layers in QGIS. In addition, you will learn how to use a QGIS Print Layout to design a well crafted map deliverable. The final map will include standard map elements such as the title and map legend.

This exercise will also continue to introduce you to the QGIS interface, as QGIS will be used throughout the book. It is important to learn the concepts in this exercise as future exercises will require the skills covered in this exercise.

This exercise includes the following tasks:

- Task 1 – Add data, organize map layers and set map projections.
- Task 2 – Style data layers.
- Task 3 – Compose map deliverable.

2.2 Objective: Create a Map that Meets the Customer's Requirements

Cartographers are frequently provided with a map requirements document from a coworker or customer. For this exercise, the you'll respond to a map requirements document from a customer who is writing a paper about the state of Greater sage-grouse habitat in the western United States. The map requirements from the customer are below.

Map Requirements from Customer:

Hi, my name is Steve Darwin. I am a wildlife biologist writing a paper on the state of Greater sage-grouse (see figure 2.1, on the next page) populations in the western United States. I need a letter sized, color, map figure that shows the relationship between current occupied Greater sage-grouse habitat and federal land ownership. I am interested in seeing how much habitat is under federal versus non-federal ownership.

I have been provided data from the US Fish and Wildlife Service depicting current occupied range for Greater sage-grouse. I also have federal land ownership, state boundaries and country boundaries from the US National Atlas. The land ownership data has an attribute column describing which federal agency manages the land (AGBUR).

I want to have the habitat data shown so that the federal land ownership data is visible beneath. I would like each different type of federal land styled with standard Bureau of Land Management colors. The map should also include a title ("Greater sage-grouse Current Distribution"), a legend, data sources and the date. The map should be a high-resolution (300 dpi) jpg image.

I trust that you will get the figure right the first time, so please just submit the completed figures to the managing editor directly.

Figure 2.1: Greater Sage-grouse

Image attribution: By Pacific Southwest Region from Sacramento, US (Greater Sage-Grouse) CC BY 2.0 (`http://creativecommons.org/licenses/by/2.0`), via Wikimedia Commons.

2.3 Task 1 - Add Data, Organize Map Layers and Set Coordinate Reference System

In this first task you will learn a new way to add data to QGIS Desktop. You will then set the projection for the map project, organize the data layers in the Table of Contents and change the layer names.

1. Open QGIS 3.x and make sure the Browser Panel is open.

2. Using the file tree in the Browser Panel navigate to the `Exercise 2\Data` folder.

3. Right click on the `Exercise 2\Data` folder and choose Add as a Favorite from the context menu.

4. Sometimes when recent changes have been made, such as setting a folder as a favorite, the Refresh button needs to be pressed in order to see the changes. Click the Refresh button (Figure: 2.2, on the facing page).

5. Now expand Favorites near the top of the file tree in the Browser Panel by clicking the plus sign to the left. You will see the `Exercise 2\Data` folder listed. Setting the folder as a favorite allows you to quickly navigate to your working folder.

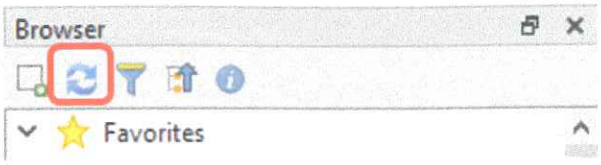

Figure 2.2: Refresh button

6. You will see 5 shapefiles in the exercise data folder:

- Canada.shp
- Land_ownership.shp
- Mexico.shp
- Sage_grouse_current_distribution.shp
- States.shp

7. You can select them all by holding down the `Ctrl` key on your keyboard while left clicking on each shapefile. Select the five shapefiles (Figure: 2.3).

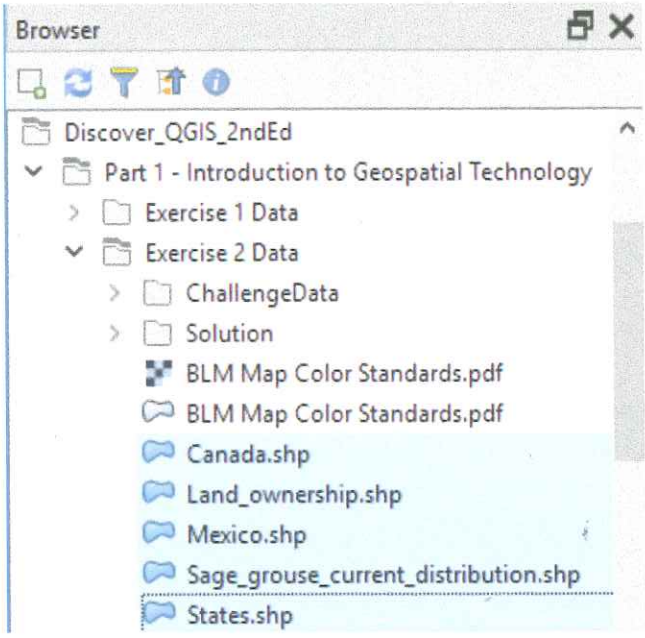

Figure 2.3: Selected shapefiles

8. Drag the five selected shapefiles onto the map canvas from the Browser Panel. You can also right-click on these layers and choose Add Selected Layers to Project. QGIS should now look like figure 2.4, on the following page. The random colors that QGIS assigns to the layers may be different than the figure below but that is fine.

Note: If you do not see anything displayed in the map canvas, you may need to zoom to full extents of the map by pressing the Zoom Full button. Alternatively, you can click View | Zoom Full.

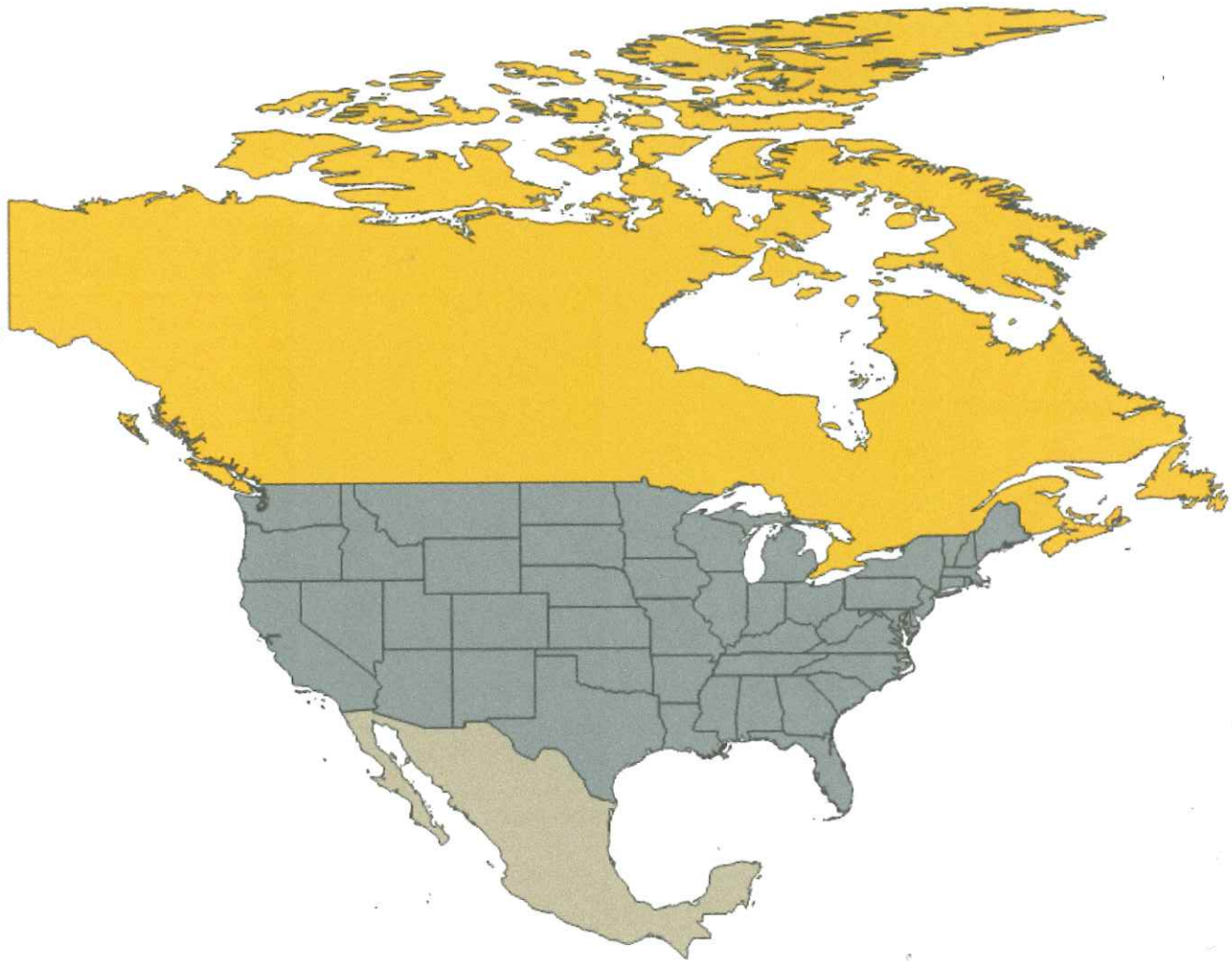

Figure 2.4: Shapefiles Added to QGIS

9. Now you will save the QGIS project. Click on `Project | Save` from the menu bar (`Ctrl + S`). Navigate to your `Exercise 2\Data` folder and save your project as `Exercise 2`.

