Sequoia National Park GIS Analysis Project

GIS 325 Final Report

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Abstract

To create a safe and well-rounded trip to any national park, an analysis of its characteristics, natural environment and climate is necessary. This report's purpose is to help a potential visitor of Sequoia National Park make informed decisions about where to go, what activities to do and what areas of the park to see. Geospatial tools were used to find the ideal time of year to visit, the types of wildlife one may encounter depending on the season and the park's proximity to important landmarks and resources like healthcare facilities. I used Optimized Hot Spot Analysis to show the spots several famous species are most likely to be located in the park. 2D and 3D analyses of the park's topography were conducted to show the elevation changes near waterways and some hiking trails. Watershed analysis used on digital elevation models (DEMs) provided by USGS helped identify 7 large watersheds throughout the park. This information can be used to make informed decisions on where to stay and which trails are the safest. I used the Hillshade and Flow Direction tool to show what areas of the park were the steepest so visitors that intend to hike during their stay can know where they can find terrain that suits their personal skill level. Spatial interpolation tools such as Inverse Distance Weighting and Kriging were used to predict the climate and potential rainfall that visitors may experience depending on the year. By interpolating the data, a potential visitor can get a fairly accurate idea of what the weather may be like in the park during the months of June and August. With this information, potential visitors of the park can hopefully make even more informed decisions when deciding what parts of the park to see.

Introduction

Sequoia National Forest is an American park best known for its Giant Sequoia trees. The forest is located in the Sierra Nevada mountains, spanning 1,193,315 acres in total and ranging from 1,000 to 12,000 feet in elevation. Some of its other more notable features are its glacier-carved mountain faces and its granite monoliths. The park is home to hundreds of animal and plant species and is a favorite spot among wildlife spotters and bird watchers. The purpose of this report is to give potential visitors of the park an idea of what they can expect on a trip to Sequoia National Park.

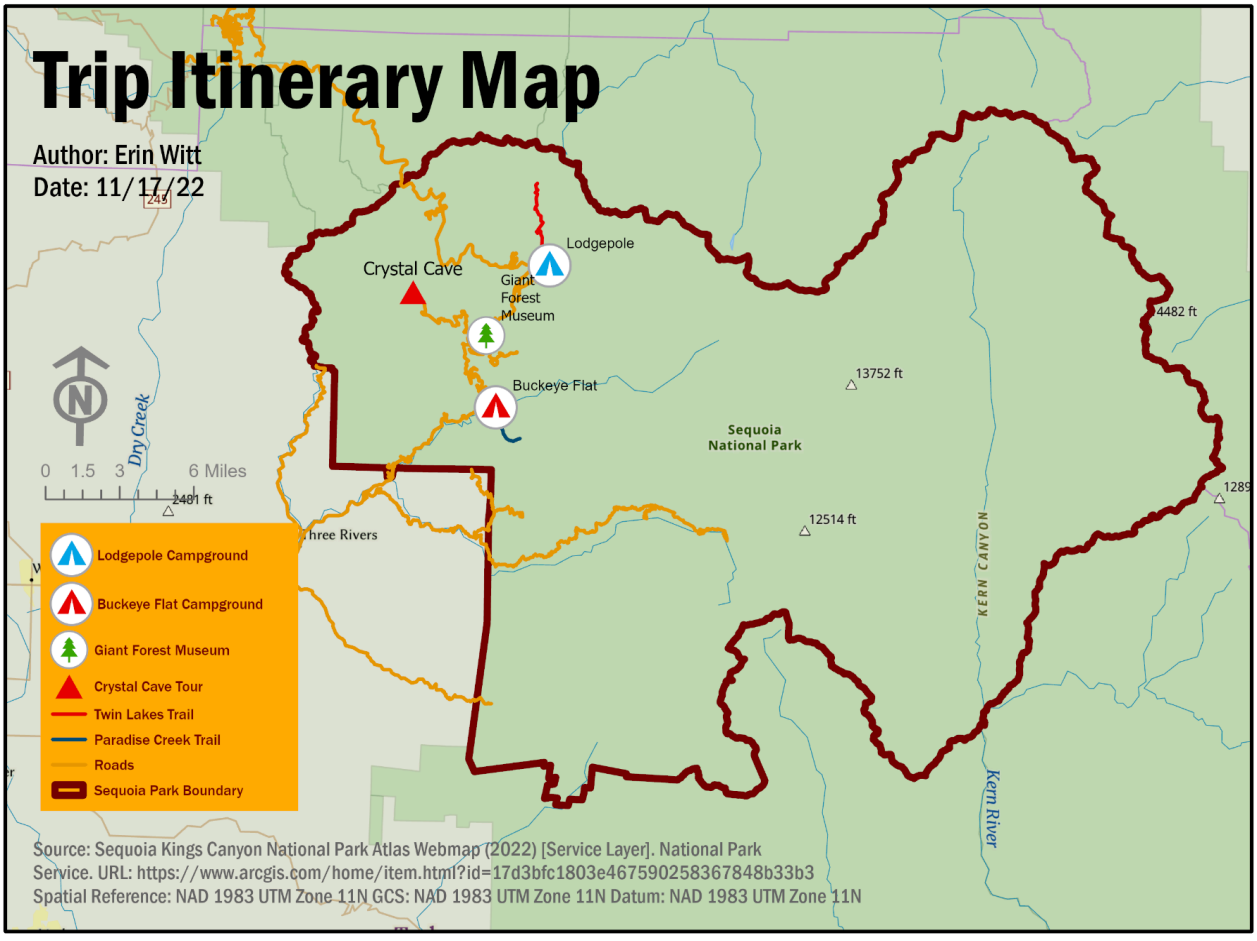
Applications Assignments & How They Were Used

- **Application 1 -** These layouts detail the boundary of the park and its location in the state of California. They also show the trail locations and roadways in the park.
- **Application 2 -** By highlighting California Newt, Mule Deer, and the American Pika sighting hotspots, we can make informed decisions about where the best wildlife spotting locations are, and how accessible these places are to the average tourist.
- **Application 4 -** The data found in this report will be used to find the best place in the park to spot the Steller's Jay.
- **Application 5 -** The watershed data of this park can be used to analyze the best places to camp and stay in the park. If there is a chance of flooding, an informed visitor should know where potential risks are in the area.
- **Application 6 -** These layouts were useful in assessing the best time of year for visiting Sequoia. By using the climate station data to interpolate the precipitation and expected weather conditions for two different months of the year, we can make a more informed decision about when it is best to see the park.

Trip Itinerary

Day	Activity Location Description	Planned Activity
1	Buckeye Flat Campground (towards the western edge of the park, not far from the border), Paradise Creek Trail	The first day will be spent setting up camp at Buckeye, hiking near the campground on a trail called Paradise Creek Trail and birdwatching.
2	Giant Forest Museum, Lodgepole Campground (located very centrally in the park)	The second day will be spent sightseeing at the Giant Forest Museum and camping at the Lodgepole Campground.
3	Twin Lakes Trailhead (near the Giant Forest Museum)	The third day we will hike the Twin Lakes Trailhead. We will birdwatch, spot wildlife and go herping.
4	Crystal Cave (located more towards the western edge of the park)	A small guided hike is required to go through Crystal Cave. It is about an hour long and very informative.

Table 1: This table shows a proposed itinerary for a four day trip to Sequoia National Park. Most of these destinations are on the western half of the park while still giving the visitor a great overview of all this area has to offer.



Itinerary Overview

Figure 1: The map above shows different places in Sequoia National Park that I suggest visiting in my itinerary along with roads and other useful features.

Sequoia National Park contains the habitats of thousands of birds, mammals and reptiles. In preparing this itinerary, I assessed the data I had collected for several species of animals to ensure great wildlife spotting and bird watching opportunities. I also assessed the optimal times of year to visit, and where the safest spots are in the park based on rattlesnake population hot spots and more.

The first day of the proposed trip will be spent traveling to Buckeye Flat Campground, a very popular spot for tourists to visit. The campground contains a beginner-friendly hiking trail called Paradise Creek Trail. It is only 0.5 miles round-trip with flat to medium elevation throughout. (National Park Service. 2022) This hike will be a great opportunity to see wildlife such as the Steller's Jay, the Mule Deer, and the California Newt. The second day, we will drive to the Giant Forest Museum which is only 20 minutes away from Buckeye. The Giant Forest Museum is a museum dedicated to educating tourists about the environment and species of the park. Its exhibits feature information about the park's famous trees and human history. (National Park Service. 2022) We will spend the night at Lodgepole Campground, where we will spend the rest of the trip. Lodgepole is a very popular campground within walking distance of Lodgepole Village. The campground has a market, a visitor center and laundry facilities. There are also shuttle stops nearby which can be taken during the summer months.

On the third day we will take the Twin Lakes Trailhead located near Lodgepole. It is considered a moderately difficult trail, and is roughly 5 miles long. (AllTrails, 2019) It is located in a good spot for wildlife spotting and bird watching. The final day of the trip, we will travel to Crystal Cave, a half-mile trail loop through a marble cavern. (National Park Service. 2019) Because of some of the more fragile formations in the caves, the only way to visit is with a guided tour.

Figure 2: Shown here is the boundary of Sequoia National Park and its location relative to the state of California.

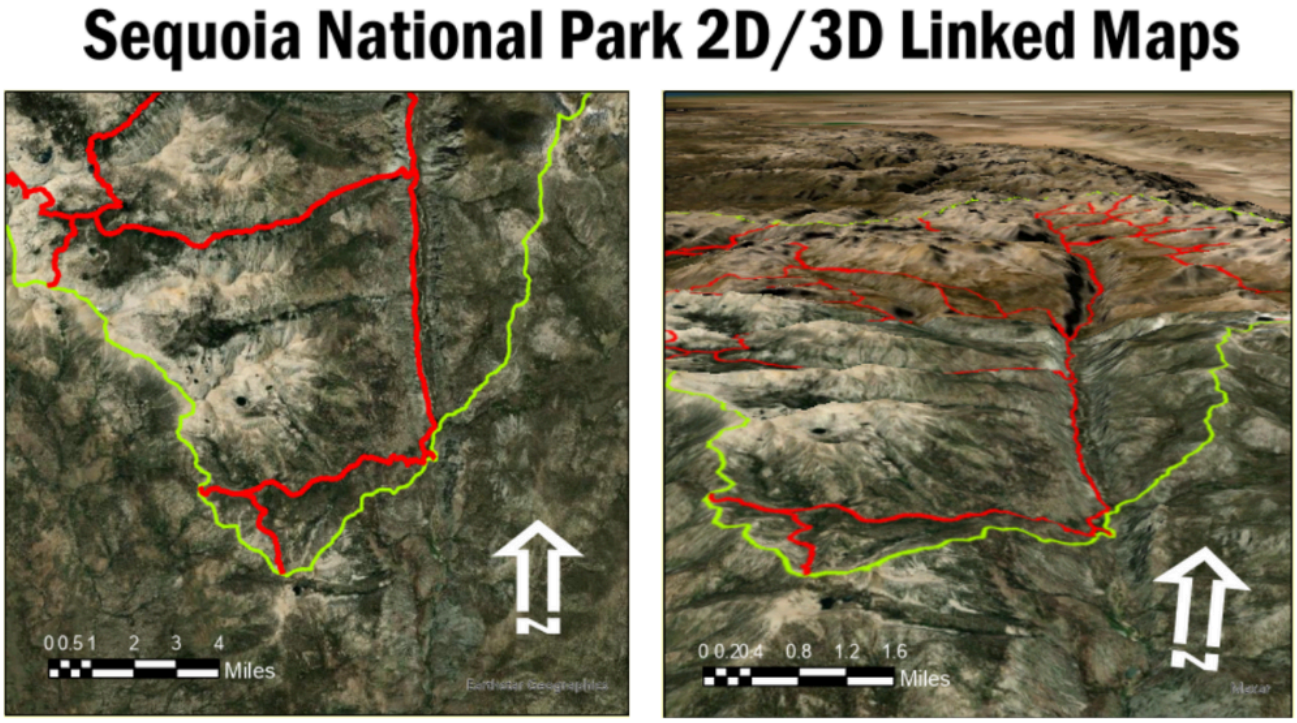
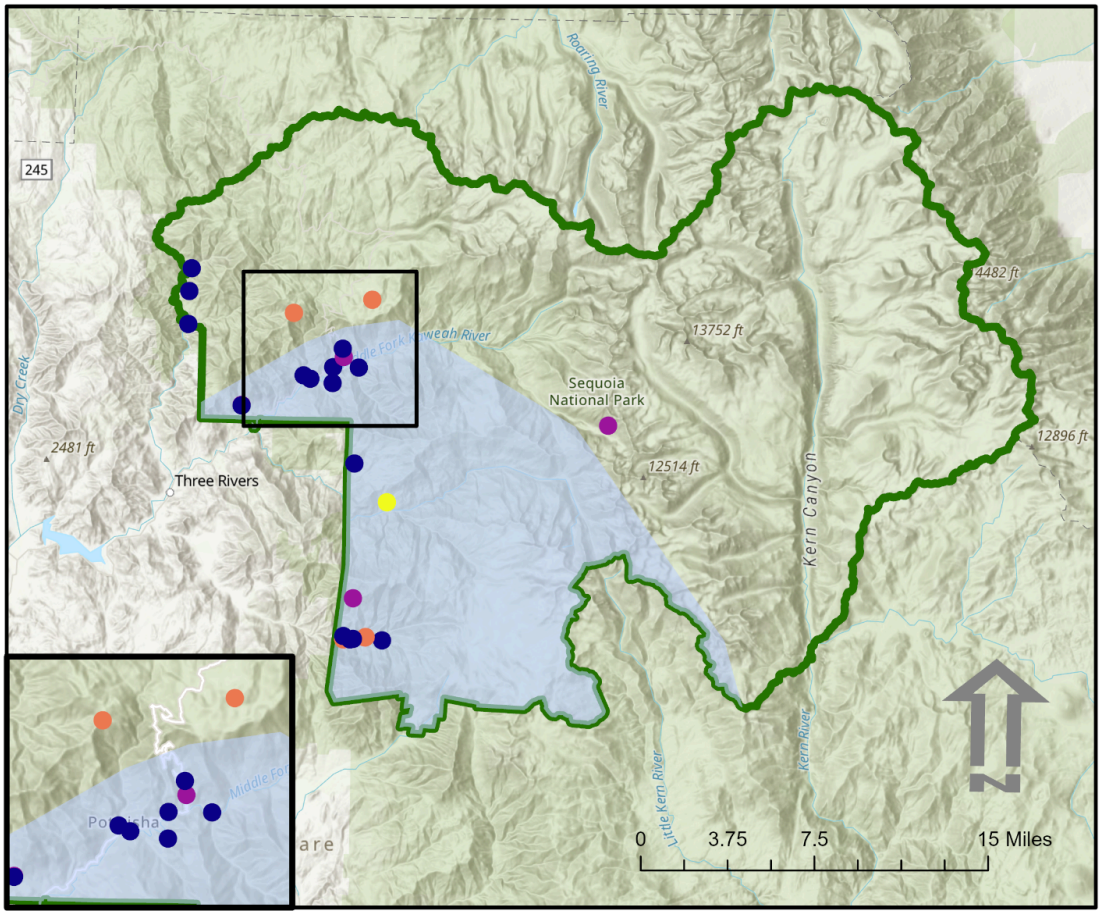


