Exercise 4

Vector Data Analysis - Overlay Techniques

Objective - Understanding Basic Vector Analysis Using Overlays

4.1 Introduction

In this exercise, you will be learn about several powerful vector analysis tools. The tools are all considered overlay tools, since they produce outputs defined by how features overlap one another. You will be working with several datasets covering the Sierra National Forest in California.
This exercise includes the following tasks:

- Task 1 - Clip
- Task 2 - Intersection
- Task 3 - Union
- Task 4 - Intersection # 2

4.2 Objective Understanding Basic Vector Analysis Using Overlays

The objective of this exercise is to understand basic use of vector overlays in a geospatial analysis.

Vector Overlays – A set of tools, which work on the spatial relationships between two input vector datasets. The output is a new dataset derived from those spatial relationships.

Clip – Outputs the features of the input dataset that fall within the features of the clip dataset. It is commonly used to cut datasets to the study area boundary.

Intersection – Takes two polygon datasets and outputs the areas common to both.

Union – A topological overlay of two polygon datasets, the output preserves the features that fall within the spatial extent of either input dataset.

4.3 Task 1 - Clip

This exercise focuses on the Sierra National Forest in California. Datasets include: the National Forest boundary, Ranger Districts, and habitat data for both spotted owl and Southwest willow flycatcher. In this first task, you will be clipping data to the study area. The spotted owl is listed as Threatened and the southwest willow flycatcher is listed as endangered by the U.S. Fish and Wildlife Service.

Figure 4.1: Southwest Willow Flycatcher - Photo credit Jim Rorabaugh/USFWS [Public domain]

Figure 4.2: Spotted Owl - Photo credit John and Karen Hollingsworth; photo by USFS Region 5 (Pacific Southwest) [Public domain]

1. Open QGIS.

2. From the exercise directory, add both the `Sierra_Natl_Forest.shp` and `CA_Spotted_Owl_HmRngCore.shp` shapefiles to QGIS.

3. Move the Sierra National Forest layer below the spotted owl layer so the map canvas resembles the figure 4.3, on the next page.

In this case, you are only interested in the data covering the Sierra National Forest. Notice that the spotted owl data covers far more territory than the forest. Therefore, you will clip the spotted owl data to the forest boundary. Clip will create a new shapefile consisting of the spotted owl polygons within the forest boundary. It is standard protocol to clip datasets to the extent of the study area. This reduces data to only that which needs to be processed, and makes processing and rendering faster.

Before conducting a spatial analysis, you need to ensure that all the involved layers are in the same coordinate reference system.

4. Open the Layer Properties for each layer, and identify the coordinate reference system.

Question # 1 – Are both layers in the same coordinate reference system? What is the coordinate reference system of each layer?

5. From the menu bar choose `Vector | Geoprocessing Tools | Clip`. This will open the Clip tool. Enter the following options:

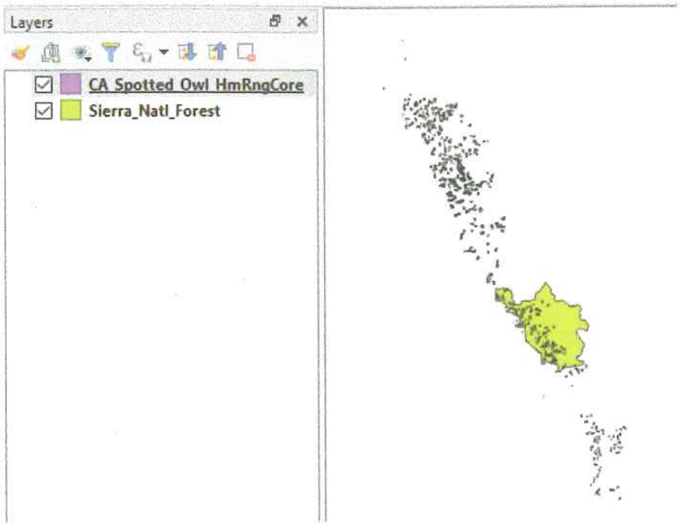

Figure 4.3: Sierra National Forest and Spotted Owl Data

a. Input layer = CA_Spotted_Owl_HmRngCore
b. Overlay layer = Sierra_Natl_Forest
c. Clipped output = `Exercise_4_Data/MyData/Sierra_Spotted_Owl.shp`