A QGIS project is saved as a *.qgs file. A new feature of QGIS 3 is that a project database (*.qgd) is also saved with the project. The *.qgd file is a spatialite database. At QGIS 3.2 projects began being saved as *.qgz files. These are zipped project files that contain both the *.qgs and *.qgd files. Here your project will be saved as Exercise 2.qgz. Note that you still have the option of choosing Project | Save Project As and choosing a Save as type of *.qgs.

10. Right click on the Sage_grouse_current_distribution layer in the Layers Panel, and choose Zoom to Layer from the context menu. This will zoom you into the extent of that dataset.

The data layers are rendered on the map canvas in the order they appear in the Layers Panel. The layer that is on the top of the list in the Layers Panel will be drawn on top of the other layers in the map canvas. Notice that the the Land_ownership layer is above the Sage_grouse_current_distribution layer. This means that Land_ownership is covering up the Sage_grouse_current_distribution layer on the map.

Now you will change this drawing order.

11. Select the Sage_grouse_current_distribution data layer in the Layers Panel and drag it to the top position. You will see a line as you drag this layer up the list. Drop it when it is in the desired position. Next drag Land_ownership so that it is the second layer in the list.

12. Your map should now resemble the figure 2.5.

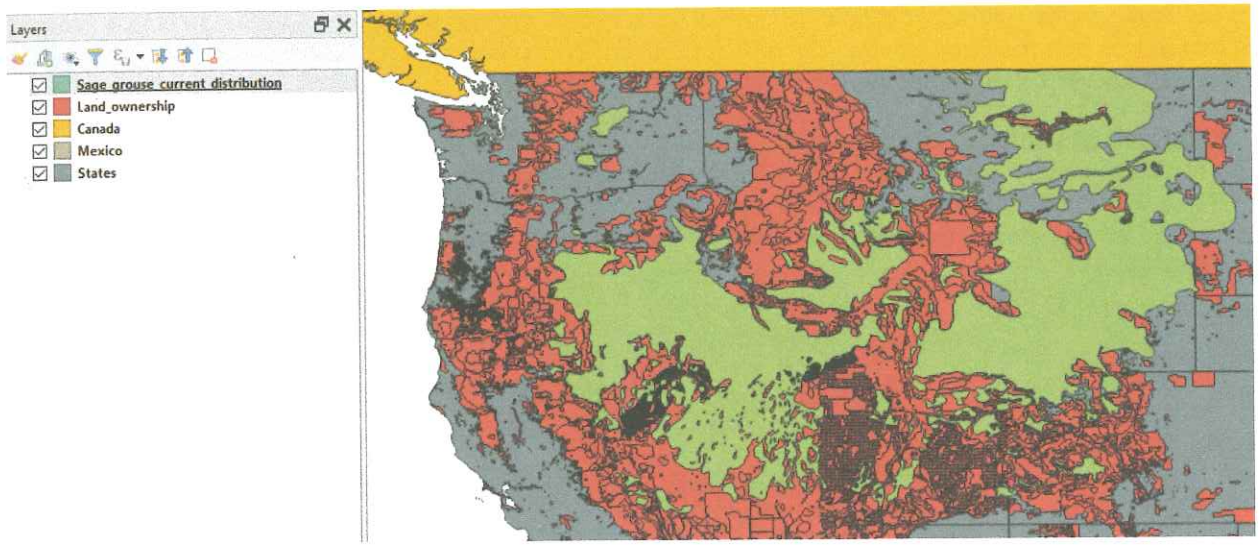

Figure 2.5: Layers Reordered and Zoomed into Sage-grouse Range

Now all the data layers should be in the correct order. Typically, data layers will be organized with point data layers on top of line layers on top of polygon layers. Raster data layers are usually placed at the bottom.

With the layers in the best drawing order, let's turn our attention to the coordinate reference system for the map.

13. Note that the lower right hand corner of QGIS displays EPSG: 4269. The number 4269 is the EPSG code for the coordinate reference system (CRS) the map is currently in (shown in figure 2.6).

Figure 2.6: Project CRS

EPSG codes are id numbers for different coordinate reference systems. They can be searched for from this website: `http://spatialreference.org/ref/epsg/`.

14. Click on `Project | Project Properties` from the menu bar to open the Project Properties window.

15. Select the CRS tab.

You can also simply click on the EPSG code in the lower right hand corner to open the Project Properties window to the CRS tab. This is a handy shortcut

The CRS for the current QGIS map project is highlighted in the Coordinate systems of the world section. The well known text version is displayed in the Selected CRS section. This is a detailed explanation of the CRS which is a

geographic coordinate system using the NAD83 datum. This section also shows a map with the valid bounds of the CRS. This CRS makes the lower 48 look stretched out and distorted, so you'll want to change the maps CRS into something that makes the lower 48 "look correct".

16. Click OK to close the Project Properties window.

Since the Sage_grouse_current_distribution layer is in an Albers projection, and the QGIS map is in a geographic CRS, that means that the Sage_grouse_current_distribution layer is being projected on-the-fly into the geographic projection of the map. This happens automatically in QGIS 3.

17. Right-click on the Sage_grouse_current_distribution layer and choose Set CRS | Set Project CRS from Layer option from the context menu (Figure 2.7). This will put the map into the same Albers CRS of the Sage grouse layer. Note that the EPSG code in the lower right corner now reads 5070 for the Albers CRS. This CRS gives the western U.S. an appearance we are more used to. Any other map layers not in Albers, will now be projected on the fly into Albers.

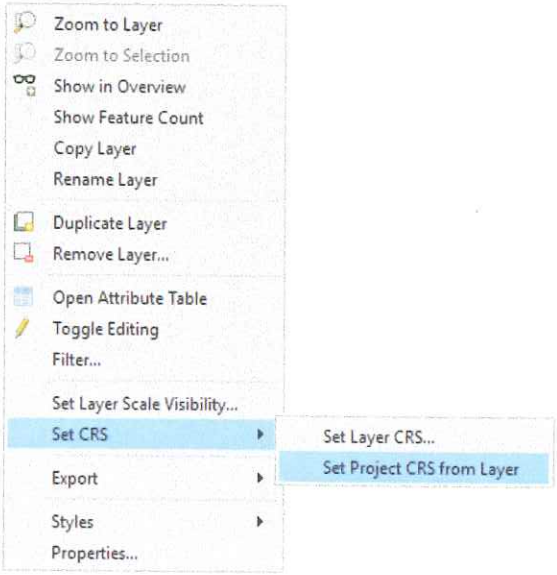

Figure 2.7: Setting the Project CRS to that of a layer

Now you will change the layer names in the Layers Panel. The layer names match the names of the shapefiles by default. However, these names will appear on the legend. So you will always want to change these to proper names that your map reading audience will understand.

18. Right-click on the Sage_grouse_current_distribution layer, and choose Properties from the context menu, to open the Layer Properties window. Choose the Source tab on the left. Click in the box next to Layer name and change the name to *Sage-grouse Habitat* (shown in figure 2.8, on the facing page). Click OK to close the Layer Properties window.

> Alternatively, you can right-click on a layer in the Layers Panel and choose Rename from the context menu to make the layer name editable directly in the Layers panel.

19. Change the other layers names as follows:

- Change Land ownership to Federal Land Ownership
- Change States to State Boundaries

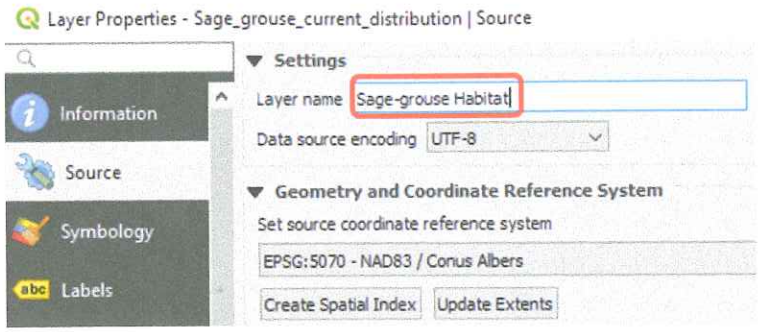

Figure 2.8: Changing the Layer Name

Notice that the Layer Properties window has a *Search* box in the upper left corner. If you cannot remember where a layer parameter is found within Layer Properties, you can use this to search for keywords. The Layer Properties tabs will be filtered based on your search term. For example, try typing *Coordinate* into the *Search* box too find information about the coordinate reference system for the layer. These search boxes are found throughout the QGIS interface.

