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Distribution Modeling for the Sierra Bighorn Sheep

Abstract

The Sierra Nevada bighorn sheep is in the list of endangered species which mainly threatened by predators, specifically mountain lions. Main aim of this research was to find the suitable places for the Sierra Nevada bighorn sheep. Generally, Sierra Nevada bighorn sheep inhabited in some portions of the Sierra Nevada located along the eastern boundary of California in Tuolumne, Mono, Fresno, Inyo, and Tulare Counties. The possibly suitable areas for the sheep are in high altitude, around 10,000 – 14,000 feet in summer and lower than 10,000 feet in winter. Most of the areas are covered by bare rock, shrub, and evergreen forest and herbaceous. The range of temperature is between 38.9 to 49.7 degrees Fahrenheit with 817 to 990 millimeters of precipitation.

Introduction

"Our research question is the following: *Is it possible to create an accurate distribution map of the Sierra Nevada Bighorn Sheep that is based on easily accessible, public data in a limited time frame?* To address the issue, we collected data about the Sierra Nevada Bighorn Sheep. Then we searched through government sources that would provide detailed data. Finally, we processed and analyzed the data to result in a distribution map."

The Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) are one of the two species of mountain sheep in North America, inhabits in some portions of the Sierra

Nevada located along the boundary of California. Its habitats mostly are located 4,800 feet to 14,000 feet above mean sea level. The area that Sierra Nevada bighorn sheep prefers is steep slopes and canyons just to avoid being a prey of mountain lions and other predators by using and thick brush to hide itself. Interestingly, the bighorn sheep found to be in the open space for food. This is so because bighorn sheep can detect its predators easily from distance and have enough time to reach to the safety place. Bighorn sheep is primarily diurnal. They are primarily grazers; however, they may browse woody vegetation at times. Plants consumed include various grasses, browse, and forbs, depending on season and location. Naturally occurring mineral licks provide necessary nutrients for bone and muscle growth (Wikipedia: The Free Encyclopedia). Sierra Nevada bighorn sheep is affable which will be grouped by gender and season. The Sierra Nevada bighorn sheep is one of species that has been listed as endangered on January 3, 2000 (California Department of Fish and Wild), By the 1920, Bighorn sheep was eliminated from Washington, Oregon, Texas, North Dakota, South Dakota, Nebraska, and part of Mexico, hit a population low of about 100 total individuals distributed across 5 areas of the southern and central Sierra Nevada, and some parts of eastern California. The main causal factors are loss of habitat, predators, and diseases from domesticated sheep. Some current conservation efforts included preventing domesticated sheep from coming in contact with the Bighorns, inhibiting predators, mainly the mountain lion, from attacking the sheep, and habitat protection and recovery. Nobody realizes how many Sierra Nevada bighorn sheep originally ranged over the Sierra Nevada, but if they occupied all suitable habitats, they probably numbered several thousand. Thus, the goal of this study is to focus on one of these aspects of species recovery, specifically, that of habitat. Utilizing the different

preferences that the Bighorn has to have for habitat, by attempting to locate the suitable areas where Bighorns that were bred in captivity should be released into.

Methodology

Overviews

The study area of this research is mainly the southeastern part of California State, which covers seven counties and located along the mountains and canyons. According to the topic, the main objective of this research focuses on finding the suitable places for Sierra Nevada bighorn sheep. Then, the explanations of the causal factors will be followed.

Sierra Nevada bighorn sheep

Sierra Nevada bighorn sheep data were obtained from US Fish & Wildlife Service's online service for information regarding Threatened and Endangered Species final Critical Habitat designation across the United States. The data were originally created in 1999 to display where the places the sheep mostly found.