Figure 3: This layout shows a linked 3D and 2D view of the eastern half of the park, showing the steep topography surrounding one of the main waterways. This layout was created to show the steepness of the eastern side of the park.

California Newt Sightings in Sequoia National Forest



Sources:
1. World Imagery (2010) [Tile Layer]. Esri Inc., [Sept. 19th, 2022]
2. Taricha torosa (California Newt) (2022). [Tabular Data]. Global Biodiversity Information Facility [Sept. 19th, 2022]
3. Taricha torosa (California Newt) (2022). [Polygon Data]. The IUNC Red List of Threatened Species [Sept. 19th, 2022]
4. National Park Service - Park Unit Boundaries (2019) [Feature Layer]. National Park Service, Washington D.C., [Sept. 19th, 2022]

Spatial Reference:
NAD 1983 UTM Zone 11N
GCS: NAD 1983 UTM Zone 11N
Datum: NAD 1983 UTM Zone 11N

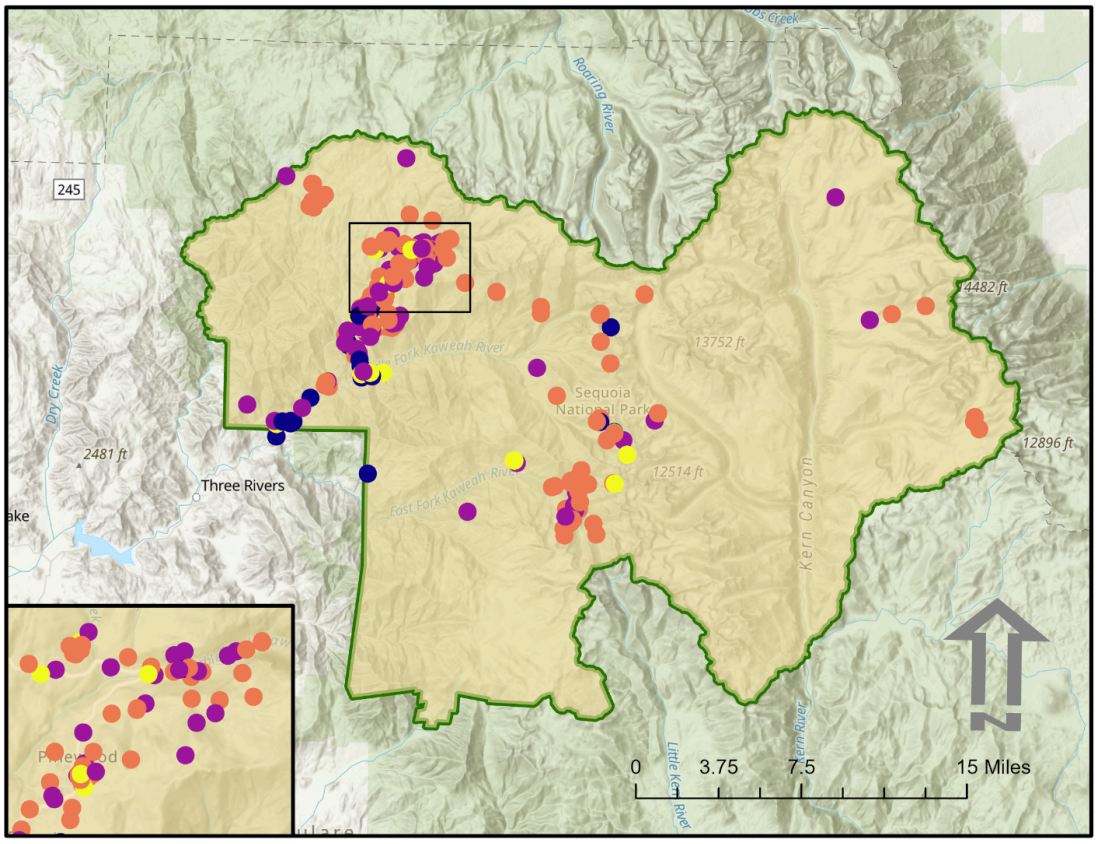
Author: Erin Witt
Sept. 20, 2022

Sequoia Park Boundary
California Newt Range

California Newt Sightings
- Jan - Mar
- Apr - Jun
- Jul - Sep
- Oct - Dec

Figure 4: These are the reported sightings of the California Newt colored by month. Some of them fall outside of their supposed range.

Mule Deer Sightings in Sequoia National Forest



Sources:
1. World Imagery (2010) [Tile Layer]. Esri Inc., [Sept. 19th, 2022]
2. Odocoileus hemionus (Mule Deer) (2022). [Tabular Data]. Global Biodiversity Information Facility [Sept. 19th, 2022]
3. Odocoileus hemionus (Mule Deer) (2022). [Polygon Data]. The IUNC Red List of Threatened Species [Sept. 19th, 2022]
4. National Park Service - Park Unit Boundaries (2019) [Feature Layer]. National Park Service, Washington D.C., [Sept. 19th, 2022]

Spatial Reference:
NAD 1983 UTM Zone 11N
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Datum: NAD 1983 UTM Zone 11N

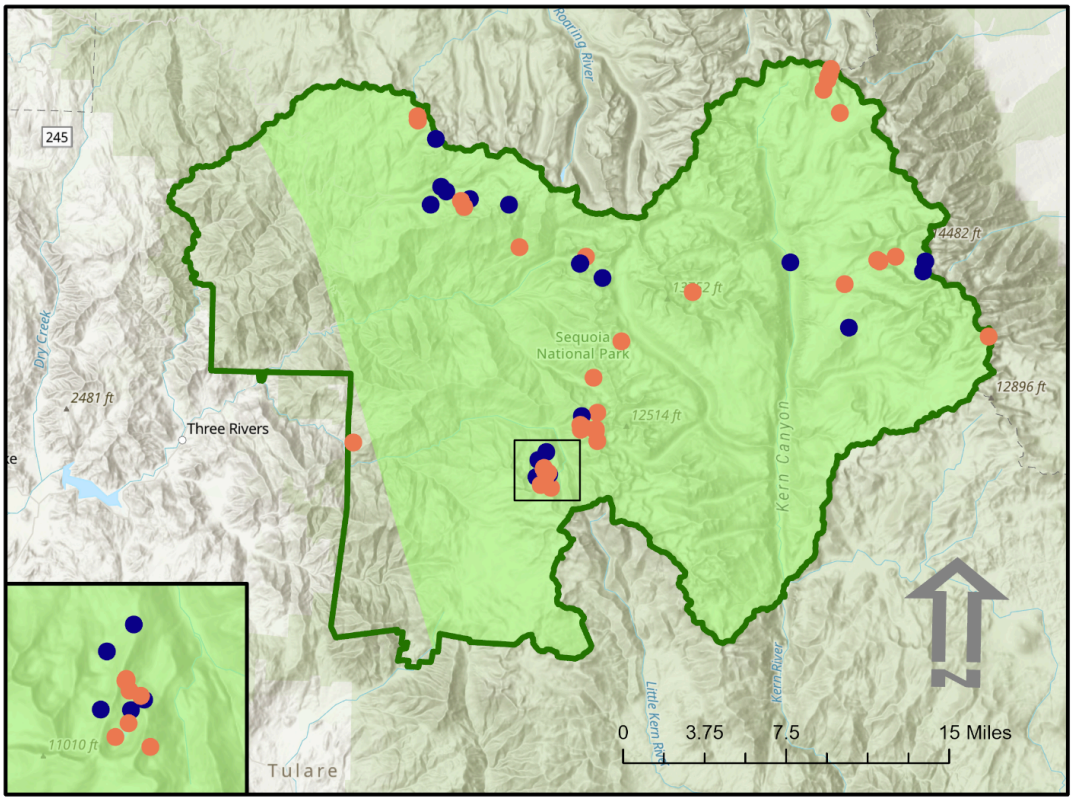
Author: Erin Witt
Sept. 20, 2022

Sequoia Park Boundary
Mule Deer Range

Mule Deer Sightings
- Jan - Mar
- Apr - Jun
- Jul - Sep
- Oct - Dec

Figure 5: These are the Mule Deer sightings colored by month and their range in Sequoia.

American Pika Sightings in Sequoia National Forest



Spatial Reference:
NAD 1983 UTM Zone 11N
GCS: NAD 1983 UTM Zone 11N
Datum: NAD 1983 UTM Zone 11N

American Pika Range
Sequoia Park Boundary

American Pika Sightings
- May - Jun
- Jul - Sep

Sources:
1. World Imagery (2010) [Tile Layer]. Esri Inc., [Sept. 19th, 2022]
2. Ochotona princeps (American Pika) (2022). [Tabular Data]. Global Biodiversity Information Facility [Sept. 19th, 2022]
3. Ochotona princeps (American Pika) (2022). [Polygon Data]. The IUNC Red List of Threatened Species [Sept. 19th, 2022]
4. National Park Service - Park Unit Boundaries (2019) [Feature Layer]. National Park Service, Washington D.C., [Sept. 19th, 2022]

Author: Erin Witt
Sept. 20, 2022

Figure 6: This layout shows the distribution of American Pika sightings colored by the month they occurred in.