20. Press `Ctrl + S` or choose `Project | Save` to save the changes you have made to your project.

2.4 Task 2 - Style Data Layers

Now that you have set up your map, you will symbolize your layers and begin to craft a well-designed map.

Visually you will want the land ownership and sage-grouse habitat to have the most weight. Canada and Mexico are there for reference but should fall to the background. You will make them both light gray.

1. Double-click on the Canada layer to open the Layer Properties window (this is a short cut to open Layer Properties).

2. Click on the Symbology tab.

3. Select Simple fill (reference figure 2.9).

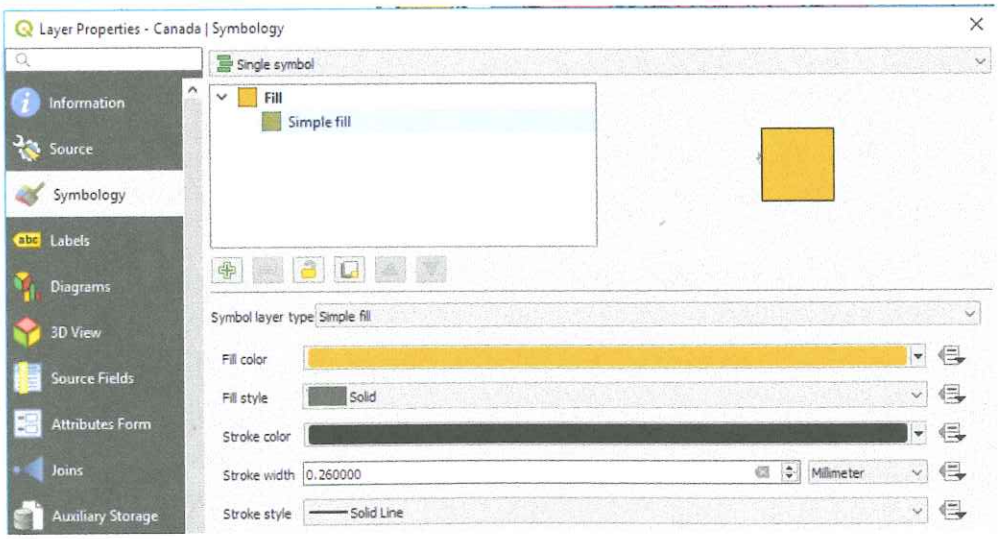

Figure 2.9: Simple Fill Settings

4. Below Symbol layer type are settings for both the fill and stroke for this polygon layer. Click on the color bar to the right of Fill color (shown in figure 2.10) to open the Select Fill Color window.

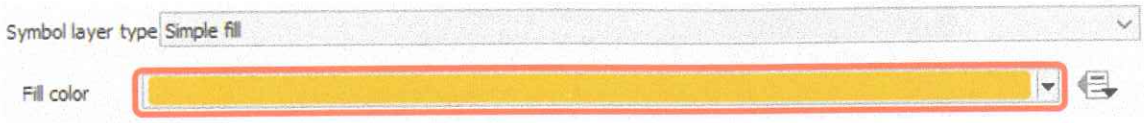

Figure 2.10: Changing the Fill Color

With the Select Fill Color window you can pick existing colors in a multitude of ways (shown in figure 2.11). To the left are four tabs that let you choose colors (from left to right) A) Color Ramp, B) a Color Wheel, C) Color Swatches, or a D) Color Picker. To the right you can define colors based on E) hue, saturation and value (HSV), F) red blue and green (RGB) values or G) HTML notation. There is also an Opacity slider.

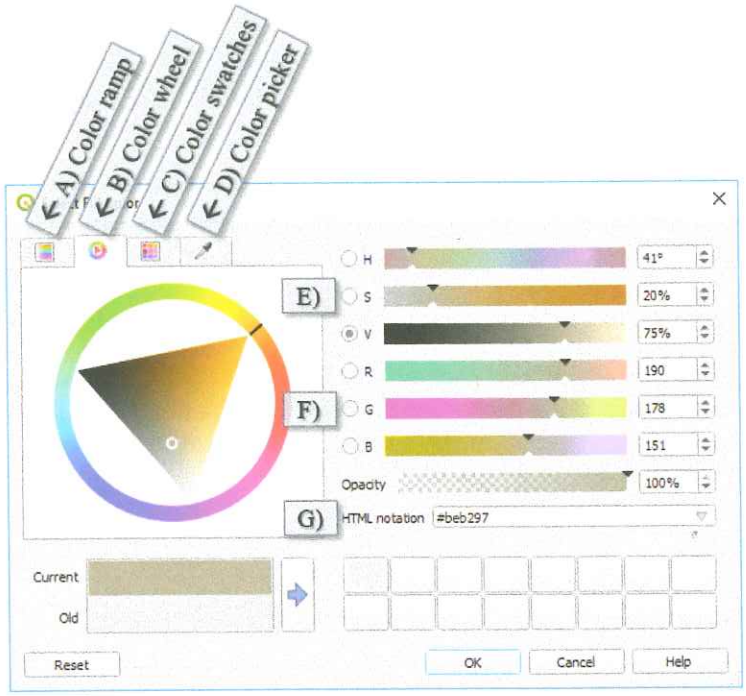

Figure 2.11: Color Picker Fill Settings

5. Set the color to Hue: 0 Sat: 0% and Val: 90%.

6. Click OK to close the Select Fill Color window.

7. Back in the Layer Properties window, keep the default Stroke style of Solid Line but note the other options from the dropdown menu.

8. Click OK on the Layer Properties window to close and accept the symbology settings for the Canada layer.

9. You will symbolize Mexico with the same symbol as Canada. Instead of going through the same steps you will use a short cut. Right-click on the Canada layer and choose Styles | Copy Styles | All Style Categories. Then right-click on Mexico and choose Styles | Paste Styles | All Style Categories.

Your map should now look like figure 2.12, on the facing page.

10. Using the same workflow, give the State Boundaries a white fill. You will be able to find white in the Color

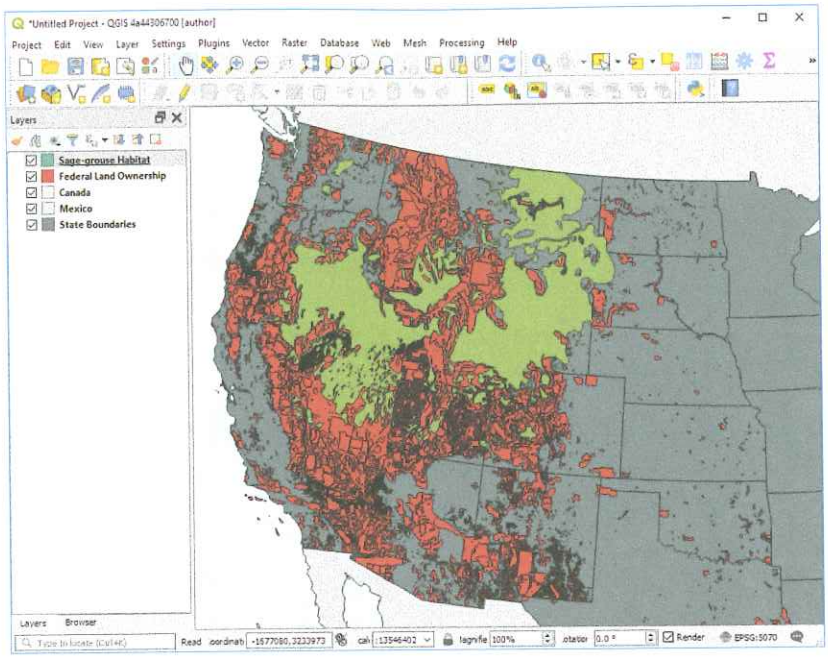

Figure 2.12: Mexico and Canada changed to a gray fill

swatches | Standard colors palette.

Now you will style the Land Ownership layer. Instead of making the entire layer one color as you have done thus far, you will assign a unique color to each land managing agency. You will also learn how to symbolize the layer using the Layer Styling Panel. How do you know which agency is managing each parcel? This will be information contained in the attribute table.