e. Click Run
f. Click Close

> NOTE that QGIS lets you save geoprocessing output into a variety of formats including File (shapefile etc.), GeoPackages, PostGIS and the default of a temporary layer. The latter can be very useful when generating intermediate datasets or for testing an algorithm.

6. The new layer will appear in the Layers Panel. Remove the original CA_Spotted_Owl_HmRngCore layer as you no longer need it.

7. Right-click on the Sierra_Natl_Forest layer and choose Zoom to Layer.

Your map should now resemble the figure 4.4, on the following page. Unlike selecting by location and exporting the selected set to a new layer, the Clip operation actually cuts spotted owl polygons at the forest boundary where they crossed the forest boundary.

8. Save the project as `Exercise4.qgz` in the data folder.

4.4 Task 2 - Intersection

You will now include the southwest willow flycatcher habitat data in the analysis.

1. Open QGIS and open `Exercise_4_Data/Exercise4.qgz` if it is not already.

2. Add `Sierra_WillowFlycatcher.shp` shapefile to QGIS. This data set falls completely within the forest boundary so there is no need to clip it.

3. Drag the Sierra_WillowFlycatcher layer to the top of the layers list in the Layers Panel so it draws on top of all other layers.

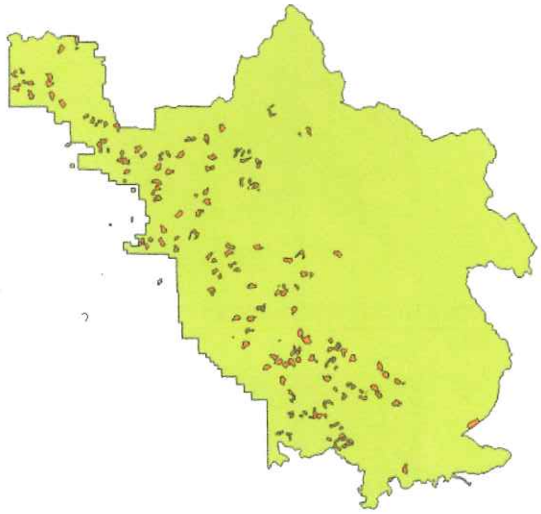

Figure 4.4: Spotted Owl Data Clipped to the National Forest Boundary

4. Spend a few minutes styling your data.

   a. Give the National forest a light green color and black outline.
   b. Give the spotted owl habitat an orange fill and black outline.
   c. Give the Southwest willow flycatcher habitat a red fill and red outline.

5. Your map should now resemble the figure 4.5, on the next page.

6. Use the Zoom In tool to drag a box and zoom in to the area outlined in black in the figure 4.5, on the facing page above.

You will notice that in this area, there is some overlap between the Southwest willow flycatcher and spotted owl habitat (shown figure 4.6, on the next page). Since these are both sensitive species, areas of habitat overlap will be important areas to protect. You could certainly conduct a spatial query to select Southwest willow flycatcher polygons that overlap spotted owl polygons. However, here you will see the value of using the Intersection tool to identify these overlapping areas.

7. Open the Processing Toolbox by choosing `Processing | Toolbox` or by clicking the Toolbox button.

> This tool can also be found by clicking the menu bar and choosing Vector menu | Geoprocessing Tools | Intersection.

8. Search for *Intersection* and find the Intersection tool in the Vector Overlay section.

9. Fill out the tool with the following parameters (shown in figure 4.8, on page 144):

   a. Input layer = Sierra_Spotted_Owl
   b. Overlay layer = Sierra_WillowFlycatcher
   c. Save the Intersection output as a shapefile named `Exercise_4_Data/MyData/OverlapAreas.shp`.
   d. Check Open output file after running algorithm.