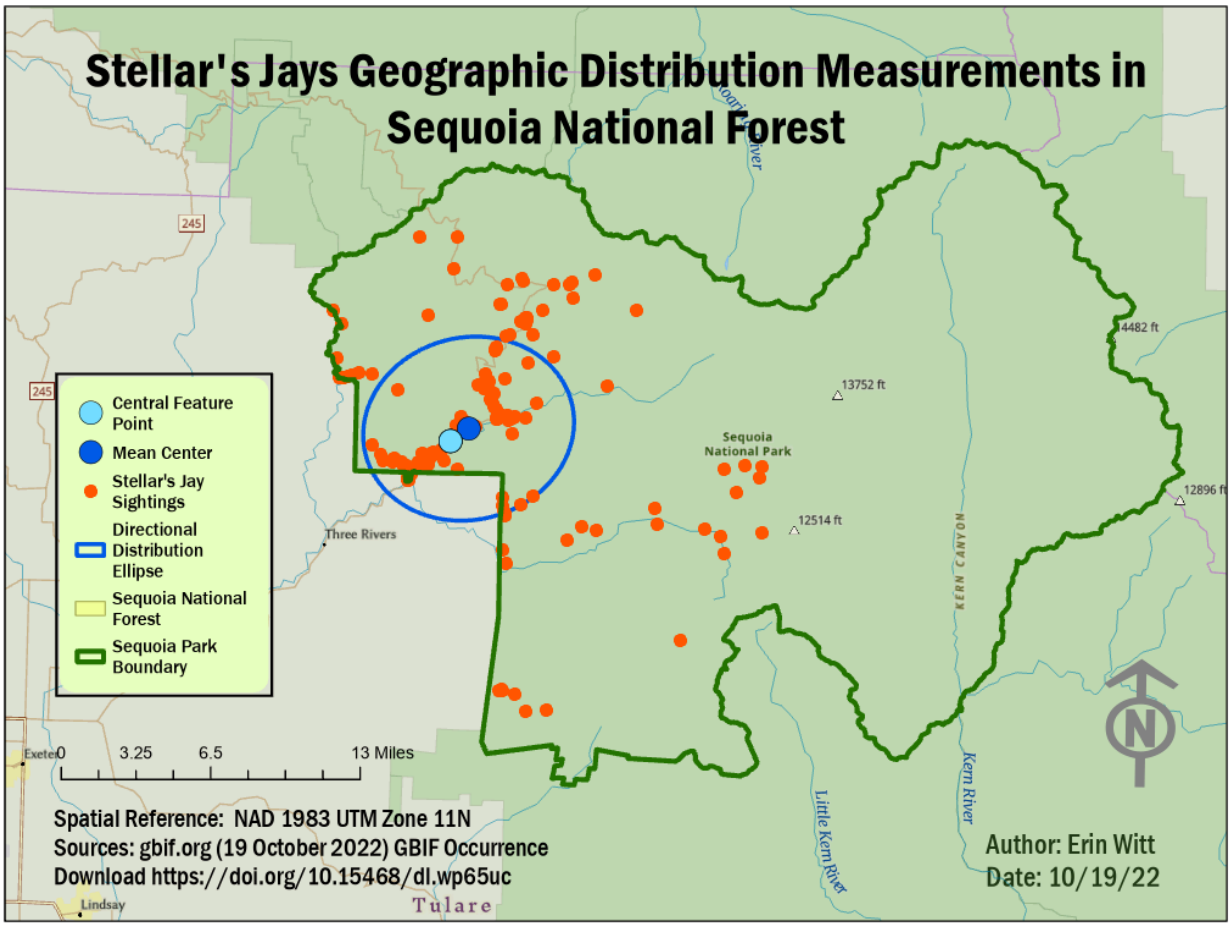
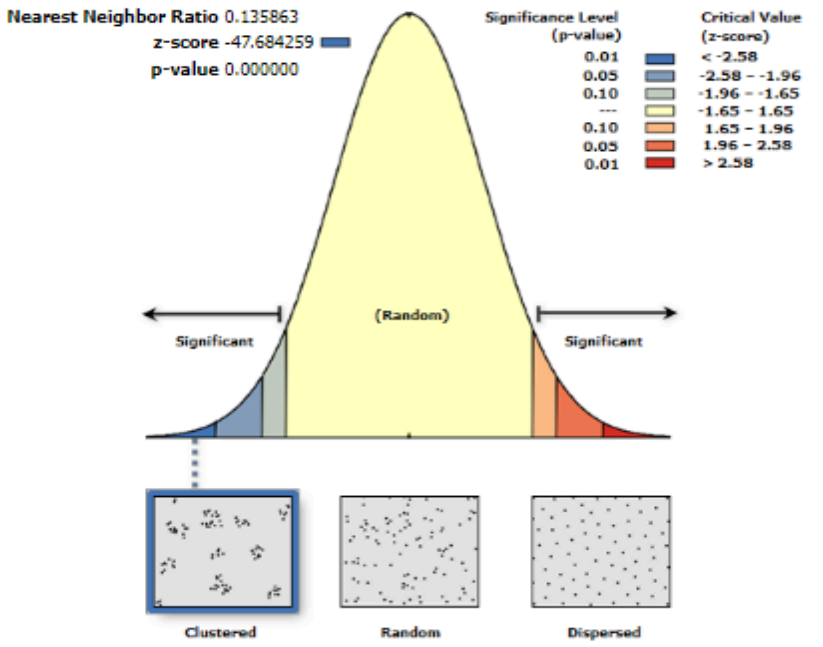


Figure 7: This layout shows the Central Feature Point, the Mean Center and the Directional Distribution Ellipse of the Steller's Jay sightings point data. The light blue dot represents the Central Point of these sightings. It represents the centermost feature of the data using the Euclidean distance or the straight-line distance between them. It represents the ideal spot in the park for accessing and observing populations of Steller's Jay. The dark blue dot represents the Mean Center, which is calculated by averaging the x and y values of all the points. This calculation does not take the topography of the park into consideration. The Mean Center and Central Point are very close to one another because of the high concentration of sightings in the western half of the forest. Using the Directional Distribution tool, I then found the standard deviational ellipse, represented by the dark blue oval drawn around the mean center and central feature. Its purpose is to encapsulate all the points that fall within one standard deviation of the mean.

Average Nearest Neighbor Summary



Given the z-score of -47.684259, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Average Nearest Neighbor Summary

Observed Mean Distance	66.0179 Meters
Expected Mean Distance	485.9143 Meters
Nearest Neighbor Ratio	0.135863
z-score	-47.684259
p-value	0.000000

Dataset Information

Input Feature Class:	Stellar's Jay Sightings
Distance Method:	EUCLIDEAN
Study Area:	785783125.148123
Selection Set:	False

Figure 7a: This table was the product of running the Average Nearest Neighbor tool. The low z-score of -47.684 means that there is a less than 1% chance that this clustering of data points happened randomly. The p-value of 0 also supports this conclusion because a p-value of less than 0.05 means that there is statistical significance to the way the data is clustered. The low z-score and p-value of 0 suggest that we can reject the null hypothesis that the data points for Stellar's Jay are distributed randomly.

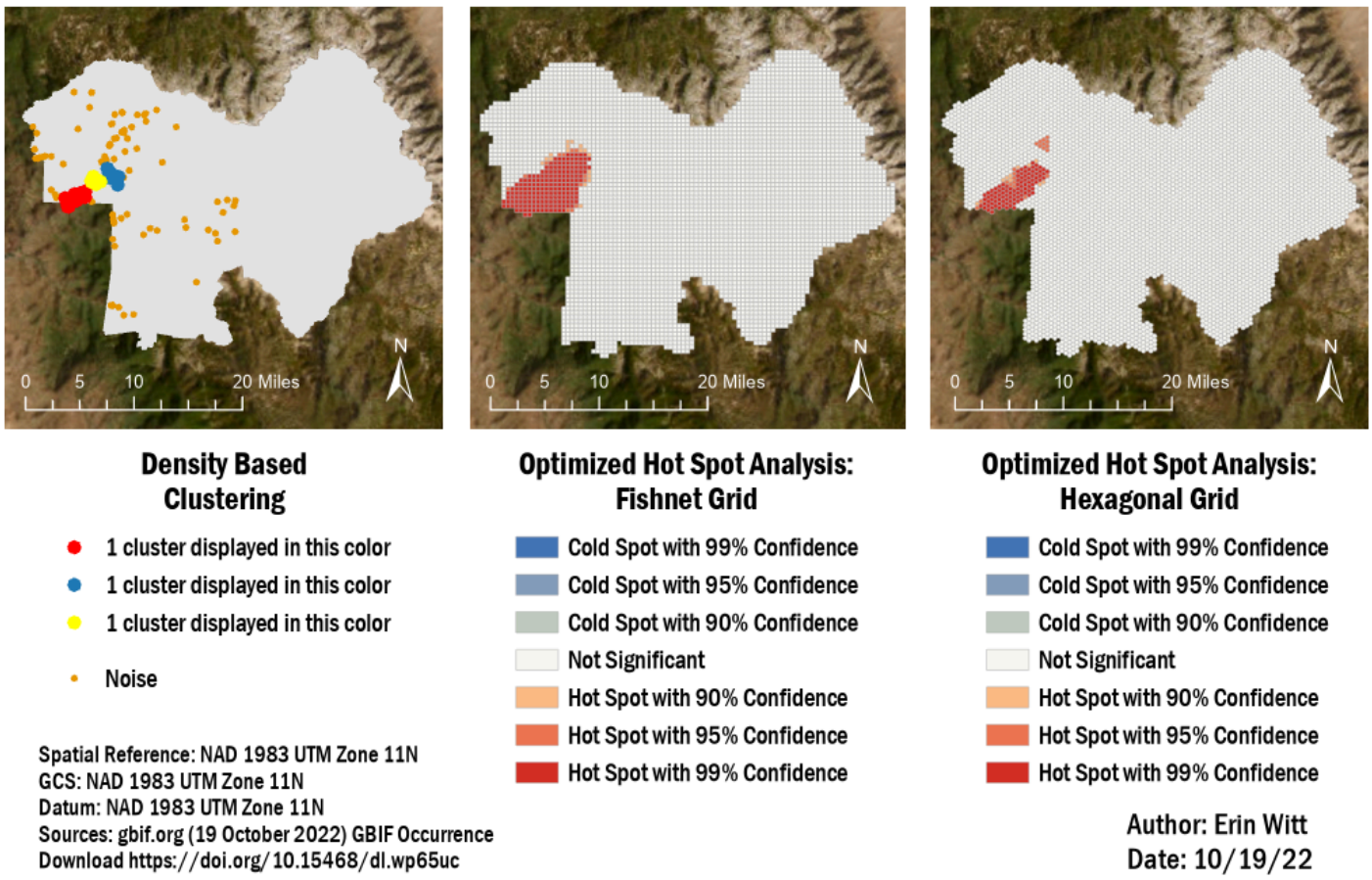


Figure 8: This layout shows the results of running the Density Based Clustering tool and the Optimized Hot Spot Analysis tool. It identified 3 main clusters and labeled the remaining points as noise. The three clusters are all found in the western half of Sequoia and contain the majority of the points on the map. The fishnet grid and hexagonal grid were both made using the Optimized Hot Spot Analysis tool. The fishnet found one very large hot spot of 99% certainty on the western side of Sequoia. There are a few cells on the border with 90% confidence, but the large majority of them are very dark red. The hexagonal one found the same hotspot but depicted it as slightly smaller. These maps show a clear pattern and highlight where most of the sightings of Steller's Jay can be found in Sequoia.

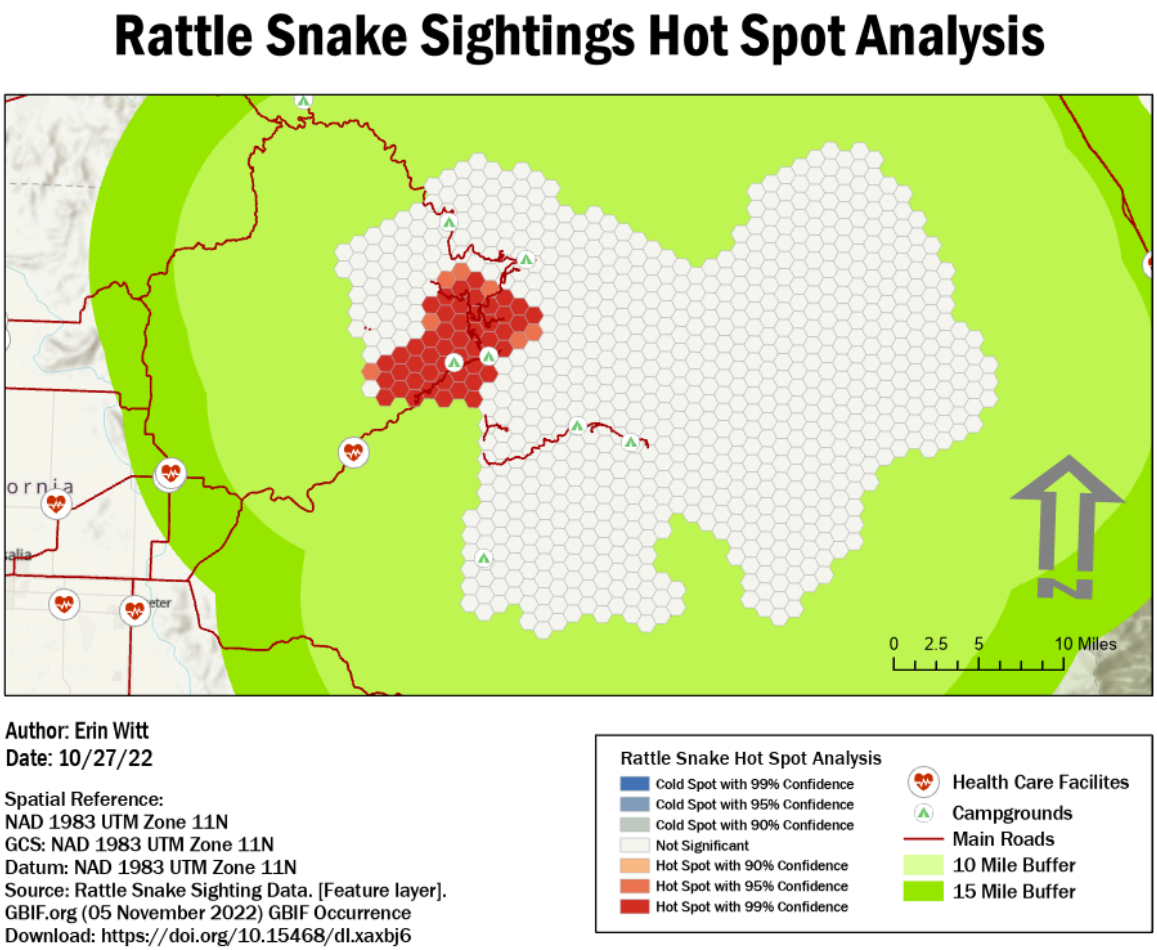


Figure 9: This map shows the Optimized Hot Spot Analysis for rattlesnakes in Sequoia National Park. This map can be used to make an informed decision on where to stay in the park or where to be the most careful when hiking or being in the forest.