11. Right-click on Federal Land Ownership layer in the Layers Panel, and choose Open the Attribute Table from the context menu.

There are thirteen columns of information. Can you find the one that contains the land manager?

12. Close the Attribute table when done.

13. Find the row of buttons atop the Layers Panel. To open the Layer Styling Panel, click the left most button which looks like a paint brush (See figure 2.13, on the next page). You can also use the keyboard shortcut F7 to open this pane. The panel will open on the right side of the QGIS map canvas. Like all panels this can be undocked to a free floating panel or moved to a different docking position. In a dual monitor environment it can be nice to have the Styling Panel in a different monitor. At the top of the panel is a drop down menu that allows you to choose the target layer.

14. Set the target layer to Federal Land Ownership. Below the target layer is a dropdown for render type. So far you have used the default Single Symbol renderer. Now you will switch to Categorized renderer.

15. Click the drop down menu and change from Single Symbol to Categorized (Figure 2.14, on the following page). Next you need to choose the attribute column to symbolize the layer by. The column AGBUR is the one that contains the managing agency values.

16. Click the drop down arrow and choose AGBUR as the Column.

17. Click the Classify button (shown in figure 2.14, on the next page). This tells QGIS to sort through all the records in the table and identify all the unique values in that column. Now you will be able to assign a specific color to

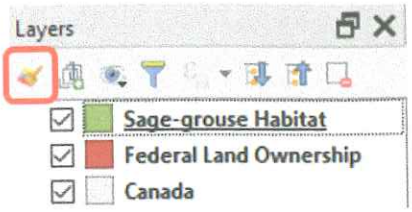

Figure 2.13: Opening the Layer Styling Panel

each class by double clicking on the color square.

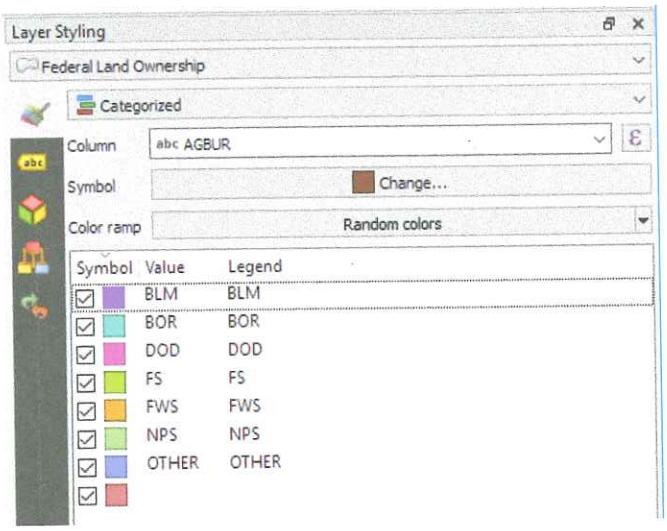

Figure 2.14: Setting up the Categorical Renderer

Notice that there is a symbol with no values. These are parcels with no values (NULL) in the `AGBUR` field. They represent private and state inholdings within federal lands. Since you are just interested in depicting federal land ownership you'll delete that symbol class.

18. Select that bottom symbol by clicking on it, and then click the Delete button  to remove that symbol. Now those parcels will not be included on the map.

For the remaining federal land ownership symbols you will use the BLM Standards Manual for land ownership maps `https://www.ntc.blm.gov/krc/uploads/223/Ownership_Map_Color_Reference_Sheet.pdf`

> Note: A PDF of the BLM Map Color Standards is also available in your exercise folder and is named `BLM Map Color Standards.pdf`.

The BLM has designated colors for each type of land ownership. When composing a map it is important to pay attention to industry specific standards. Following them will make the map more intuitive to the target audience. For example, people are used to seeing Forest Service land depicted in a certain shade of green.

19. To color BLM lands, double-click on the color patch left of BLM in the Layer Styling Panel. The Symbol selector for BLM lands will open.

20. Select Simple fill.

21. Click on the Fill color patch to open the Symbol Selector > Select Fill Color window.

22. In the Symbol Select Fill Color window, change the Red, Green, and Blue values to 254, 230, and 121 respectively (shown in figure 2.15). This will change the color to a specific shade of tan representing BLM lands. Click the Go back button twice to return to the main layer in the Layer Styling Panel.

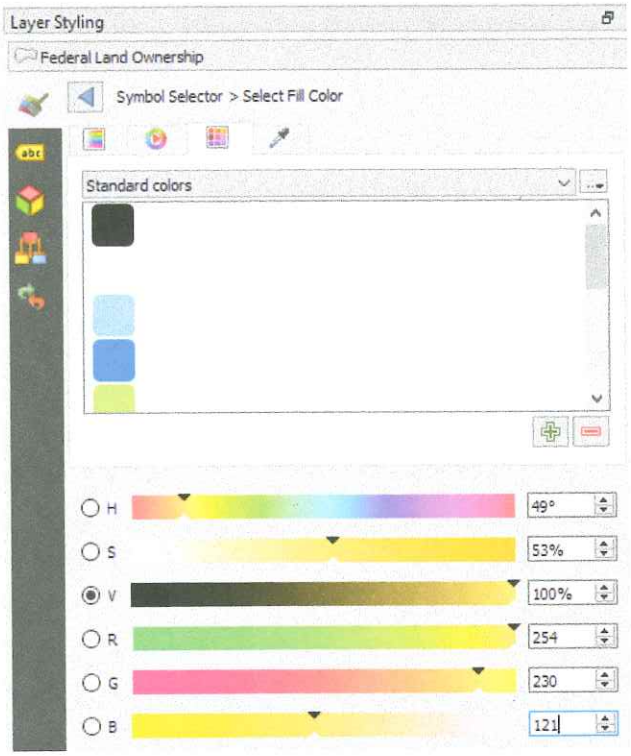

Figure 2.15: Setting the Fill Color for BLM Lands

Notice as you make changes with the Layer Styling Panel, that those changes appear instantly on the Map Canvas, without having to click an Apply button! This becomes even more powerful when using tools like the Color wheel to find just the right color interactively. All symbology and Labeling options are available from the Panel. So there are two places to make Symbology changes in QGIS: Layer Properties | Symbology and the Layer Styling Panel. Many users find making changes from the Panel to be so efficient that they rarely use Layer Properties | Symbology.

23. Use the values below to change the RGB colors for the remaining six land ownership classes.

- BOR -- 255, 255, 179
- DOD -- 251, 180, 206
- FS -- 179, 222, 105
- FWS -- 127, 204, 167
- NPS -- 177, 137, 193
- OTHER -- 150, 150, 150

Finally you do not want any border lines on these polygons. They are too visually distracting on such a complicated thematic polygon layer.

24. Make sure you are back at the main layer styling with all land ownership classes visible in the Layer Styling Panel.

25. Unselect all the layers by clicking in the white space outside of the land ownership symbol classes.

26. Just below where the Column is specified locate the Symbol -- Change... button. Click the Change... button.

27. Select Simple fill and change the Stroke Style to No Pen. This will remove the outline for all polygons.

28. Click the Go back button to return to the main layer. Again using this setting provides a way to make a change to all symbol classes, or all selected Symbol classes, in one operation.

29. Turn off Sage-grouse Habitat by clicking the check box next to the name in the Layers Panel.

Your map should now resemble figure 2.16.

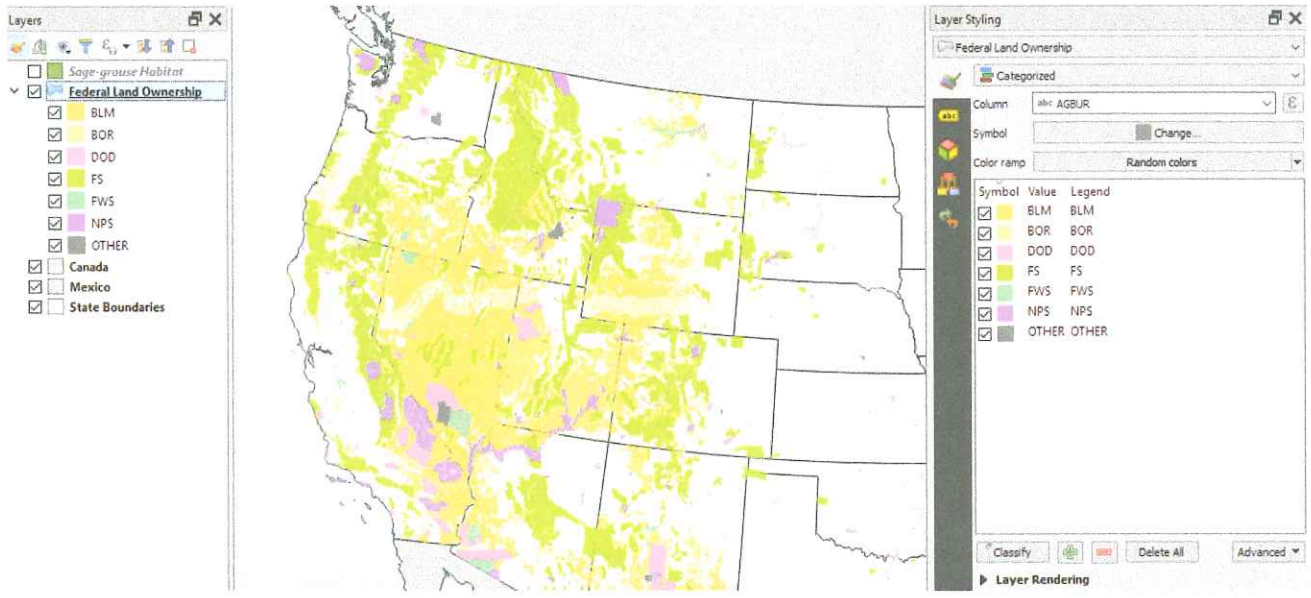

Figure 2.16: Federal Lands Symbolized

Now you will set a background color for the map. Since states are filled with white, setting a background color of light blue will serve to represent the Pacific Ocean.