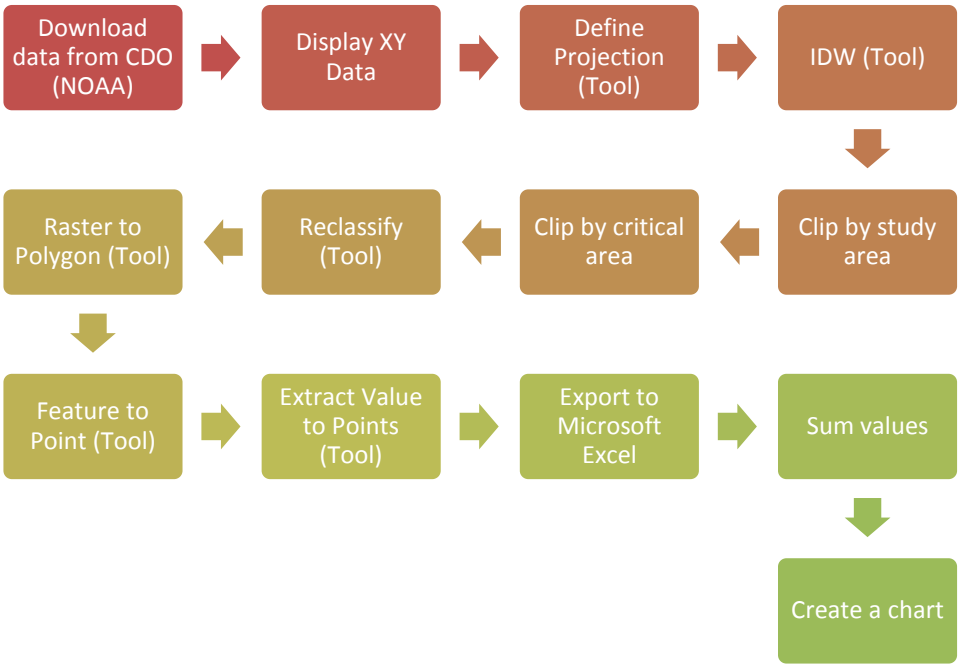
The data were in a shapefile which was checked metadata firstly, and defined geographic coordinates as same as whole data.

Temperature Data

Temperature data were used to find the particular patterns of the original areas of Sierra Nevada bighorn sheep, and evaluate further where should be the suitable areas in neighbor areas for being the sheep's habitats.

The set of data was acquired from Climate Data Online (CDO), National Oceanic and Atmospheric Administration (NOAA). They are annual summary data of 2011. Firstly, the data were determined by checking their attributes followed by metadata. Next, the data were projected onto the same format with the rest of data and interpolated them by using Inverse Distance Weighted (IDW) tool to create a raster surface of temperature points. It was done by changing the power value to 0.2

and cell size to match with National Elevation Dataset (NED) about 30 meters as well as keep other values as default. Then, the raster layer was compared with the PRISM temperature data to check the correctness and errors of the processed data. The raster layer was used then clipped. Clip Tool was used to clip the critical habitats a temperature layer. Then, the entire data were overlaid, classifying layer properties was manipulated. Statistical calculation was the last step. Interpolated data was reclassified by using Reclassify Tool in to create another feature data with its attribute. Finally, Feature to Point Tool was used to generate representative points of temperature values on each temperature ranges. Extract Value to Points Tool was lastly used to extract all values from temperature layer to points. Statistical analysis, export the attribute from ArcMap as a database file or any formats that can be opened by Microsoft Excel. The attribute shows a number of values classified by temperature ranges, Data manipulation were lastly concerned for finding statistical analysis, in this research Z or Sum function was operated to count numbers of data and performed as a pie chart.