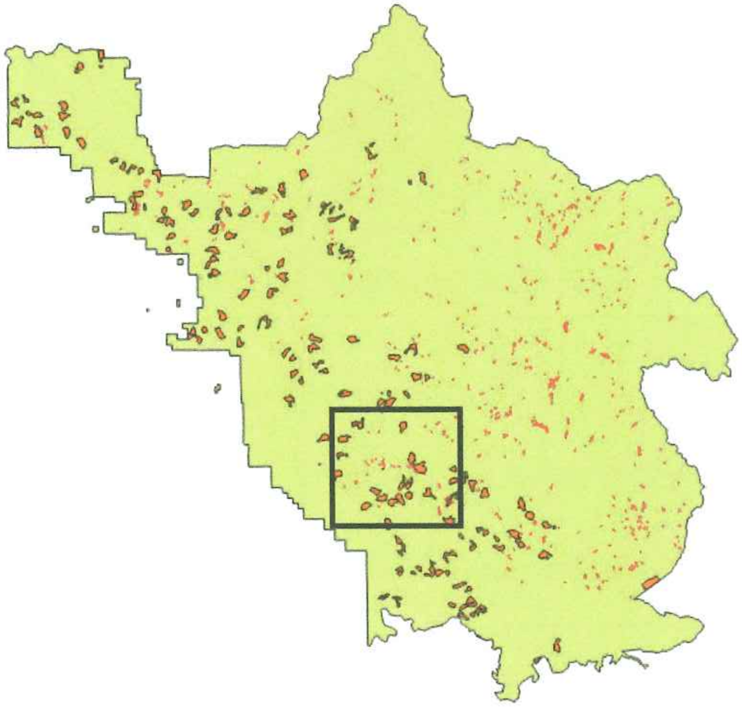

Figure 4.5: All Three Layers Loaded and Symbolized

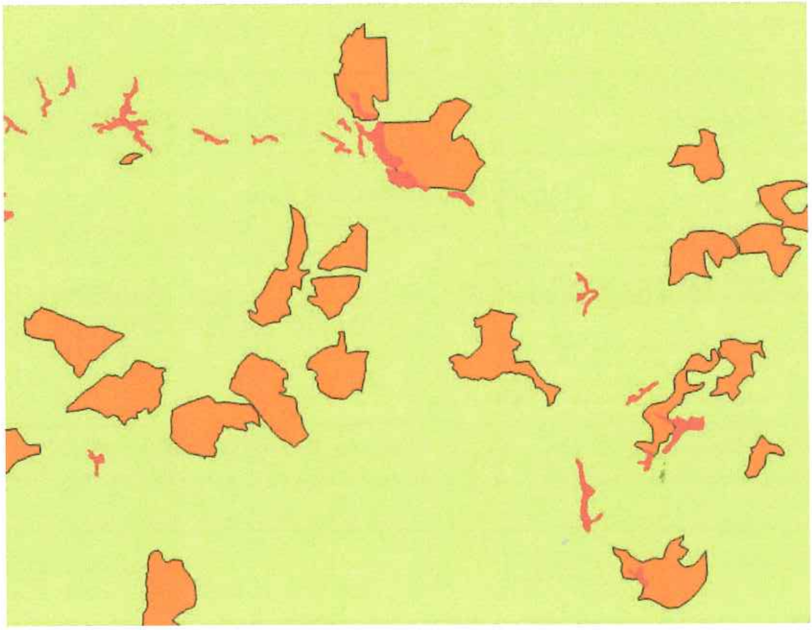

Figure 4.6: Zoomed in to Overlap Areas

e. Click Run to perform the intersect operation and Close when it has finished.

10. Drag the OverlapAreas layer to the top of the layers list in the Layers Panel so it draws on top of all other layers.