30. From the menu bar choose `Project | Project Properties`.

31. On the General tab, click the white color patch next to Background color to open the Select Color window.

32. Set the RGB value to: 224, 254, 254.

33. Click OK on the Select Color window and OK on Project Properties to save the setting.

The states are white with a black border and serve to show non-federal land as white which is great. However, the Sage-grouse_Habitat_styling34 are obscured since they are below Federal Land Ownership.

34. Right-click on the State Boundaries layer and choose Duplicate from the context menu. You can have multiple copies of layers for cartographic purposes.

35. Drag the Duplicated layer (State Boundaries copy) to the top of the Layers Panel and turn it on.

36. Set State Boundaries copy as the target layer in the Layer Styling Panel.

37. Click on Simple fill.

38. Give the layer a Fill style of No Brush (see figure below). It will now just be the state outlines above Federal Land Ownership.

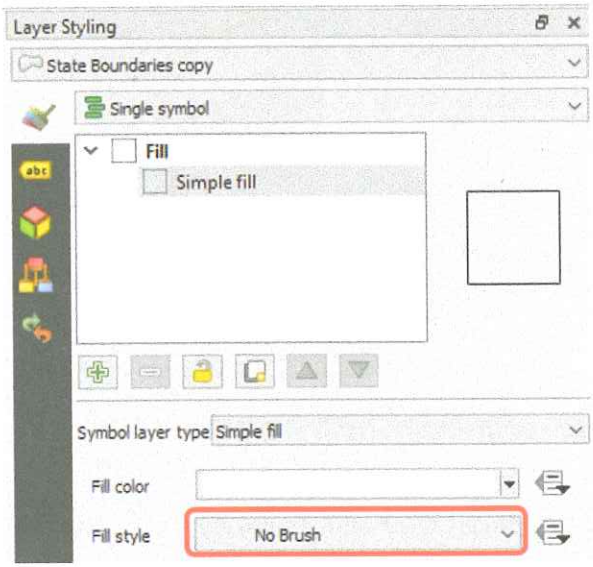

Figure 2.17: Duplicated State Boundaries Set to No Brush

The last layer to work with is the Sage-grouse Habitat. You will make the Sage-grouse Habitat polygons have a crosshatch pattern. This will allow the map reader to see the land ownership data beneath.

39. Turn on the visibility for the Sage-grouse Habitat layer.

40. Set the Sage-grouse Habitat as the target layer in the Layer Styling Panel.

41. Click on Simple fill.

42. Change the Symbol layer type to Line pattern fill. This fills the polygons with a line pattern and allows you to adjust line width, color, angle and spacing.

43. Click on Simple line. Change the Color to RGB 170, 0, 255.

44. Click on Line pattern fill. Change the Spacing to 1.5.

45. Now you will add an outline to this symbol. To do this you will add a new symbol element. Select the Fill and click the Add symbol layer button.

46. A Simple fill symbol layer is added. Change the Fill style to No Brush.

47. To set the Stroke color you choose the purple you just chose for the Line pattern fill from the set of recently used colors. Click the drop down arrow to the right of the Stroke color. Find the Recently Used Colors, locate the purple, and click on it. See Figure 2.18, on the following page.

48. Set the Stroke width to 0.46.

49. Now you will zoom in tighter to the Sage-grouse Habitat data.

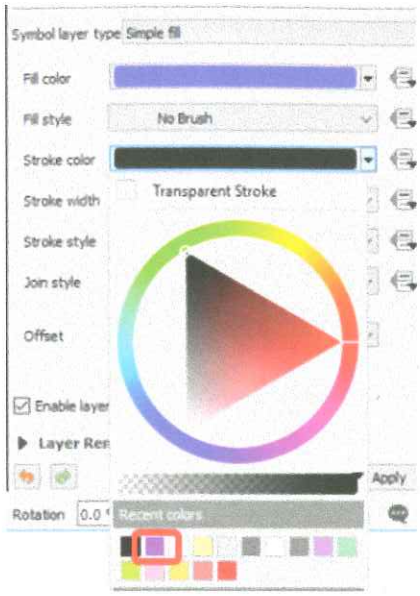

Figure 2.18: Choosing a Recent Color

50. Right-click on the Sage-grouse Habitat layer and choose Zoom to Layer from the context menu. (see figure 2.19).

As it turns out, the data for Mexico is not needed. Sometimes you are given data that does not end up being used, but is nice to have in case you do need it.

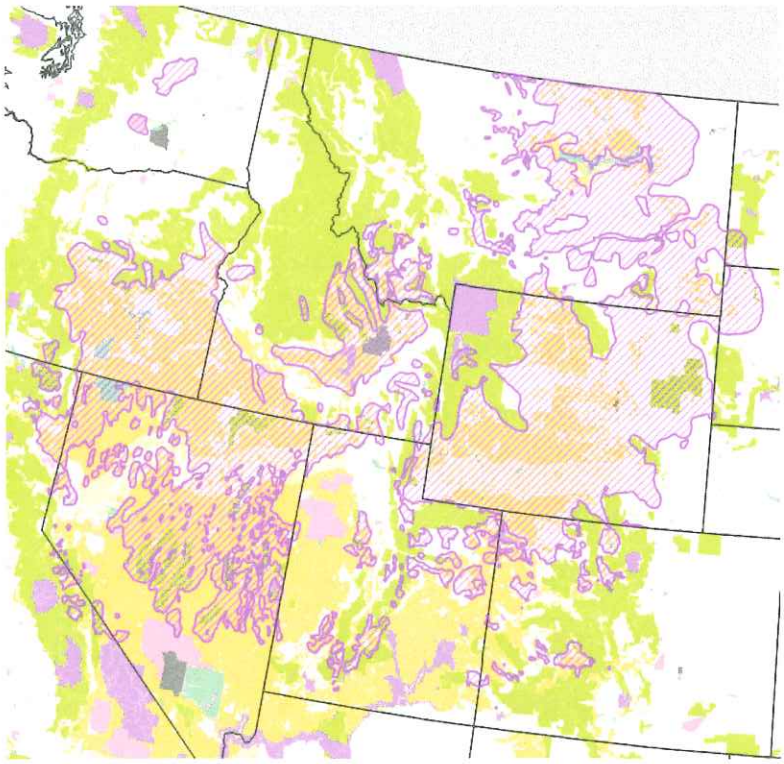

Figure 2.19: Final Map Extent

51. Save your project!

2.5 Task 3 - Compose Map Deliverable

Now that all the data is well styled you can compose the map deliverable.

> Note that this task incorporates some changes to the layout new to QGIS 3.6. There is nothing that will prevent you from completing it in 3.4 however. If using 3.4 you will just see different options for setting the map extent in the Print Composer.

1. First you will open a New Print Layout. From the menu bar choose `Project | New Print Layout`, click the New Print Layout button or use the keyboard shortcut `Ctrl + P`.