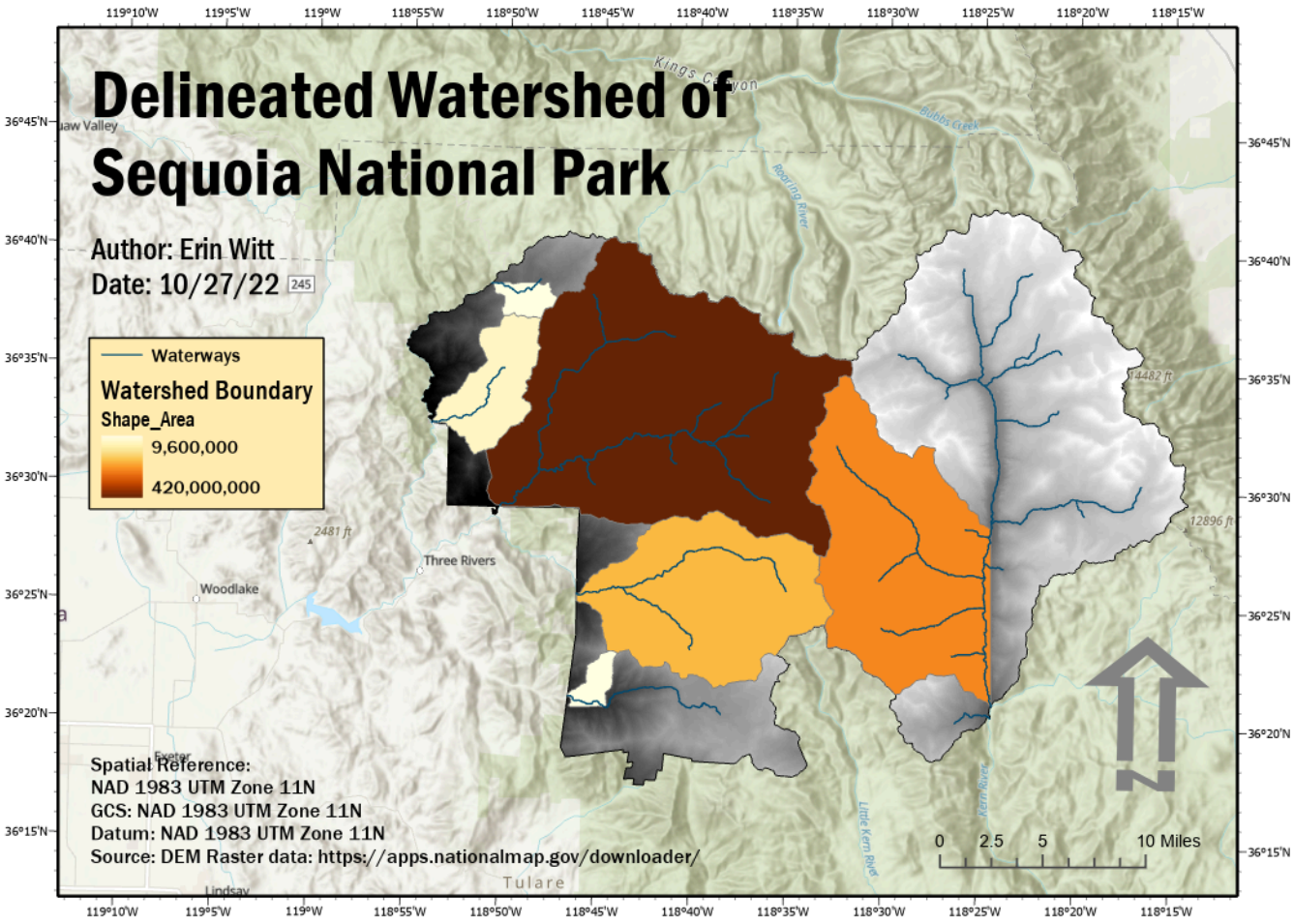


Figure 10: This map shows the delineated watersheds of Sequoia National Park. To create this map, I started by clipping my DEM to the boundaries of the park. I then used the Fill tool to remove imperfections in the data.

I used the Flow Direction and Flow Accumulation tools to further define the park's waterways. By looking at the new Flow Accumulation layer, I placed Pour Points where the water would be flowing out of the park. I then ran the Watershed tool to define the four main watersheds of Sequoia National Forest. I converted the Flow Accumulation feature class into a polyline of the park's waterways using the Raster to Polyline tool. I defined what points of the raster I wanted to convert to a polyline so I used the Raster Calculator to define the cells that make up the waterways. Each watershed represents the catchment area based on the stream's flow direction.

The drainage area of the watershed is calculated by multiplying flow accumulation raster cell values by cell size from the original DEM. I found this by using the Summary Statistics tool and calculating the Sum of the Count attribute.

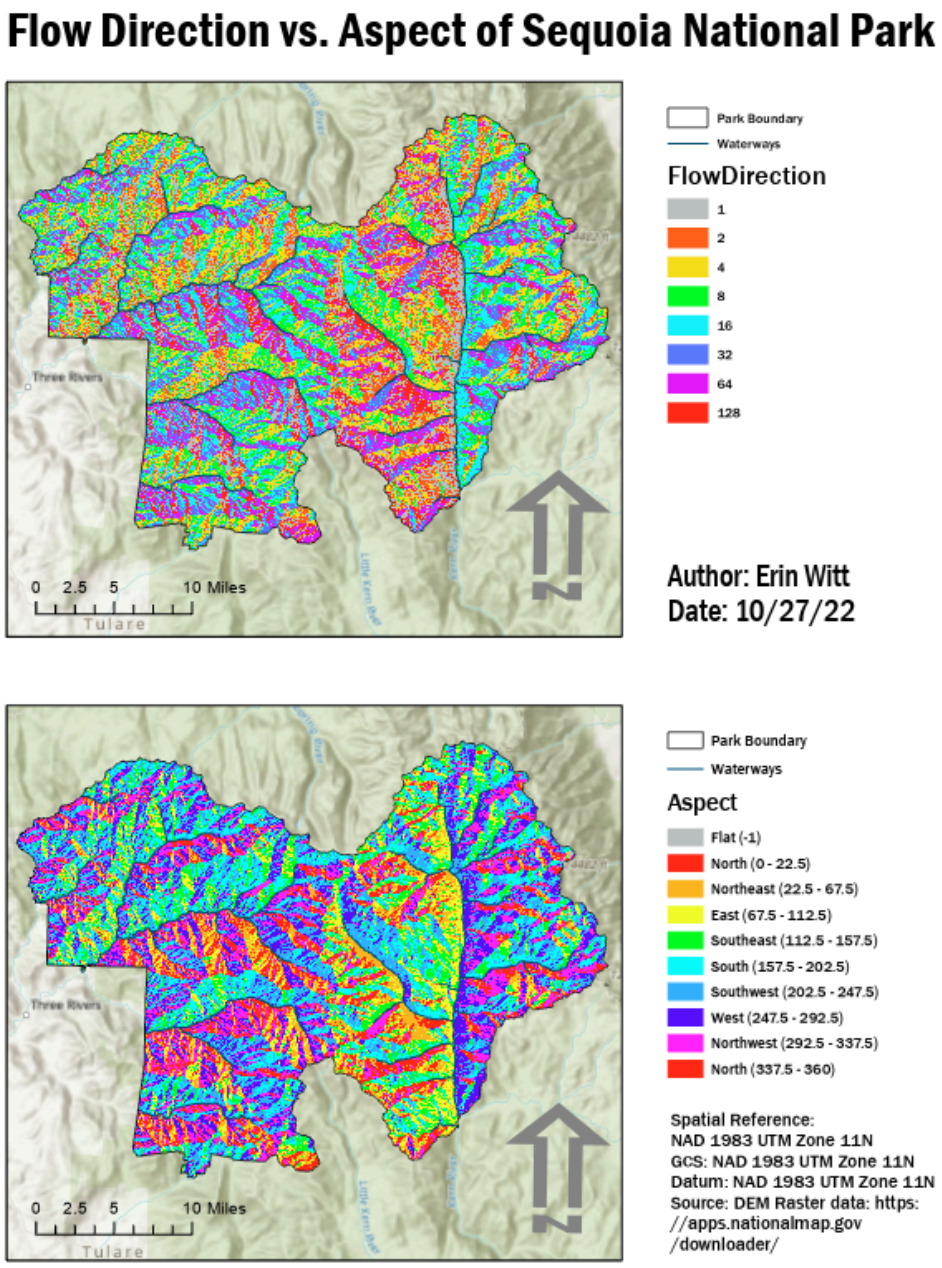


Figure 11: These layouts are a result of running the Flow Direction and Aspect tools. They show the elevation of the park. Potential visitors that wish to hike in Sequoia can use it to know the difficulty of the terrain they will be hiking on.