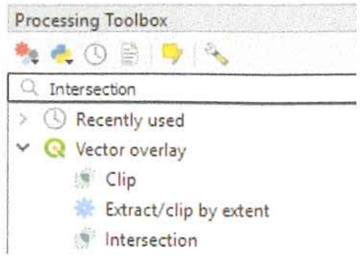

Figure 4.7: Searching the Processing Toolbox

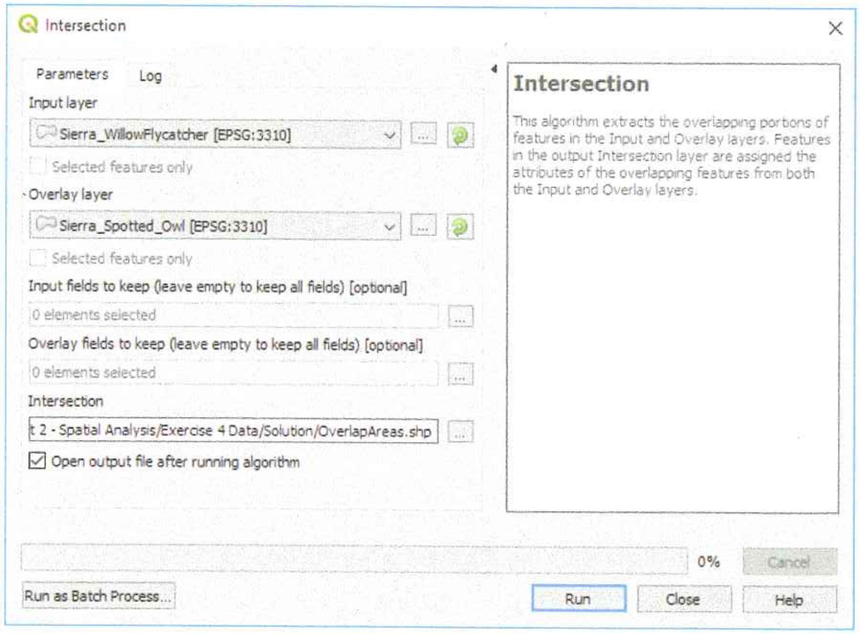

Figure 4.8: Intersection Tool

11. Style the OverlapAreas with a bright yellow Fill and Border. Your map should now resemble the figure 4.9, on the next page.

12. Save your map.

> The GEOS geometry engine used by QGIS has a high standard for feature geometries. Especially when running vector overlay operations you may recieve invalid geometry errors. In that case you can run the Vectory Geometry | Fix geometries tool.

4.5 Task 3 - Union

You will now combine both habitat layers in different ways using both the Union and Dissolve tools. Union creates a new GIS layer that combines all the geometries of both input layers. Dissolve merges all coincident polygons together.