2. Name the Layout *"Exercise 2 - Sage-grouse Habitat"* (shown in figure 2.20).

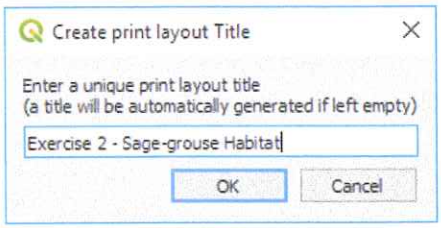

Figure 2.20: Beginning a New Print Layout by Entering a Title

3. Click OK. A new Print Layout will open. This is where you craft your map.

The Print Layout is an application window with many tools that allow you to craft a map. For detailed information about the Print Layout, refer to the QGIS manual: `https://docs.qgis.org/testing/en/docs/user_manual/print_composer/overview_composer.html` The main window of the Print Layout displays the piece of paper upon which the map will be designed. There are buttons along the left side of the window that allow you to add various map elements: map, scale bar, photo, text, shapes, attribute tables, etc. Each item added to the map canvas becomes a graphic object that can be further manipulated (if selected) by the Item Properties tab on the right side of the layout. Across the top are buttons for exporting the composition, navigating within the composition and some other graphic tools (grouping/ungrouping etc.)

4. Your first task will be to set the paper size. The default paper size is A4. The requirements document specified a letter sized map. To change the sheet size right-click on the blank page and choose Page properties from the context menu. The Item Properties tab changes to display Page properties (figure 2.21, on the next page).

> QGIS Print Layouts allow you to add as many pages to a Layout as you wish. These can also be of differing page sizes and orientations. You need to right-click on a given page to access the page dimensions.

5. Here you can specify details about the overall composition. Set the Size to Letter.

6. Next set the Orientation to Landscape.

7. Using the Add new map to layout button, drag a box on the map sheet where you'd like the map to go. Remember that you'll need room for a title at the top of the page and a legend to the right of the map (reference figure 2.22, on page 49).

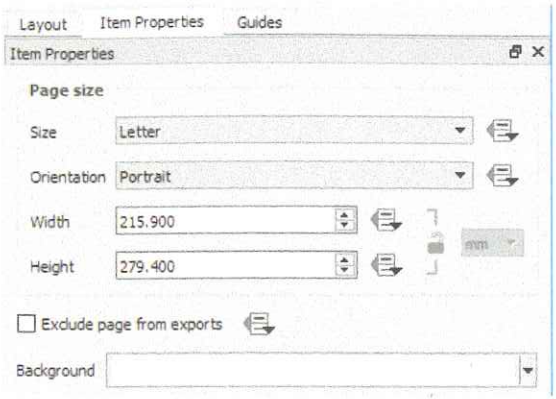

Figure 2.21: Page Properties

The map object can be resized after it's added by selecting it and using the handles around the perimeter to resize with the Select/Move item tool. This tool lets you select map features such as the map, a text block, legend etc. Remember when an object is selected, the Item Properties tab will show properties specific to that object.

8. With the map selected click on the Item Properties tab. New to QGIS 3.6 are a series of buttons across the top of the panel for controlling the map extent. Click the Set Map Extent to Match Main Canvas Extent button. That will help orient the map on the sheet of paper as it appears in QGIS Desktop. *(There is a fuller explanation for this button series in Part 4 - Exercise 1.)*

If you need to make adjustments to the scale in the Main properties section you can adjust the Scale value. Map scale is a ratio of Map Distance/Ground Distance. Here the number is roughly 8400000 which can be read as a scale of 1:8,400,000. To zoom out you increase this number. To zoom in you reduce this number. Clicking the Update Map Preview button forces the map view to refresh.

9. Set the Scale value to 9000000

10. If you need to pan the map you can use the Move Item Content button. This allows you to pan the map content in the map frame without changing the scale. It is normal to have to make adjustments to get the map extent just right. Try to make your figure match the figure 2.22, on the next page.

Now you will add the title to your map.

11. Use the Add new label tool to drag a box all the way across the top of the composition. The text box can be resized after the fact by using the graphic handles.

12. By default the text box will be populated with the placeholder text *Lorem ipsum*. Using the Item Properties tab Main Properties section, replace the holder text with the title: *'Greater sage-grouse Current Distribution'*.

13. In the Appearance section you can change the font. Click the Font button to open the Text Format window. Change the font to : Times New Roman, Bold, Size 36. You can use the search box above the font list to search for Times New Roman.

14. Below the font settings are some alignment settings. Set the Horizontal and Vertical alignment to center.

15. Now you will add a legend. Use the Add new legend tool to drag a box on the right side of the map (shown in figure 2.24, on page 50).

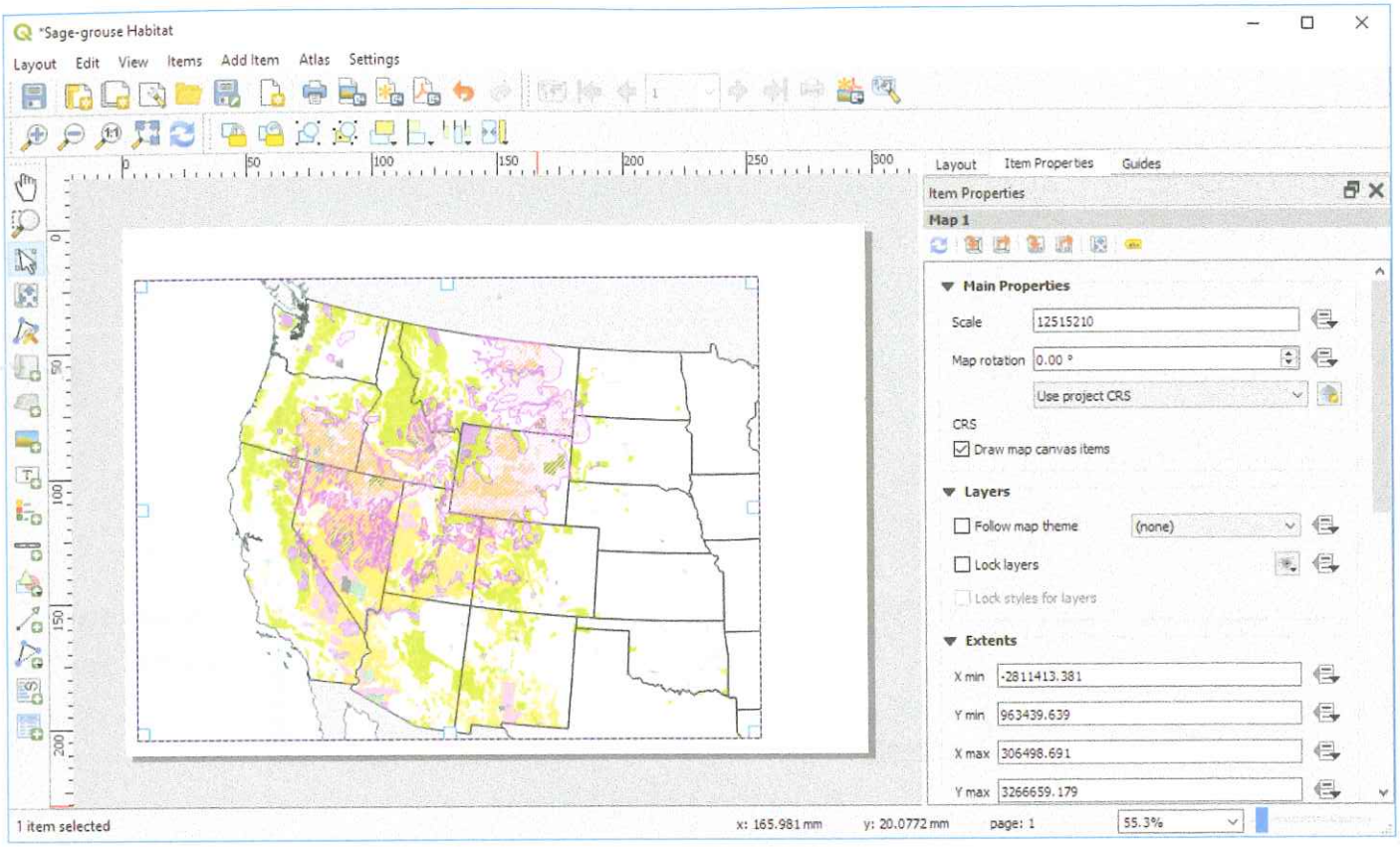

Figure 2.22: Print Layout Extent

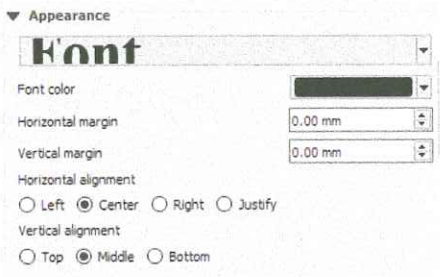

Figure 2.23: Title Font Settings

The upper most State boundaries copy layer does not need to appear in the legend, nor does Mexico. State boundaries copy is there purely for cartographic reasons and Mexico does not appear on the map. The Item Properties tab will be used to configure the legend (see figure 2.25, on the next page).

16. Uncheck Auto update. This will enable you to modify the legend, however, updates to the map will no longer be reflected in the legend unless you re-enable Auto update.