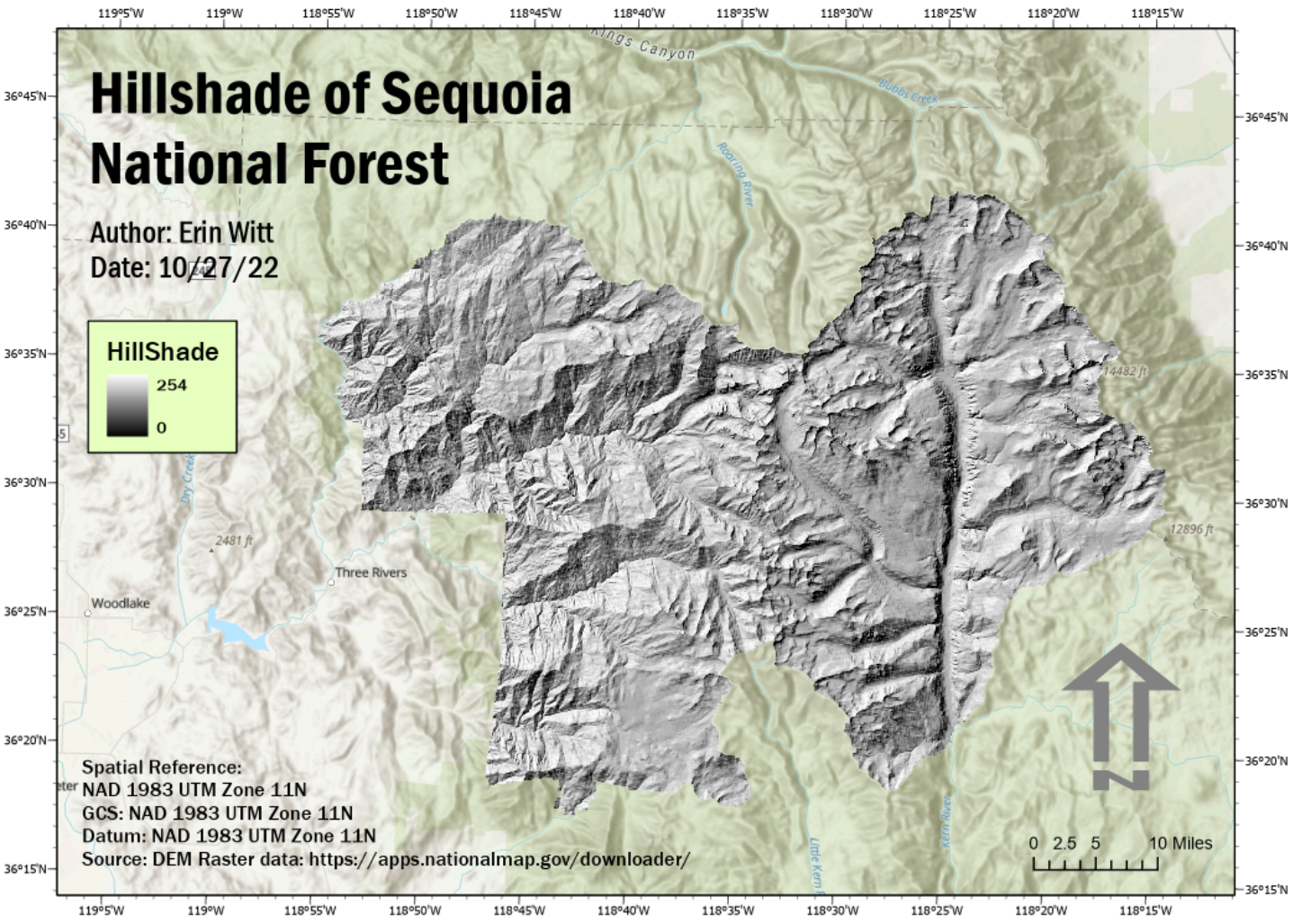
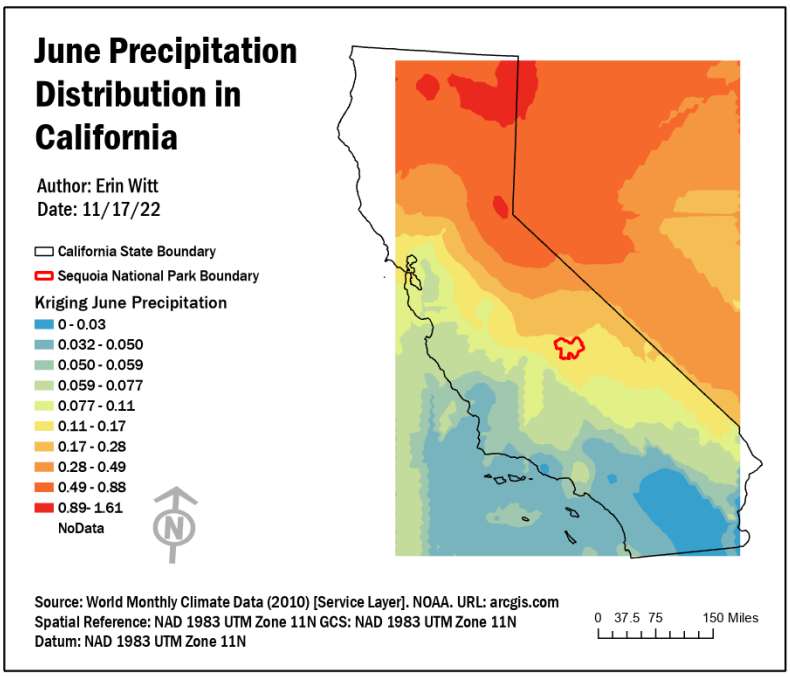
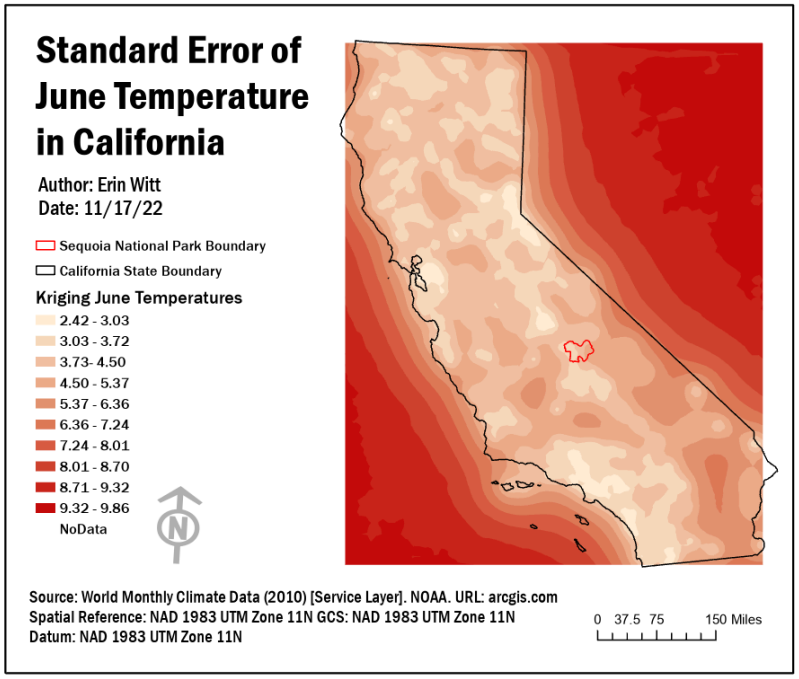
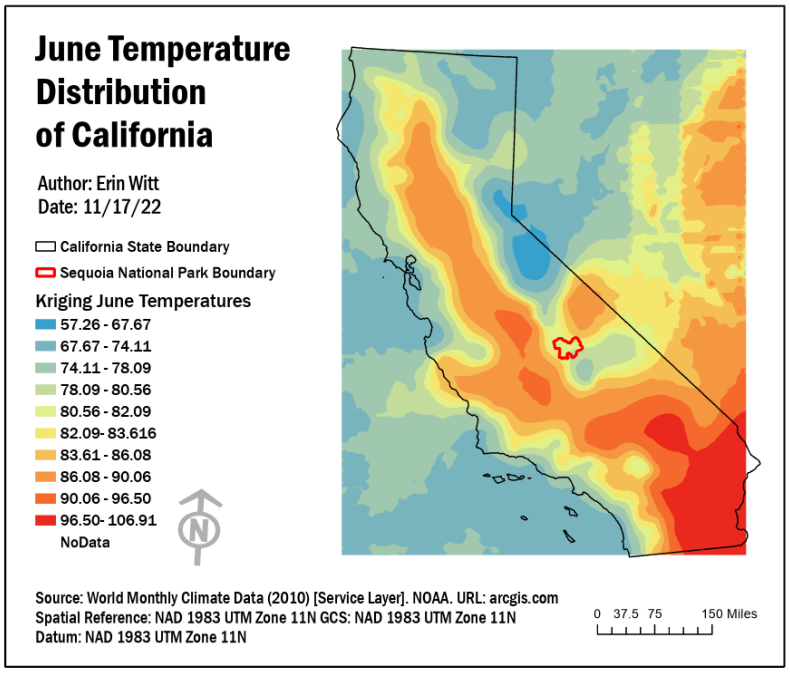


Figure 12: This map is a Hillshade depiction of Sequoia National Park. The steepest parts of the parks are located in the eastern half of the park nearest the waterway.







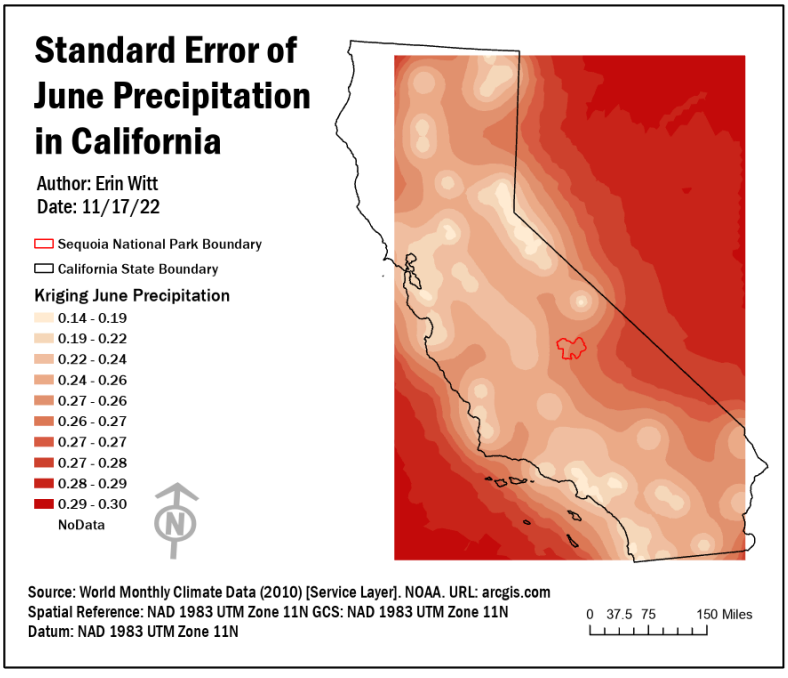


Figure 13: This layout shows the precipitation and temperature distribution of California for the month of June. During this month, California is the most temperate and receives some rainfall. This means that wildfire risk will be slightly lower than it would be in August and the temperature overall would be cooler and better for hiking and other outdoor activities.

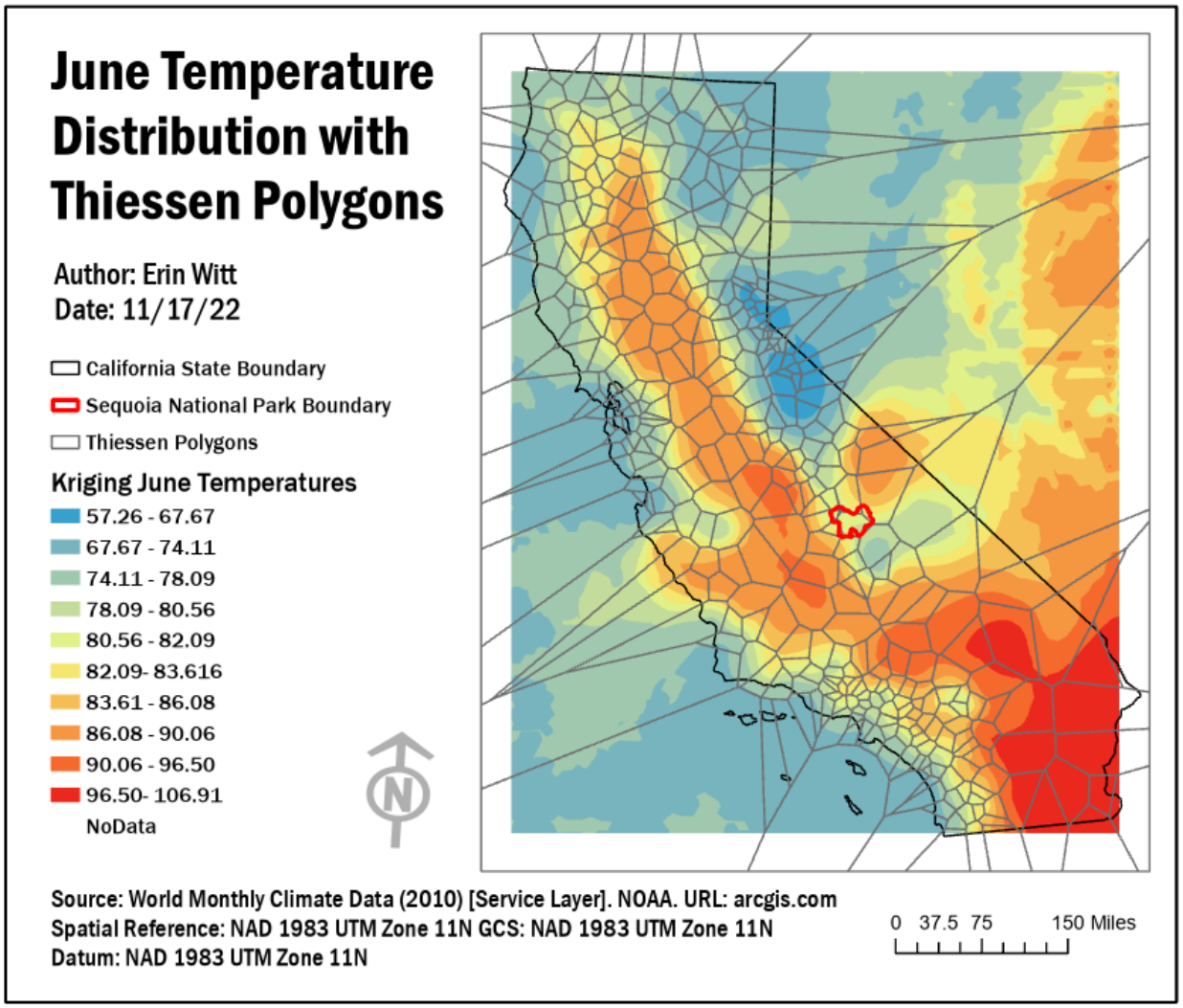


Figure 14: This map shows the Californian temperature distribution for the month of June. From the previous maps I determined that June is an ideal time to visit Sequoia because it is more temperate for hiking and traveling. This map uses Thiessen polygons to show how accurate the interpolation of the points between climate stations is.