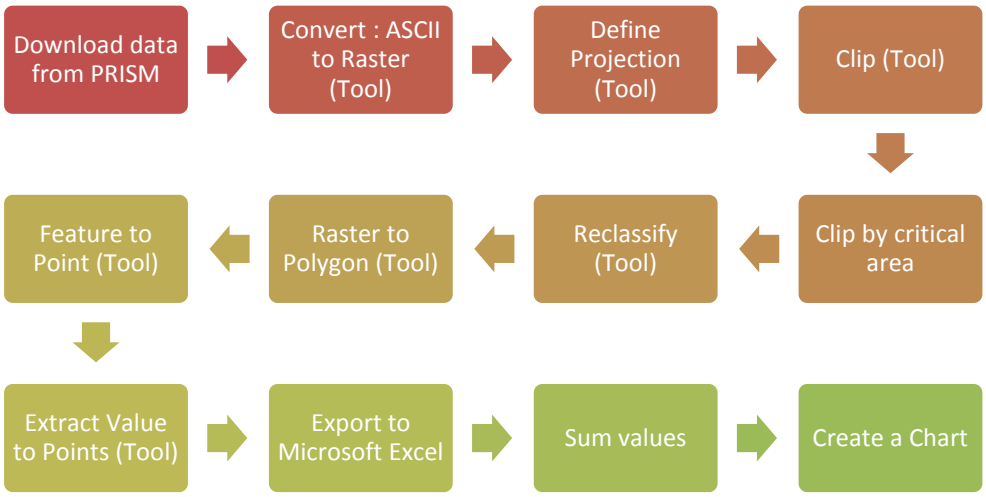
(I.) Hierarchy of methods

Precipitation Data

Precipitation was used for evaluation how much rainfall in the areas yearly where the sheep lives in. It was used as well to locate other places which have the similar patterns and to assess the types of vegetation which are the sheep's feed by referencing from precipitation data.

The annual percentage of precipitation of 2011 was downloaded from PRISM as an ASCII file. The data was then converted and imported from ASCII format to a raster file by using ASCII to Raster Tool. The data was defined geographic coordinates, clipped and resampled to fit with the rest of data and cell sizes by using Clip Tool and Resample Tool. Then, Reclassify Tool was selected to reclassify data from raster to feature and created an attribute. Afterward, Feature to Point Tool and Raster to Polygon Tool were employed to create a feature point layer as well as a feature polygon layer for further processing. The last step was extracting values of

precipitation using Extract Value to Point Tool to collect precipitation values to its attribute. Precipitation also uses statistical analysis. Exported the attribute from ArcMap as a database file and open in Microsoft Excel. The attribute shows a number of values classified by precipitation ranges; Data manipulation was importantly concerned for finding statistical numbers, in this research Z or Sum function was operated to count numbers of data and performed as a pie chart and converted all values to percentage.



(II.) Hierarchy of methods

National Elevation Dataset (NED)

The National Elevation Data was used to create an elevation model to define the highest and lowest height the sheep would live. As same as other data, this model will be evaluated the nearby places that have same elevations to assess the suitable places for the sheep.

The National Elevation Data was defined and acquired as a layer from U.S. Geological Survey (USGS). In this research, 20 layers of each areas of interest were downloaded from the website by selecting downloadable product theme. Then, all

layers were defined geographic coordinates to match the entire data. All layers were appended together by using Mosaic Toolset.

Water Bodies Data

Water Bodies represented the open water rivers, lakes, seas, ponds, playas and oceans. This data were another data used as a reference and a component to show where the water bodies are in the study areas and also were used to determine as another living factor for the sheep.

The dataset was obtained from U.S. Geological Survey (USGS) as a shapefile. Afterward, the data was checked and defined the geographic coordinates to North American Datum of 1983 (NAD83) as same as the rest of data. Regularly, the dataset come with a bunch of water types and sizes. To deduct some types of water bodies, query attributes was operated. In this case, water bodies which the sizes smaller than a controlled size will be removed.

National Land Cover Database 2006 (NLCD2006)

The NLCD was used to evaluate what kinds of land covers the sheep are living on. It was used to investigate the places where the same significant types of covers the sheep prefer.