17. Select the State Boundaries copy layer and click the Remove item button to remove it. Do the same for Mexico.

18. Now you will work with the Federal Land Ownership layer. The land ownership classes are abbreviations. Here you will edit them to be more clear to the map readers. Click on the BLM class and click the Edit button.

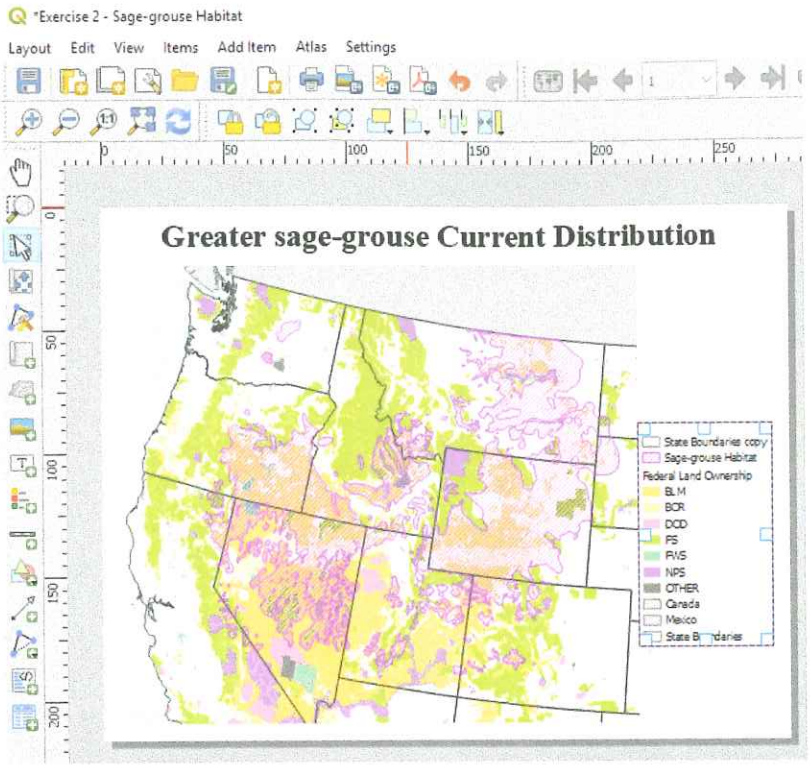

Figure 2.24: Adding A Legend

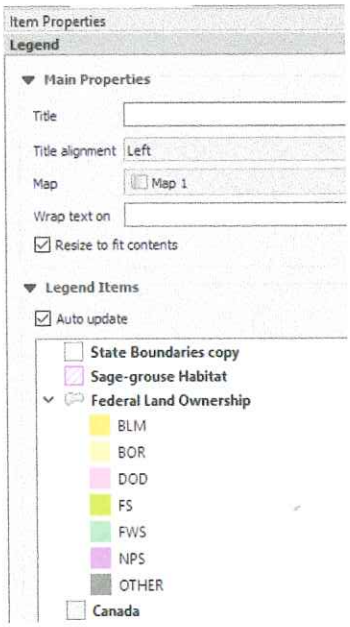

Figure 2.25: Legend Properties

19. In the Legend item properties window change the name to "Bureau of Land Management". Go through each remaining land ownership class and edit them to match the figure 2.26, on the facing page.

Now you will add a neatline around our map.

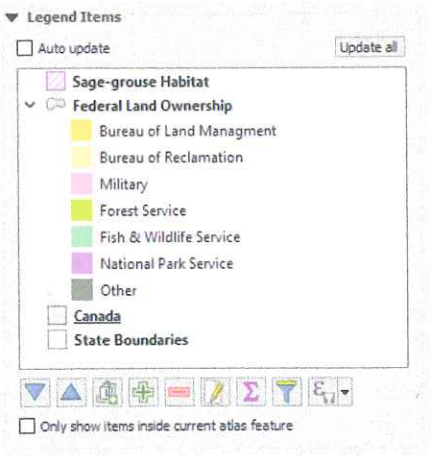

Figure 2.26: Legend Labels

20. From the set of toolbar click the Add Shape tool. It is an expandable tool with three options. Choose rectangle as shown in figure 2.27.

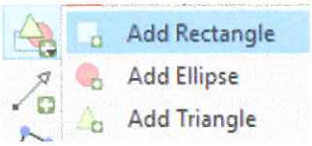

Figure 2.27: Add Shape -> Add Rectangle Tool

21. Drag a box around the map object and legend.

22. On the Item Properties tab, click the Style button.

23. Click Simple fill and give it a Fill style of No Brush.

24. Give it a Stroke width of 1.

25. Adjust the box so that it aligns with the map boundary.

You may find it necessary to send the neatline to the back so you can still select the map object or legends. Technically these are underneath the neatline object since it was added last. Across the top the Layout has a series of graphic tools on the Actions Toolbar. These allow you to control: object locking, grouping/ungrouping objects, raising/lowering objects, aligning objects, distributing objects and resizing objects.

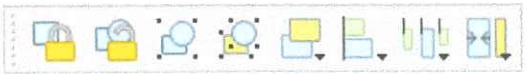

Figure 2.28: Actions Toolbar

26. Select the neatline rectangle and choose Send to back as shown in the figure 2.29, on the following page.

The last items to add to the map are the data sources and date.

27. Click the Add new label tool.

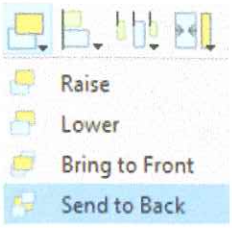

Figure 2.29: Send to Back

28. Drag a box in the lower right hand corner of the composition. Using the Item Properties type:

- Data Sources: The National Atlas & USFWS
- Cartographer: <your name>
- Date: Month, Day, Year

29. You can manually enter the date. However, as an additional challenge, it is also possible to use an expression to automate the date. To do this click on the Insert an expression button.

30. The Insert expression window opens.

31. Use the search box to find the String | concat() function.

- Double click on the function to enter it into the expression. This functions concatenates different blocks of text together.
- Inside the parenthesis type: `'Created on: '`
- As you form your expression you will see a small red triangle indicating an issue with your expression. This is to be expected since you haven't completed it yet. It is designed to be a helpful indicator of an invalid expression

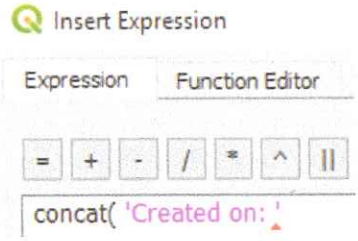

Figure 2.30: Concat Function

- Enter a comma after this first text block (after the single quote).
- Now search for the Conversions | to_date() function.
- Double-click it to add it to your expression after the comma.
- Enter the variable `$now` after the opening parenthesis.
- End your expression with two closing parentheses.

- Your expression should now look like: `concat('Created on: ', to_date($now))`
- Click OK to insert your expression.

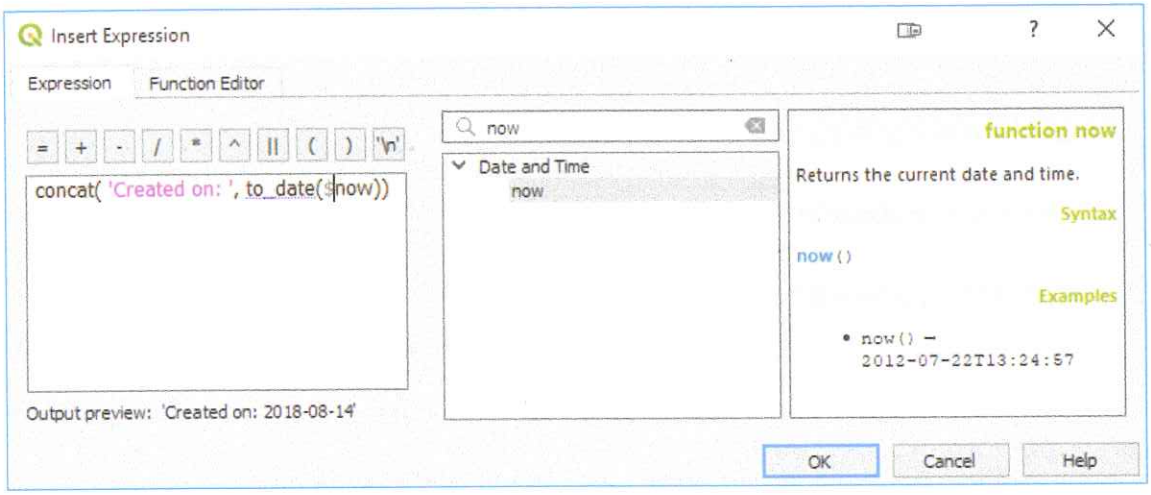

Figure 2.31: Date Expression in the Expression Window

32. Format the expression so that it is just after the Cartographer line.

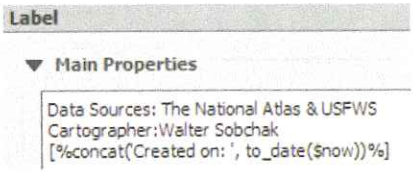

Figure 2.32: Final Text with Expression

33. To finish set to font for the text as Times New Roman with a font size of 8.

34. Congratulations your map is finished! The final step is to export it to a high-resolution jpg image.

35. Click the Export as image  button.

36. The Save Layout As window opens.

- Choose the `Exercise 2\Data` folder.
- Choose JPG as the Save as type
- Name the file `exercise2_Map.jpg` and click Save.
- The Image Export Options window will open. Since the requirements document specified 300 dpi keep this default setting and click Save.