1. Open QGIS and open `Exercise_4_Data/Exercise4.qgz` if it is not already.

2. Search the Processing Toolbox for *Union* and find the Union tool in the Vector Overlay section.

3. Fill out the Union tool as in the figure 4.10, on the facing page:

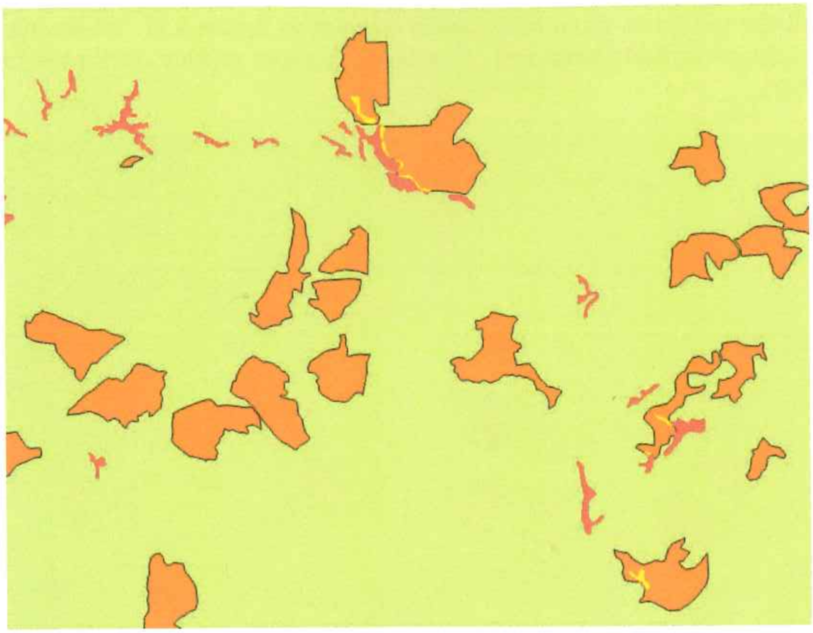

Figure 4.9: Areas of Habitat Overlap

a. Input layer = Sierra_Spotted_Owl
b. Overlay layer = Sierra_WillowFlycatcher
c. Save the Union output as a shapefile named `Exercise_4_Data/MyData/CombinedHabitat.shp`.

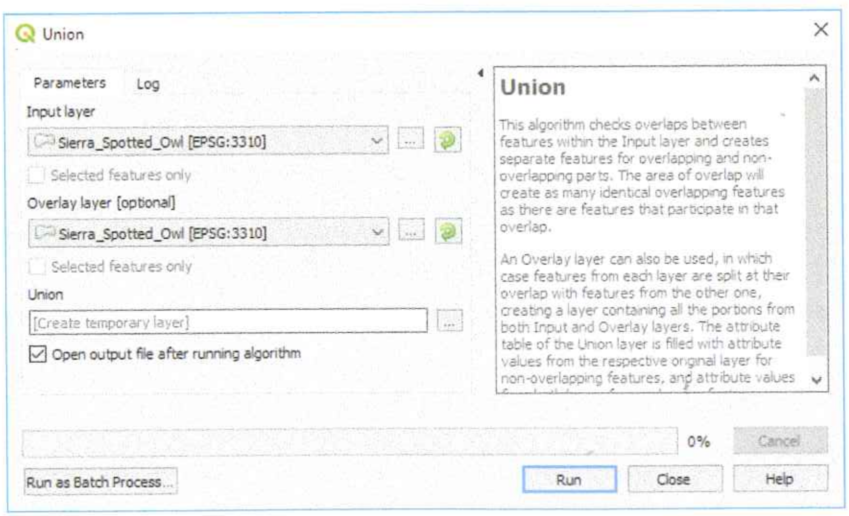

Figure 4.10: Union Tool

4. When finished click Run to perform the union operation and Close when it has finished.

> Note that while a tool runs the *Log* tab is displayed with message output. If an error occurs you can switch back to the *Parameters* tab, makes some changes and re-Run the tool.

The output contains all the polygons from both layers (shown in figure 4.11, on the next page). In addition, all the polygons retain their original attributes! Overlapping areas receive attributes from the Overlap layer (Sierra_WillowFlycatcher).