Generally, the data can be downloaded from Multi-Resolution Land Characteristics Consortium (MRLC) website and can be defined geographic coordinates to NAD 1983. Afterward, the data, NLCD 2006 was clipped by the area of interest using Clip Tool before was extracted by critical habitats, using Extract by Mask Tool. The types of land covers and counts of each type will be then shown in attribute. To analyze land cover data, the land cover was run with the Extract by

Mask tool, utilizing the critical habitats as the mask. The resulting attribute table was exported to Excel for similar counting and analysis as temperature and precipitation counting. From that, two main land covers, numbered "31" and "52" were selected. Afterwards, the Con tool from the Raster Calculator was utilized to pick out the areas with shrubs and rocky or relatively clear areas. The following is the formula utilized:

Con((("nlcd_final" == 52)|("nlcd_final" == 31)),1,0)

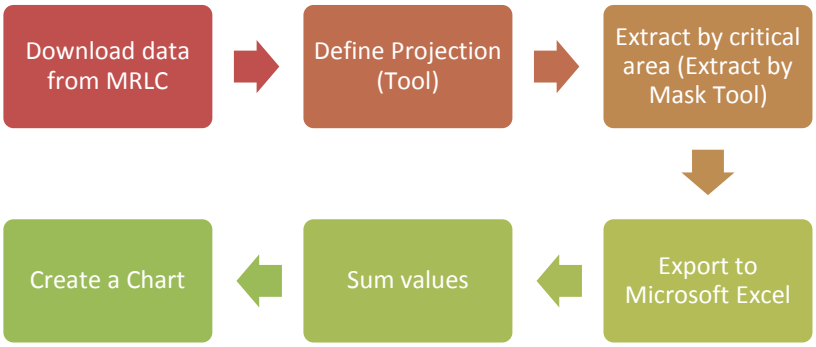
The formula created a new raster that had a value of 1 for areas with NLCD values of 52 and 31. All other areas were set to a value of 0.

For elevation, the NED data was combined into a single raster through the Mosaic tool with the option to update Overlays, create pyramids, and update statistics enabled. The resulting raster was clipped to the study area. The Con tool was run to select winter and summer elevation ranges of the sheep. The following formulas were utilized:

Con((("ned_reclip" >= 1524) & ("ned_reclip" <= 2743.2)), 1,0)

Con ((("ned_reclip" >= 3048) & ("ned_reclip" <= 4267.2)), 1,0)

These formulas calculated the winter and summer elevation ranges respectively. The values utilized were converted from feet to meters. The resulting two rasters had a value of 1 for ranges the sheep were most likely to frequent and a value of 0 for all other areas.



(III.) Hierarchy of methods

Result

The suitable habitats for bighorn sheep were determined by assessing the physical factors especially temperature, precipitation, and elevation. However, the availability of vegetation as sources of food for bighorn sheep and mountain lions as the predators were also taken into consideration.

According to temperature availability, it can be roughly analyzed by eyes and concluded that most areas are in greenish zone, or between 27.6 to 38.3 degree Fahrenheit. The statistic chart shows the greatest percentage of 33 percent was ranged between 33.87 and 35.33 degree Fahrenheit. As well, the second and the third places are in the same range from 35.33 to 36.87 degree Fahrenheit (Figure 1, 2). The reason why temperature parameter was included in this research is as followed. Firstly, the sheep lives in high altitudes which commonly relate to the temperature, and can be then used to predict the suitable areas for bighorn sheep. Secondly, temperature can affect ecosystem in the studied areas. Radically, sheep is the primary consumer in the food chain. Some plants, ecological producers, cannot grow in tropical temperature and low altitude (i.e. Coniferous,

Scrub and Herbaceous). Composers may not function properly when temperature changed. In addition, temperature has some other effects on habitats. For example, if the temperature is higher or lower than usual, land covers would be changed and the sheep might have to move to other places. Moreover, high temperature can cause increasing respiration, sometimes above the rate of photosynthesis. This means that the products of photosynthesis are being used more rapidly than they are being produced. For growth to occur, photosynthesis must be greater than respiration (Erv Evans). In this case, the studied areas would be warmer.

Precipitation is another parameter that directly relate to water supply. Since the areas where the precipitation is high, it generally effect on plants which are the sheep's feed. From the findings, the highest precipitation in the studied area is 1150 millimeters and the lowest is 76.3 millimeters. The greatest percentage of precipitation in the areas has approximately 903 millimeters, or 22 percent of the entire critical habitats (Figure 3, 4). Thus, possible habitat for the sheep could be the areas where the precipitation is between 817 to 990 millimeters. However, some other factors should be taken into account for the precision.