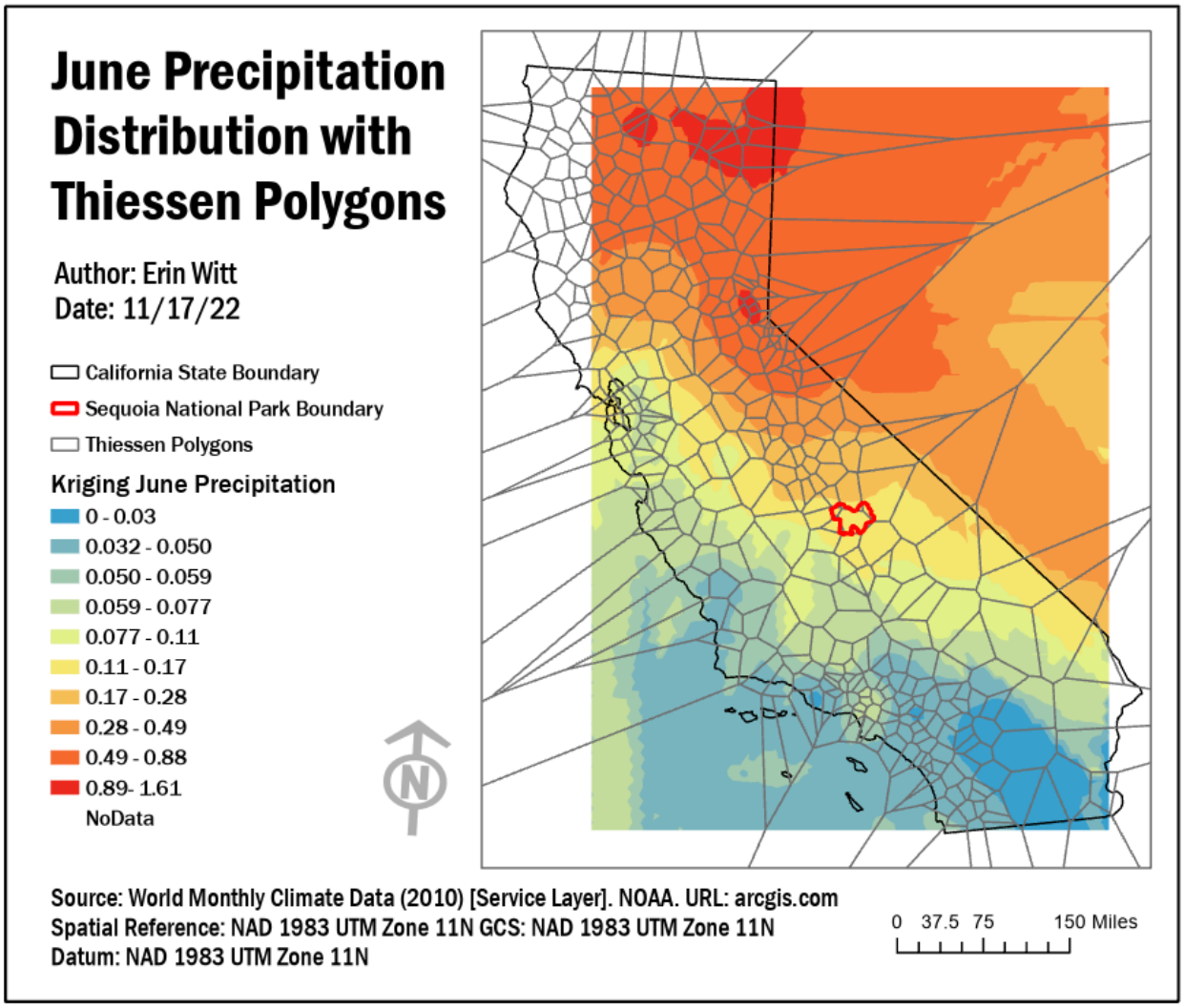


Figure 15: This map shows the Californian precipitation distribution for the month of June. From the previous maps I determined that June is an ideal time to visit Sequoia because there is less rain than during the month of August. This map uses Thiessen polygons to show how accurate the interpolation of the points between climate stations is.

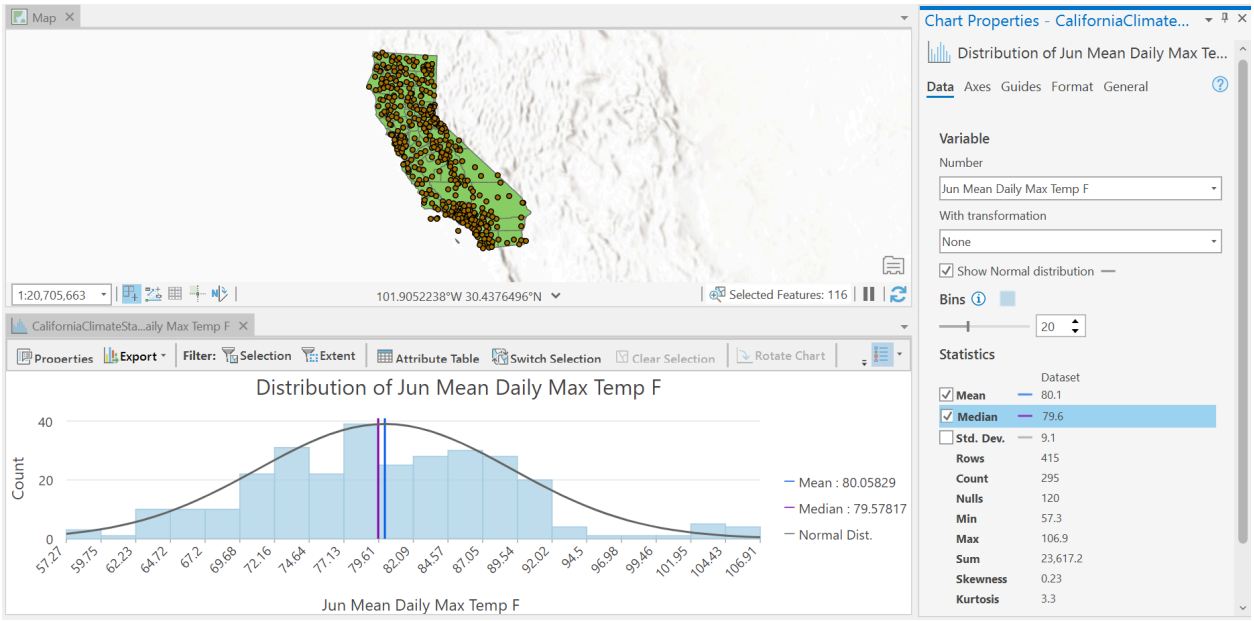


Figure 16: Histogram showing the distribution of Mean Daily Max Temperatures for the month of June.

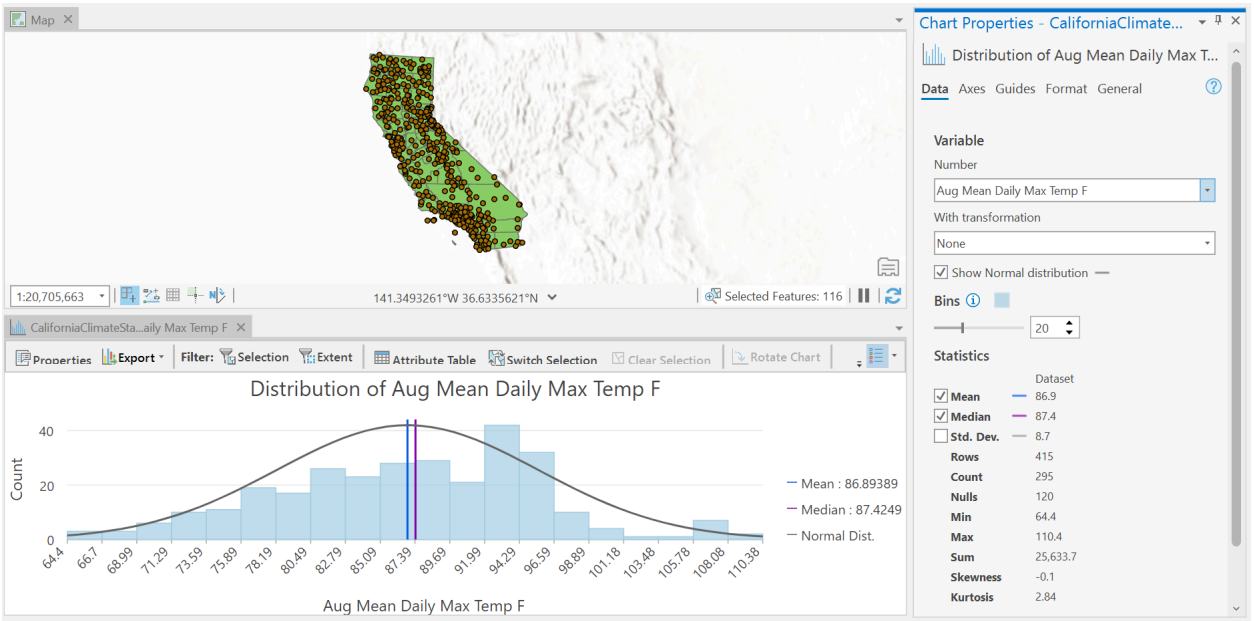


Figure 17: Histogram showing the distribution of Mean Daily Max Temperatures for the month of August.

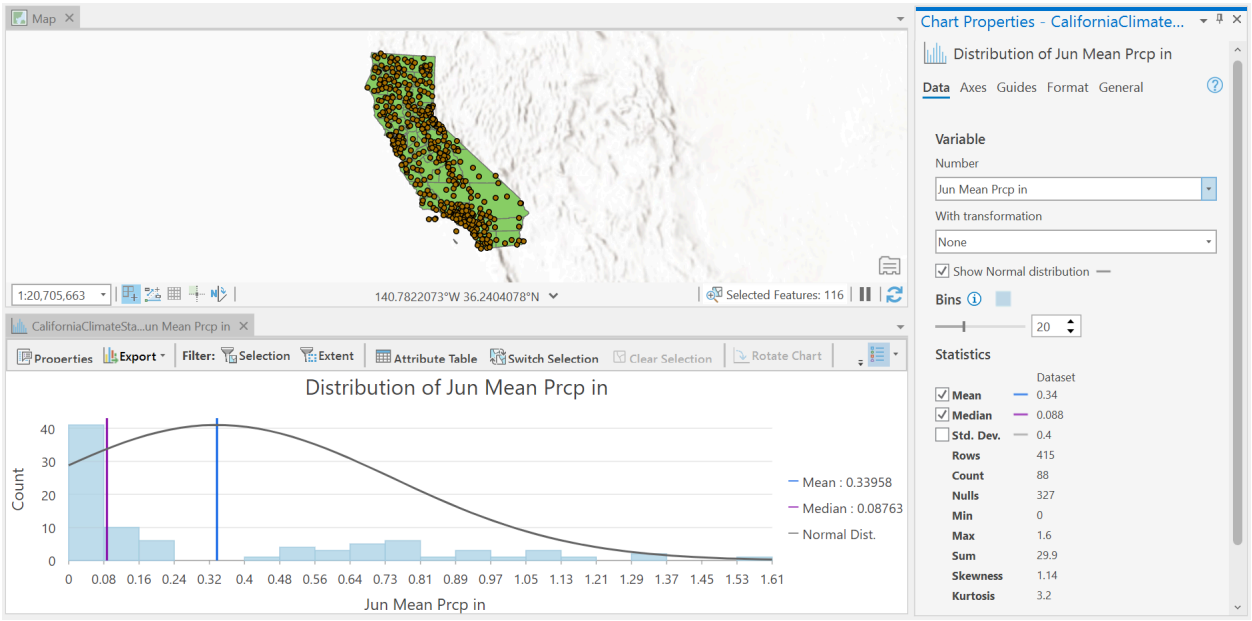


Figure 18: Histogram showing the distribution of Mean Precipitation in inches for the month of June. Most of the climate stations noted a mean precipitation of 0-0.03 inches.