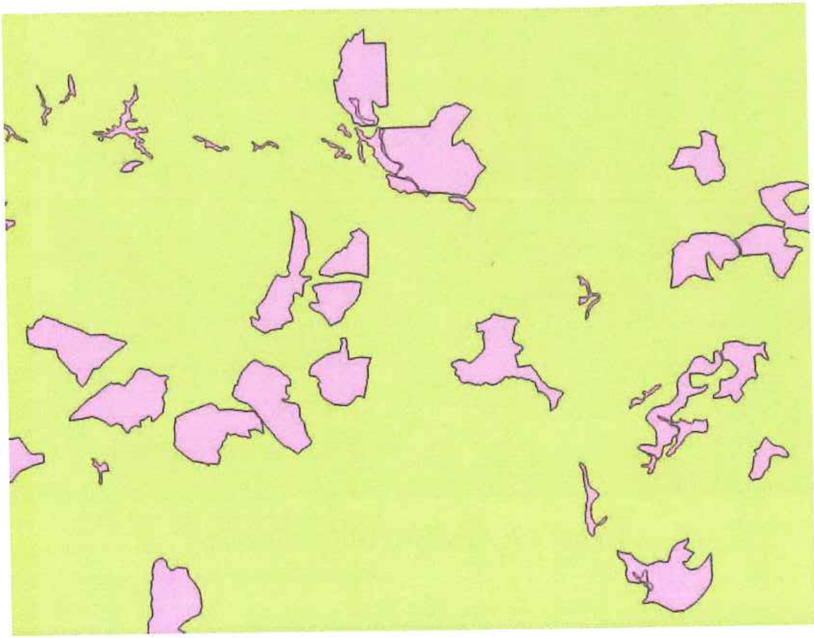

Figure 4.11: Union Output

Now you will Dissolve all the polygons into one contiguous polygon layer representing areas of habitat for both species.

5. Search the Processing Toolbox for *Dissolve* and find the Dissolve tool in the Vector Geometry section.
6. Fill out the Dissolve tool so it matches the figure 4.12:
   a. Input layer = CombinedHabitat
   b. Dissolve fields: leave this blank. If you were to dissolve based on one or more attributes you would click the ellipsis button and choose the fields that would participate.
   c. Save the Dissolved output as a shapefile named `Exercise_4_Data/MyData/CombinedHabitat_dissolved.sh`
7. When finished click Run to perform the dissolve operation, and then click Close.
8. Figure 4.13 shows the output of the Dissolve operation.
9. Save your QGIS project.

4.6 Task 4 - Intersection # 2

In this final task, you will incorporate the Ranger District shapefile into the analysis. There are three Ranger Districts in the Sierra National Forest. You will determine the Ranger District that each spotted owl habitat polygon is situated in. To do this you will conduct another intersection. This will allow you to cut habitat polygons at the ranger district boundary and attach the attributes from the Ranger District layer onto the spotted owl layer.