According to statistic findings and visual maps of NLCD, the possible living areas of the Sierra bighorn can be shown as a statistic pie. The results show the greatest percentage is 44 percent. They are Bare Rock, Sand and Clay. The second place in the studied areas covered with shrub and scrub which is the main source of foods for the sheep, 34 percent. The third place is evergreen forest which accounts approximately 16 percent. As the studied areas are located 3000 meters above mean sea level and yearly average temperature is 52 Fahrenheit, Moist forest, Montane forests, Mossy forests, Laurel

forest, Cloud forest, Fog forest, are generally tropical or subtropical or mild temperate evergreen forest are found in areas with high humidity and relatively stable and mild temperatures. Tropical evergreen forests are usually found in areas receiving more than 200 cm of rainfall and having a temperature of 15 °C to 30 °C. (Wikipedia: The Free Encyclopedia). The smallest area is grassland and herbaceous accounted for 6 percent (Figure 4, 5). Thus, using of land covers is made possible to determine the suitable areas for the sheep's habitats.

The analysis of elevation data from National Elevation Dataset can classify the studied areas into two massive areas rely on seasonal issue. First area is the appropriate area where sheep can live during the summer period which is approximately 10,000 – 14,000 feet high, shown as dark bluish. Another area may be fit for the Winter period located approximately between 5,000 – 10,000 feet high shown as light blue (Figure 7).

The final analysis consisted of using the Raster Calculator to "add" the various resulting rasters from the prior analysis

The resulting raster showed a map with cell values ranging from 2 to 6. The raster was then reclassified to only have values of 5 and 6 for the best and next best areas for a theoretical distribution (Figure 9).