37. The final map should look like the figure below.

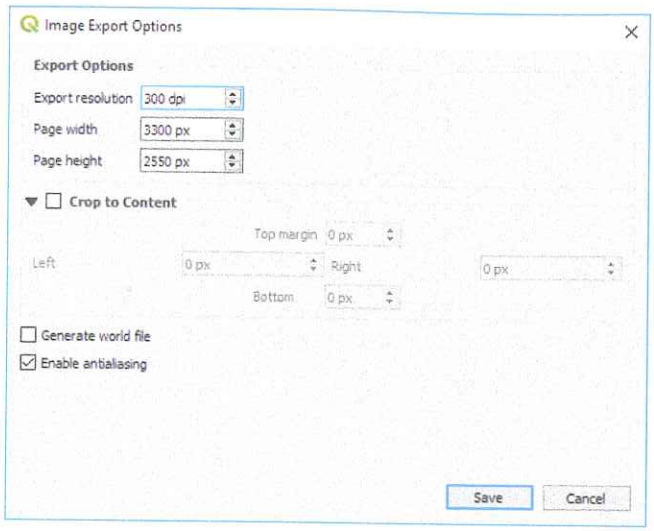

Figure 2.33: Image Export Options

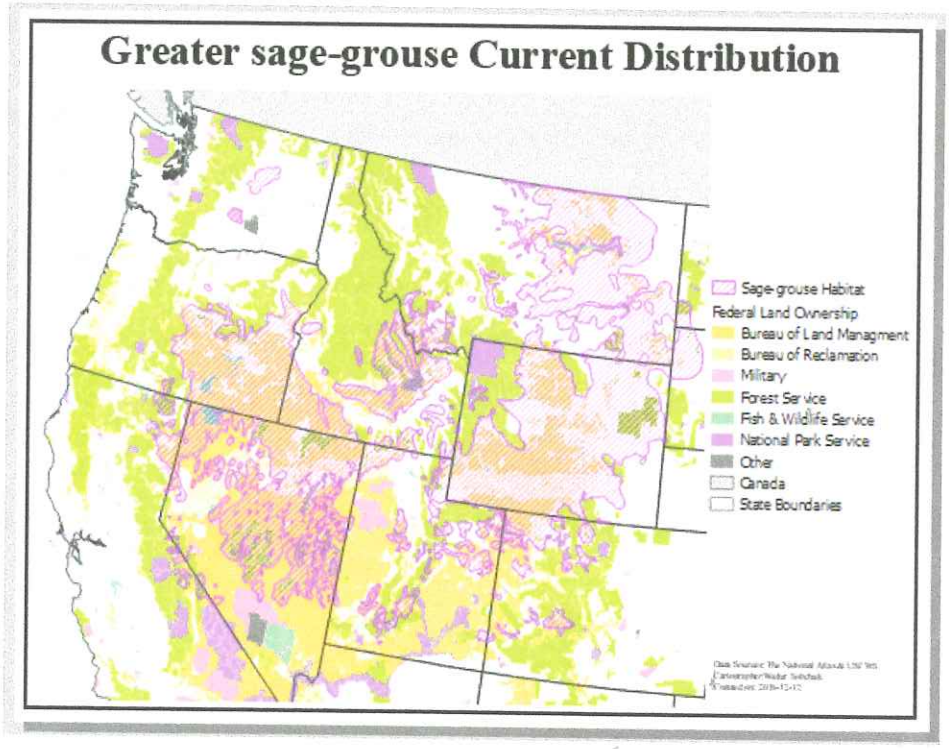

Figure 2.34: Final Map

2.6 Conclusion

In this exercise you created a well-designed map using some of the cartography tools available in QGIS Desktop. You created a nice map highlighting federal land ownership within sage-grouse habitat for a client. This involved styling layers, styling layers by categorical attributes and crafting a map composition.

2.7 Discussion Questions

1. Export the final map as a high-resolution jpg for your instructor to grade.

2. What are two ways to add vector data to QGIS Desktop?

3. How would a portrait orientation change the composition of the map? Describe how you would arrange the map elements.

4. No map is perfect. Critique this map. What do you like about it? What do you dislike about it? How would you change this map to improve it? Would you add other data layers or add labels? One of the best ways to evaluate a map is to judge how it delivers the desired message to the target audience.

2.8 Challenge Assignment

1. Another biologist working with black bears on the east coast heard about your great work on the sage-grouse map. She would like you to create a similar map for her. The data she is providing is in the `Exercise 2 Data/Challenge` folder.

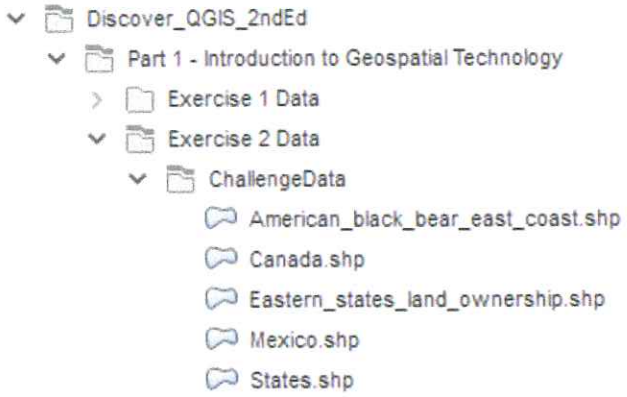

Figure 2.35: Challenge Data

2. She also needs a letter sized, color, map figure that shows the relationship between black bear habitat and federal land ownership along the eastern seaboard. She is interested in seeing how much habitat is under federal versus non-federal ownership.

3. She is providing data from the US Fish and Wildlife Service depicting current occupied range for black bear on the east coast. She is also providing federal land ownership, state boundaries and country boundaries from the US National Atlas. The land ownership data has an attribute column describing which federal agency manages the land (AGBUR). This land ownership dataset has another category in the AGBUR field for Wilderness Areas called "Wild". These should be styled with a dark green.

4. She wants to have the habitat data shown so that the federal land ownership data is visible beneath. She would like each different type of federal land styled with standard Bureau of Land Management colors. The map should also include a title ("Black Bear Current Distribution"), a legend, data sources and the date. The map should be a high-resolution (300 dpi) jpg image. Perhaps you can incorporate some improvements to this map!

5. There are several features of QGIS that can greatly speed up map production once you've already built a similar map with similar data. You don't need to start from the beginning on the new map. You can:

   a. Save a copy of the current QGIS project. (`Project | Save As...` or `Ctrl + Shift + S`). Then bring the other set of data in and Copy/Paste the symbology as you did with copying the Canada symbology to Mexico. Then remove the original Sage-grouse related data.

b. Save the symbols for these layers as QML files. Open Layer Properties | Symbology. At the bottom of the window in the Layer Rendering section find the Style drop-down menu and choose Save Style... In the Save Layer Style window save the QML file to the exercise folder. Add the new layer and open Layer Properties | Symbology and choose Style | Load Style and select the QML file. This is more steps, but is useful if you think you will use a style repeatedly for different map projects.

c. You can save map templates which helps with time spent on the Print Layout. Templates store all the map elements. You can then load a map template into a new Print Layout. To save your Sage-grouse map as a template open the Print Layout. Then choose `Layout | Save as template`. You can then choose `Layout | Add Items from Template` to load this template into Print Layouts in other projects. All map elements will be imported. This can save considerable time. Organizations often use this strategy because it allows them to create a create a consistent look. For example, which logo is used and where it is placed. Plus the template can include all required map elements, so organizational maps have a consistent style. Once a template has been imported, you will still need to tweak the positions of map elements to accommodate the new geography.

d. You can also Duplicate Print Layouts (`Layout | Duplicate Layout`) for quick duplication of a map.

6. Experiment with these techniques during this challenge to learn which workflow is best for you in this situation.