1. Open QGIS and open `Exercise_4_Data/Exercise4.qgz` .

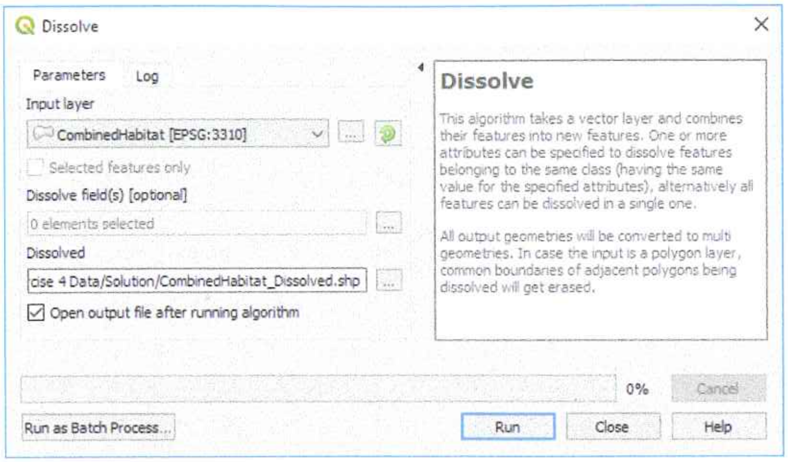

Figure 4.12: Dissolve Tool

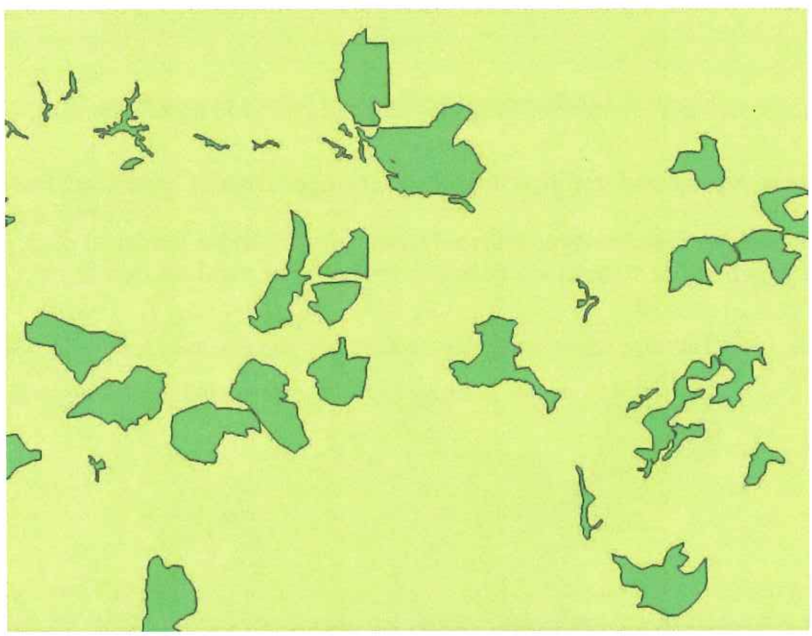

Figure 4.13: Dissolve Tool Output

2. Add the `Sierra_Ranger_Dist.shp` shapefile to the project.

Remember that data layers need to be in the same coordinate reference system when conducting a geoprocessing operation between layers.

3. Open the Layer Properties for the Ranger District layer.

Question # 2 – What is the coordinate reference system of the Ranger District layer?

4. Since it is in a different coordinate reference system than the other datasets, you will first have to save it to a new coordinate reference system.

5. Right-click on Sierra_Ranger_Dist in the Layers Panel and choose Export | Save Selected Features As....

6. Fill out the Save vector layer as... form as shown in the figure 4.14, on the following page. You can find this

CRS by searching for the EPSG code for CA Albers: 3310.

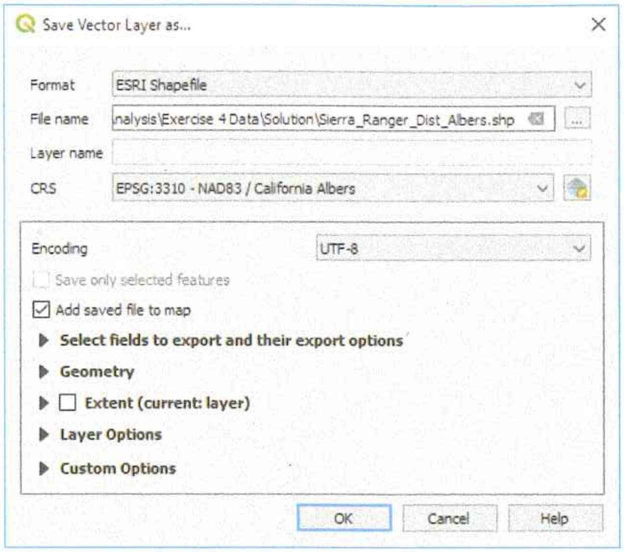

Figure 4.14: Reprojecting Ranger District Boundaries

7. Once the layer has been reprojected, remove the original Ranger District layer from the Layers Panel.

8. Style the new Albers Ranger District layer with a Transparent Fill and a Border of dark green (result shown in figure 4.15, on the next page).