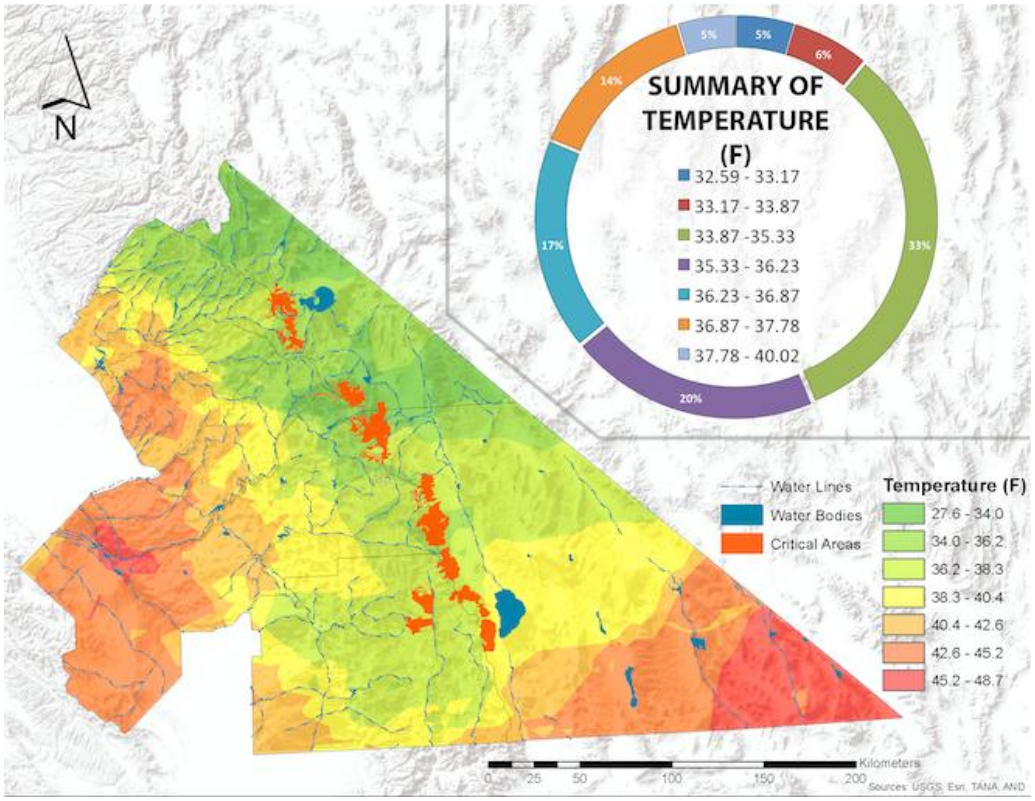


Figure 1: Temperature

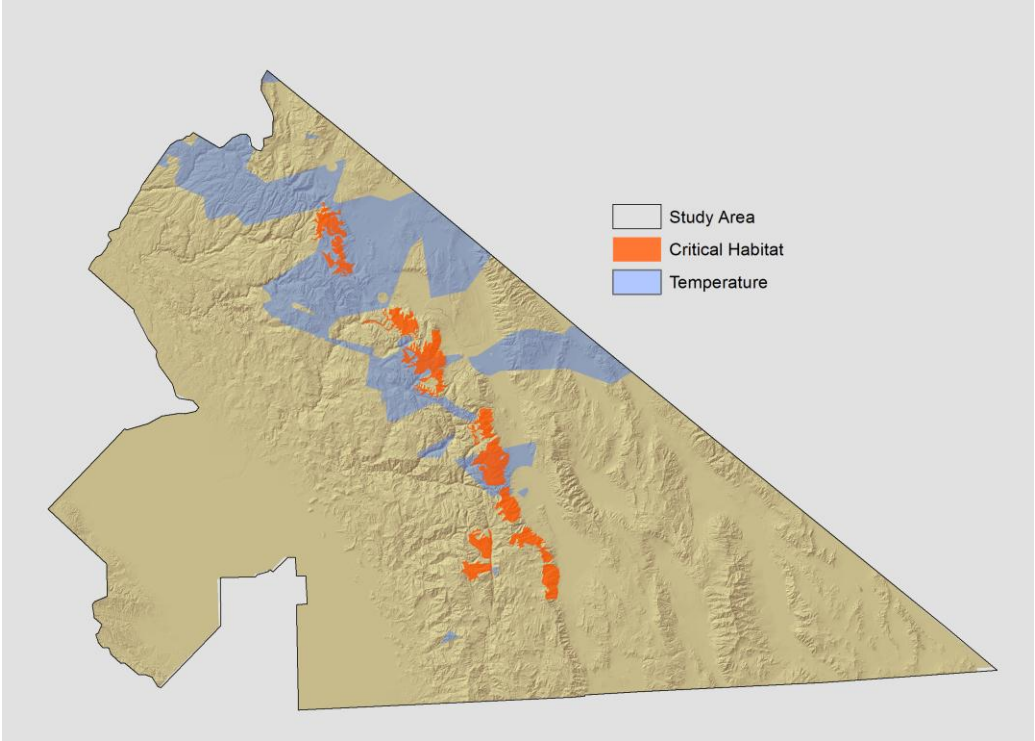


Figure 2: Analyzed Temperature