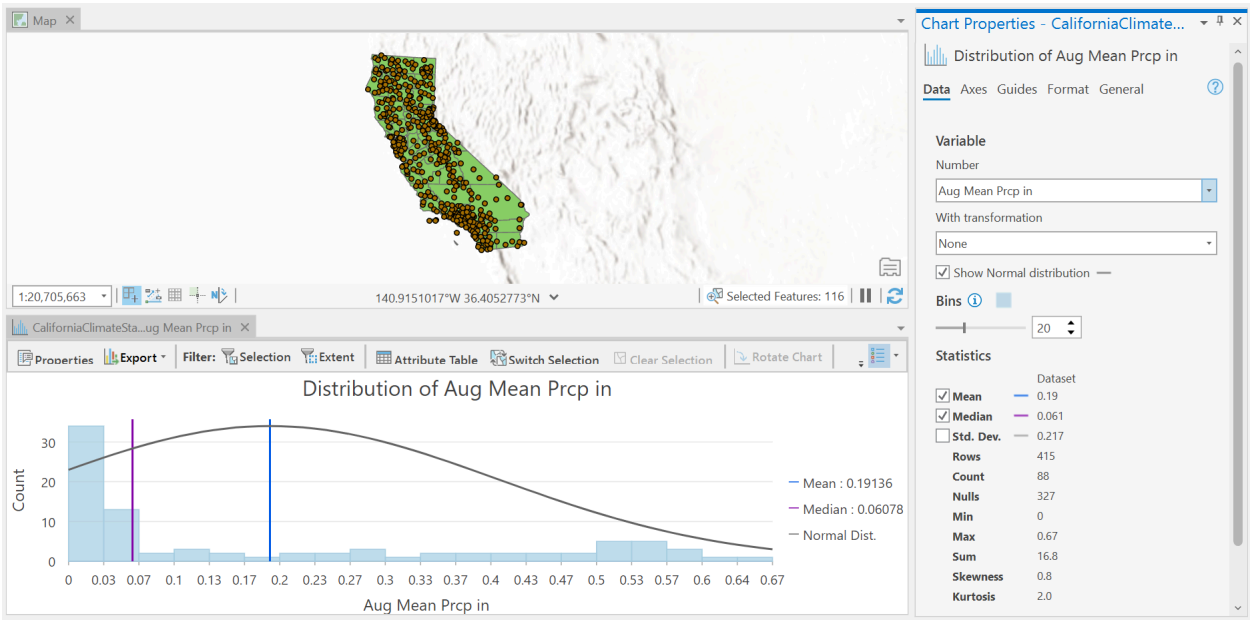


Figure 19: Histogram showing the distribution of Mean Precipitation in inches for the month of August. There are a lot of values with 0-0.03 inches of rain.

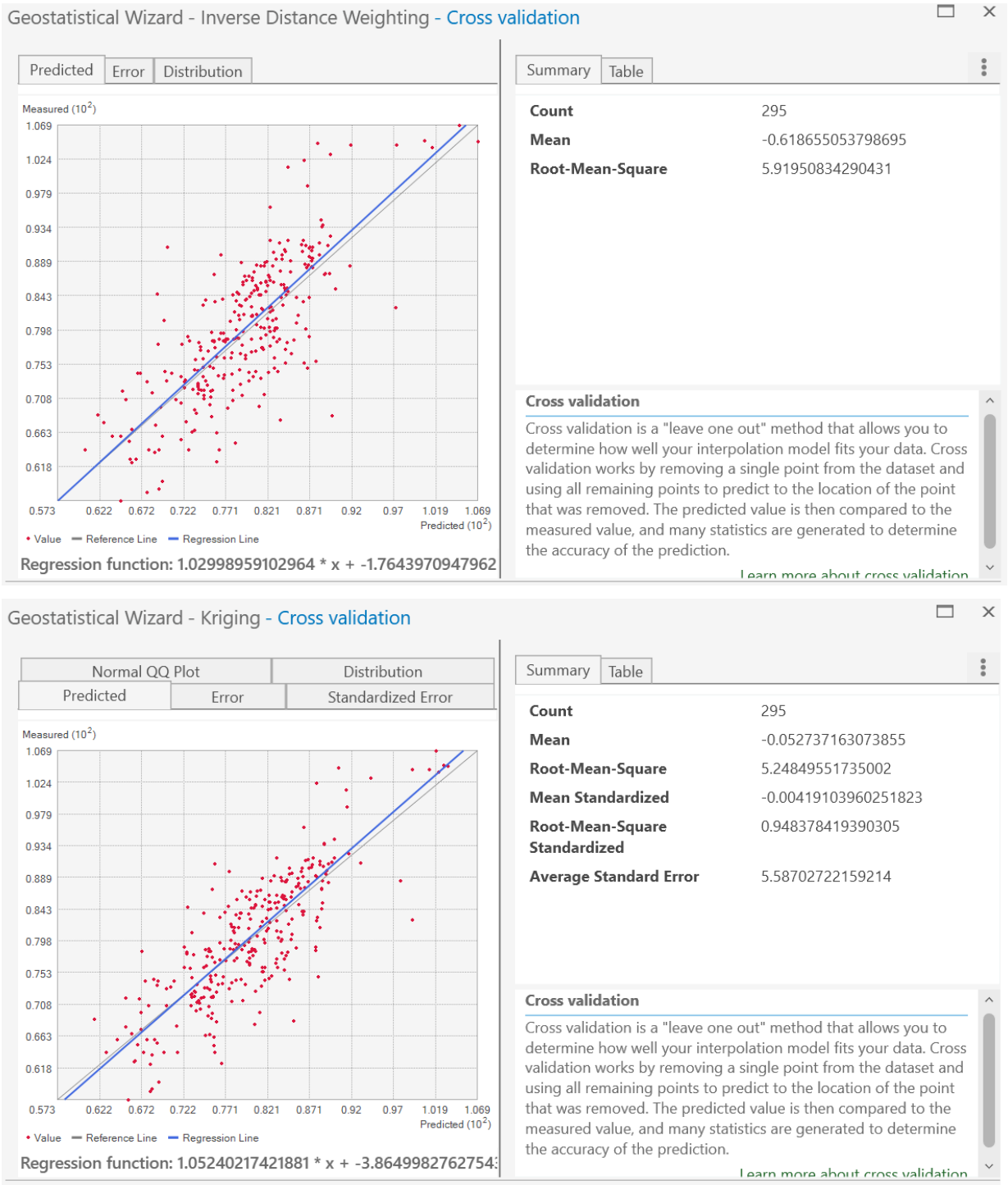


Figure 20: Shows cross-validation comparing the results of IDW (top) and Kriging (bottom) on June mean temperature values.

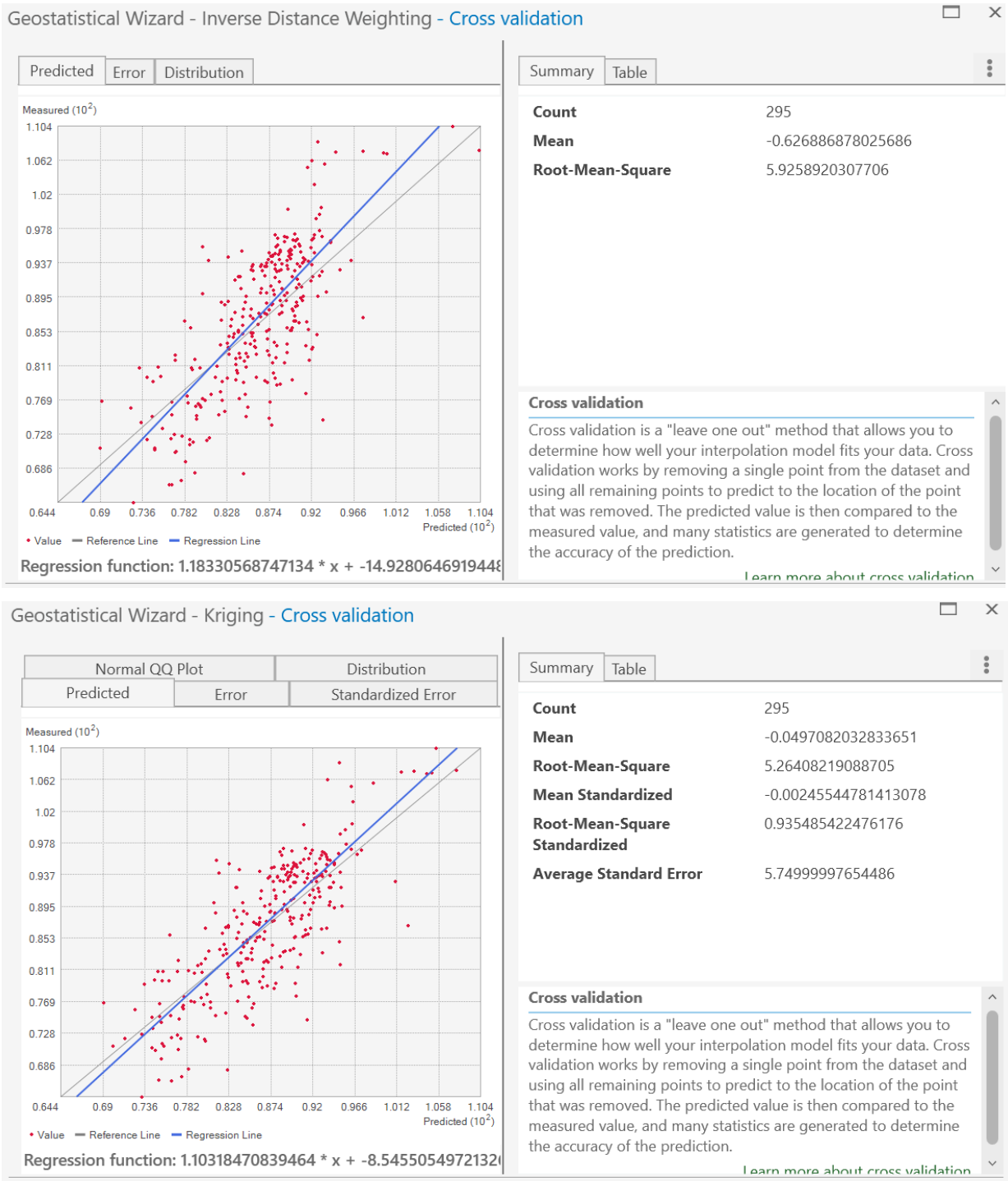


Figure 21: Shows cross-validation comparing the results of IDW (top) and Kriging (bottom) on August mean temperature values.

	Variable	Mean	RMS	RMS - Standardized	Ave Standard Error (Kriging Only)
IDW	June Temperature	-0.618655	5.919508342		
Kriging	June Temperature	-0.02737163	5.248495517	0.94837841	5.587027221
IDW	August Temperature	-0.62688687	5.925892030770		
Kriging	August Temperature	-0.04970820	5.264082190887	0.935485	5.79499999
IDW	June Precipitation	0.0292382259	0.220225062		
Kriging	June Precipitation	-0.0003125609	0.1900019039	.8421517111	0.226328217
IDW	August Precipitation	-0.00020263384	0.105307254569		
Kriging	August Precipitation	0.0004636125	0.08904500	0.8428747167	0.108463196

Table 2: This table is meant to show the comparison of Mean, Root-Mean-Square, Root-Mean-Square Standardized, and Average Standard Error between the different types of interpolation. The values highlighted in yellow are the preferred values after running the IDW and the Kriging tool on each variable. Mean and Root-Mean-Square are better the closer they are to 0 and Root-Mean-Square Standardized and Average Standard Error are better when closest to 1.

Discussion

Using my precipitation data, temperature maps and wildlife hot spot analyses, I concluded that June is the best time to visit Sequoia National Park. It is one of the most temperate months in the park and has a decent amount of precipitation, which lowers the risk of wildfire. The other maps in my report are useful for determining the best spots in the park to visit as well. They will help potential visitors of the park make informed decisions about when to be cautious due to natural hazards such as rattlesnakes. GIS tools are incredibly useful for creating a great itinerary and a safe tirp for the average tourist.

Limitations

DEM File - Some limitations of the Sequoia National Park DEM layer could be that the projection might not be 100% accurate.

Urgent Care Center Map - This file shows the urgent care facilites around the park and in major metro areas. The data is sourced relieably but is older and may not be reflective of where medical services can really be found near Sequoia.

Rattle Snake Sighting Data - Some of the data for the rattle snake layer is also older and maay not have been sourced the most reliably. Some data from gbif.org is collected by iNaturalists. Though this data is typically usable and is collected by scientists and ecologist, there may be some discrepancies in how the locations of these sightings are reported.

Optimized Hot Spot Analysis - There were only 41 points in the rattle snake layer that I used to create my Optimized Hot Spot Analysis. To create a more accurate hot spot analysis, I would need more points to create a more representative sample. Much of the sighting data I used was around the most populated parts of the park. It could be that this sample is skewed because people tend to spend most of their trips to Sequoia around these areas. I cannot say with certainty that my Optimized Hot Spot Analysis map shows an accurate concentration of rattle snake populations.

Watershed Tool - I ran the watershed tool a few times and got some variations in the results each time. Sometimes the watersheds would change shape or be entirely different all together. These shapes may not be accurate because of where I chose to place the pour points for each one. They may be inaccurate as a result of human error.

I chose many spots in my itinerary based on their proximity to wildlife spotting hotspots. The data I used to assess the spread of the California Newt, the Mule Deer, the American Pika and Steller's Jay were all found through gbif.org and pose many limitations to my analysis. Many of the sightings were located in the most populated and well-traveled areas in the park. There may be some inconsistencies between the real spread of these sightings and where these animals were reported to be seen. There may have been more sightings.