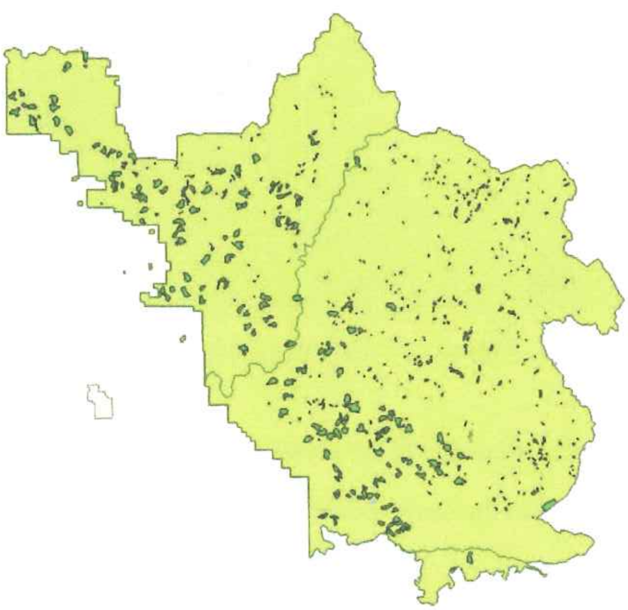

Figure 4.15: Symbolized Ranger District Boundaries

9. Now you are ready to conduct the second intersection. From the Processing toolbox expand the Recently used section and find Intersection.

10. Fill out the tool to match the figure 4.16, on the facing page. The output will be in the form of a new spotted owl habitat shapefile cut at the Ranger District boundary.

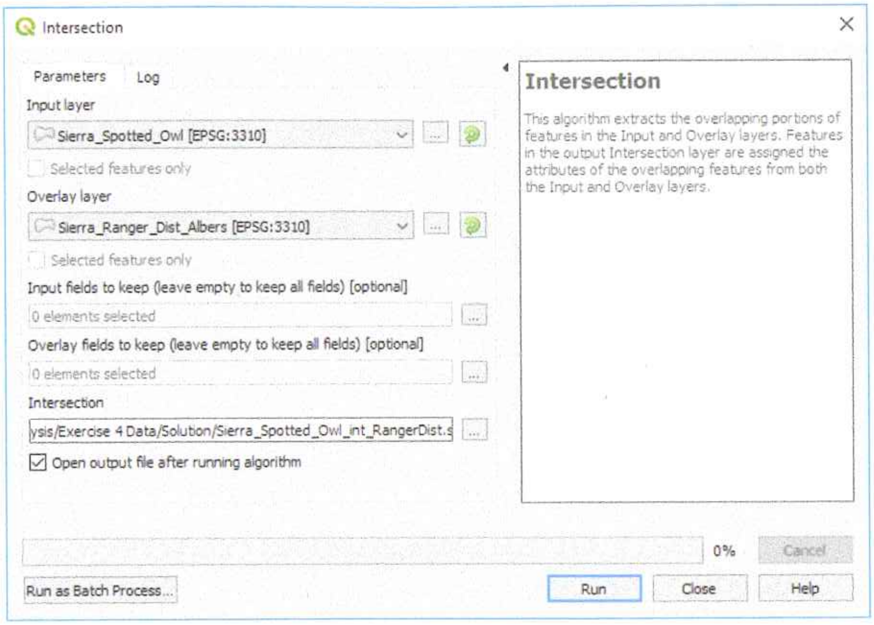

Figure 4.16: Intersection Between Spotted Owl and the Ranger District Boundaries

11. Click Run and Close when done.

12. Select the Spotted_Owl_RangDist layer in the Layers Panel by clicking on it once.

13. Now use the Identify tool to query the individual polygons of the Spotted_Owl_RangDist shapefile. You will see the additional Ranger District attribute columns added.

14. Save your project.

4.7 Conclusion

In this exercise, you explored the use of vector overlay tools with habitat data in the Sierra National Forest. There are many similar overlay tools which, when used in combination, allow you to parse the spatial relationships of multiple data layers. These tools allow you to extract data and turn it into information by narrowing down the area of interest.

4.8 Discussion Questions

1. Describe the Clip operation.

2. Describe the Intersect operation.

3. How do Intersect and Clip compare in their output?

4. Before you run an overlay tool, what aspect of your input spatial data layers should you inspect to ensure it is the same for all layers?

4.9 Challenge Assignment

The Southwest willow flycatcher data also covers multiple Ranger Districts. Conduct a spatial join between the Southwest willow flycatcher data and the Ranger districts as you did with spotted owl in the last task. Compose