Additionally, the tools used did not consider the topography of the park in their spatial calculations. This could impact the real location of the central point and the shift where the cluster is really located. For example, the Mean Center and Central Feature tools both use the location of the feature to determine how centered it is spatially. These points only have x and y values so some of them may be on entirely different planes of elevation from one another but are still treated as if they are on a flat surface by ArcGIS.

The Average Nearest Neighbor tool also does not account for vertical relief in its calculations. There could be deviations in the elevation of points that is not being accounted for whatsoever. The results of running this tool would change drastically if this was factored in.

The Spatial Autocorrelation report does not analyze the all the data points with 100% accuracy. Many of my data points were missing some information that made them unusable by this tool. 143 out of 832 points were unreadable and were not factored into the calculations. This could majorly impact the conclusions drawn using the information it produced.

The Optimized Spatial Analysis tools were good for assessing where Sequoia's major clusters of Stellar's Jay were located. However, I believe that the hexagonal grid more accurately depicted the clusters on the map. It was more useful for depicting the curvature of the cluster and gave the viewer a more accurate visual of where most of the points were located. The fishnet grid was not as precise in this instance.

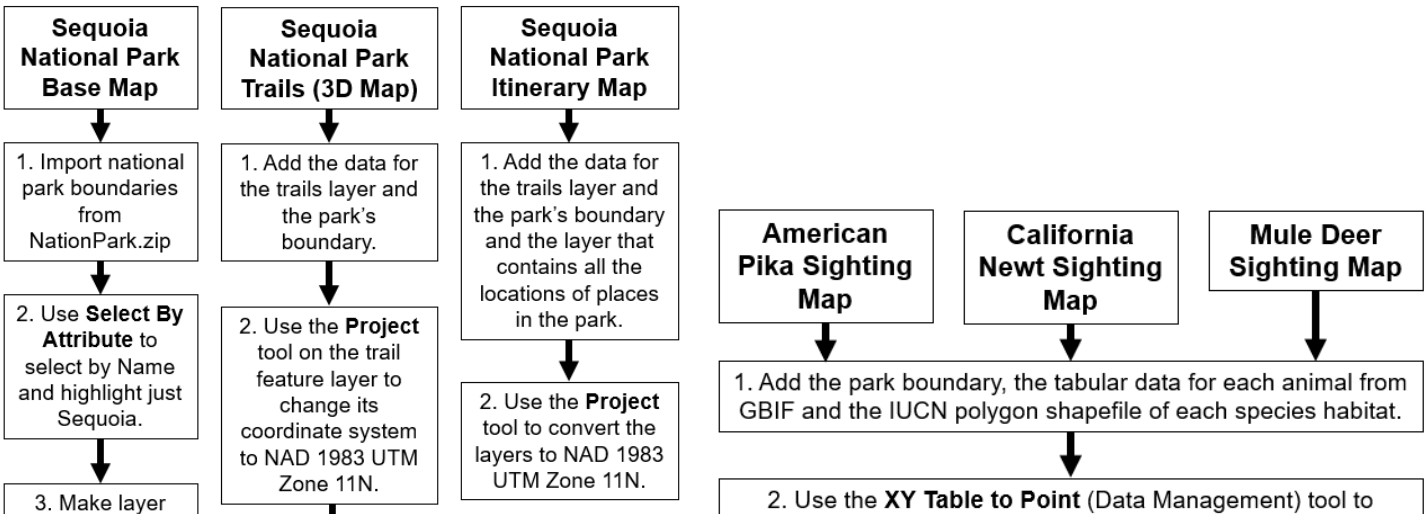
Sources Table

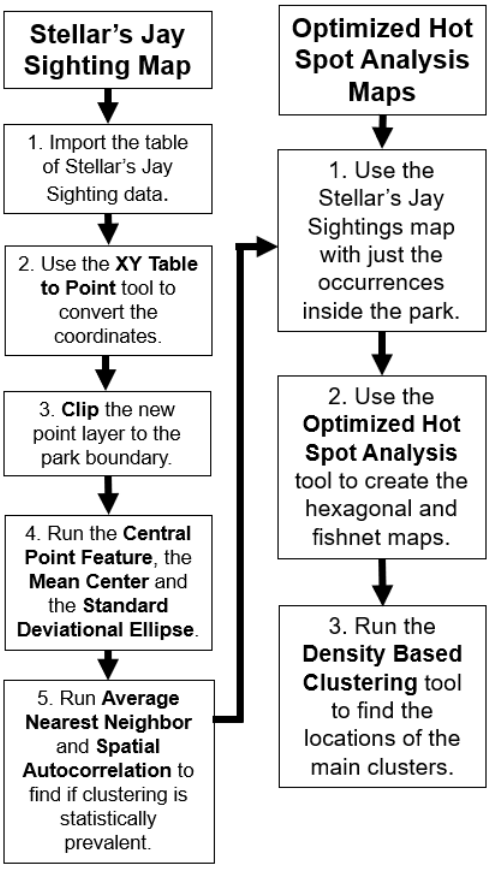
Data Name	Data Source	File Type	Coordinate System	Use

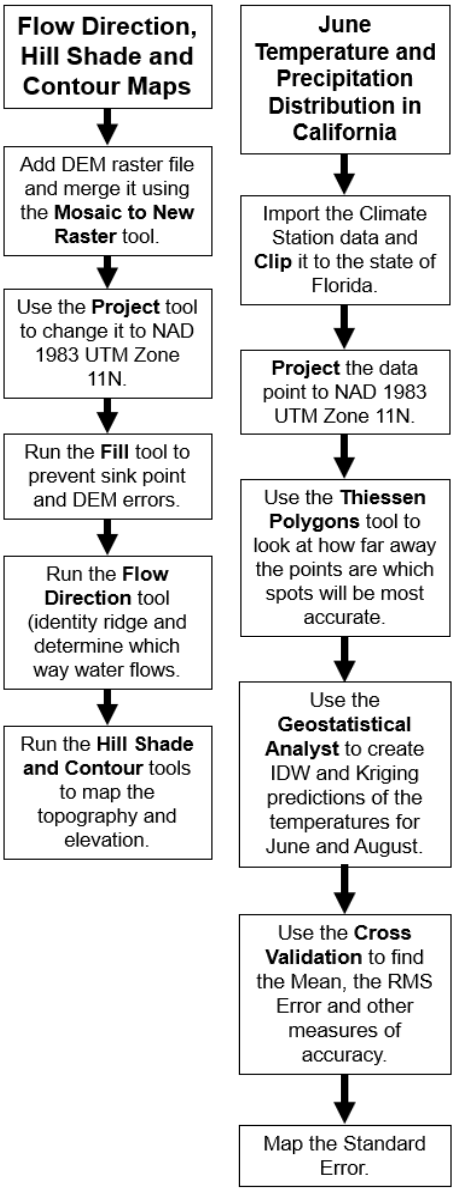
USA States	https://www.arcgis.com/home/item.html?id=774019f31f8549c39b5c72f149bbe74e	Shape file	NAD UTM Zone 11N	Shows where Sequoia National Forest is in California and in relation to other states.
Sequoia National Forest	https://www.arcgis.com/home/item.html?id=3f13adbd695a4abbbf7d85c52b539989	Shape file	NAD UTM Zone 11N	Shows where sightings fall within the park's boundaries.
DEM Raster	https://prd-tnm.s3.amazonaws.com/StagedProducts/Elevation/1/TIFF/historical/n37w119/USGS_1_n37w119_20211004.tif	TIF File	NAD UTM Zone 11N	A digital elevation raster of Sequoia that was used to assess the elevation and topography.
California Newt Sightings	https://doi.org/10.15468/dl.n3qb4u	csv	None	Shows where California Newts were most commonly sighted and what months they were seen.
California Newt Boundary	https://www.iucnredlist.org/species/59471/11946313	Shape file	NAD UTM Zone 11N	Shows the typical habitat of California Newts.
Mule Deer Sightings	https://doi.org/10.15468/dl.mweemr	csv	None	Shows where Mule Deer were most commonly sighted and what months they were seen.
Mule Deer Boundary	https://www.iucnredlist.org/species/42393/221621113	Shape file	NAD UTM Zone 11N	Shows the typical habitat of Mule Deer.
American Pika Sightings	https://doi.org/10.15468/dl.aaxvkf	csv	None	Shows where American Pika were most commonly sighted and what months they were seen.
National Park Service Trails	https://irma.nps.gov/DataStore/Reference/Profile/2223544	Shape file	NAD UTM Zone 11N	To show easily accessible roads to and from major locations.
Cyanocitta stelleri (Gmelin, 1788) Stellar's Jay Sightings	https://doi.org/10.15468/dl.wp65uc GBIF	csv	NAD 1983 UTM Zone 11	To show all the sightings of Stellar's Jay within Sequoia National Forest.
Puma concolor (Linnaeus, 1771) Mountain	https://doi.org/10.15468/dl.ptzz6m	csv		

Lion Sightings				
World Monthly Climate Data	NOAA	Point Layer	NAD 1983 UTM Zone 11N	Used to create IDW and Kriging layers to analze the weather conditions of California.
California Counties	https://www.arcgis.com/home/item.html?id=2f227372477d4cddadc0cd0b002ec657	Polygon Shapefile	NAD 1983 UTM Zone 11N	Used to define the boundary of California state.
Campgrounds	https://www.arcgis.com/home/item.html?id=17d3bfc1803e467590258367848b33b3	Point File	NAD 1983	Used in the Intinerary Map to show where the campgrounds in the park are located.
Crystal Cave	https://www.arcgis.com/home/item.html?id=17d3bfc1803e467590258367848b33b3	Point File	NAD 1983 UTM Zone 11N	To show the location of a great attraction of the park.
Health Care Facilities	https://www.arcgis.com/home/item.html?id=41daac7fcfc0413badf6b9a9298acdfc	Point File	NAD 1983	To show where healthcare facilities are located in relation to certain areas of the park.
Sequoia Kings Canyon National Park Atlas	https://www.arcgis.com/home/item.html?id=17d3bfc1803e467590258367848b33b3	Shape File	NAD 1983	This was used to create the itinerary map

Table 2: This table details the source information for each piece of data I used for my Applications Assignments.




Stellar's Jay Sighting Map
1. Import the table of Stellar's Jay Sighting data.
2. Use the **XY Table to Point** tool to convert the coordinates.
3. **Clip** the new point layer to the park boundary.
4. Run the **Central Point Feature**, the **Mean Center** and the **Standard Deviational Ellipse**.
5. Run **Average Nearest Neighbor** and **Spatial Autocorrelation** to find if clustering is statistically prevalent.
Optimized Hot Spot Analysis Maps
1. Use the Stellar's Jay Sightings map with just the occurrences inside the park.
2. Use the **Optimized Hot Spot Analysis** tool to create the hexagonal and fishnet maps.
3. Run the **Density Based Clustering** tool to find the locations of the main clusters.


Flow Direction, Hill Shade and Contour Maps
Add DEM raster file and merge it using the **Mosaic to New Raster** tool.
Use the **Project** tool to change it to NAD 1983 UTM Zone 11N.
Run the **Fill** tool to prevent sink point and DEM errors.
Run the **Flow Direction** tool (identity ridge and determine which way water flows.
Run the **Hill Shade and Contour** tools to map the topography and elevation.
June Temperature and Precipitation Distribution in California
Import the Climate Station data and **Clip** it to the state of Florida.
Project the data point to NAD 1983 UTM Zone 11N.
Use the **Thiessen Polygons** tool to look at how far away the points are which spots will be most accurate.
Use the **Geostatistical Analyst** to create IDW and Kriging predictions of the temperatures for June and August.
Use the **Cross Validation** to find the Mean, the RMS Error and other measures of accuracy.
Map the Standard Error.

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National Park Service. Paradise Creek Trail. (2020). [Accessed Dec. 1st, 2022] https://www.nps.gov/places/000/paradise-creek-trailhead.htm

National Park Service. Giant Tree Museum. (2022). [Accessed Dec. 1st, 2022]https://www.nps.gov/seki/learn/historyculture/gfgfm.htm
Sources

USA_Parks [Feature layer], ArcGIS Online Living Atlas, [Accessed Dec. 1st, 2022] Found: https://services.arcgis.com/P3ePLMYs2RVChkJx/arcgis/rest/services/USA_Parks/FeatureServer

United States News. (2022). *Best Times to Visit Sequoia National Park*. U.S. News Travel. [Accessed Nov. 09, 2022]. Found at: https://travel.usnews.com/Sequoia_National_Park_CA/When_To_Visit/#:~:text=The%20best%20time%20to%20visit,roads%20during%20the%20winter%20months.

ESRI. Kriging (Spatial Analyst). ArcGIS Pro Documentation. [Accessed Nov. 09, 2022]. Found at: https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/kriging.htm

National Oceanic and Atmospheric Administration (NOAA). (2010). *World Monthly Climate Data.* [Accessed Nov. 09, 2022].