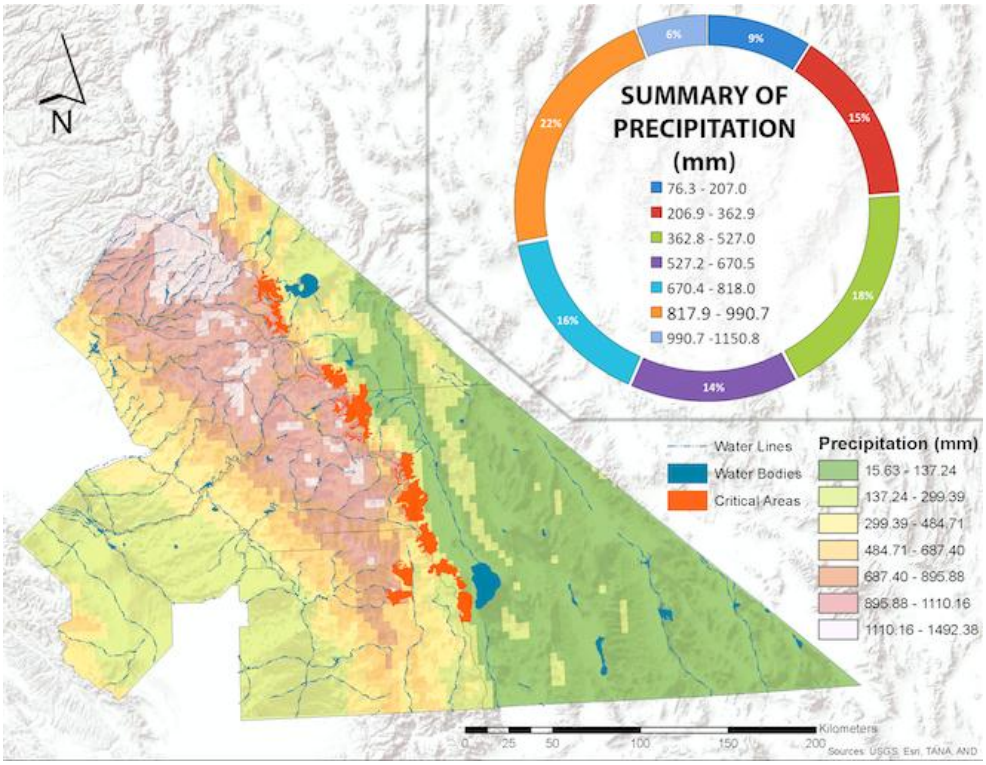


Figure 3: Precipitation

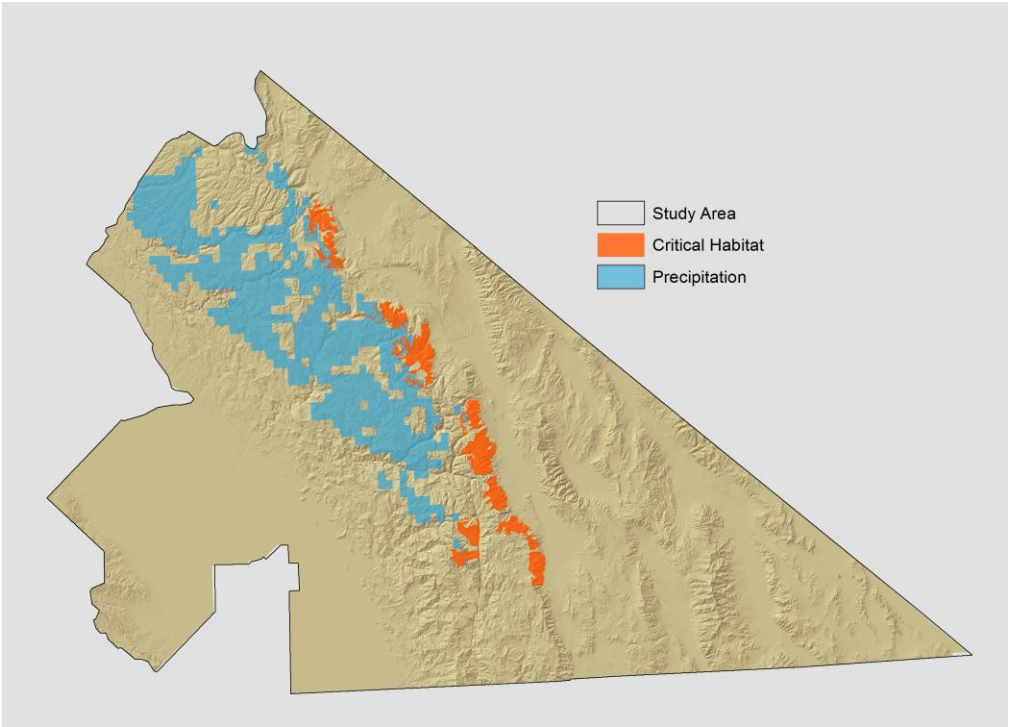


Figure 4: Analyzed Precipitation

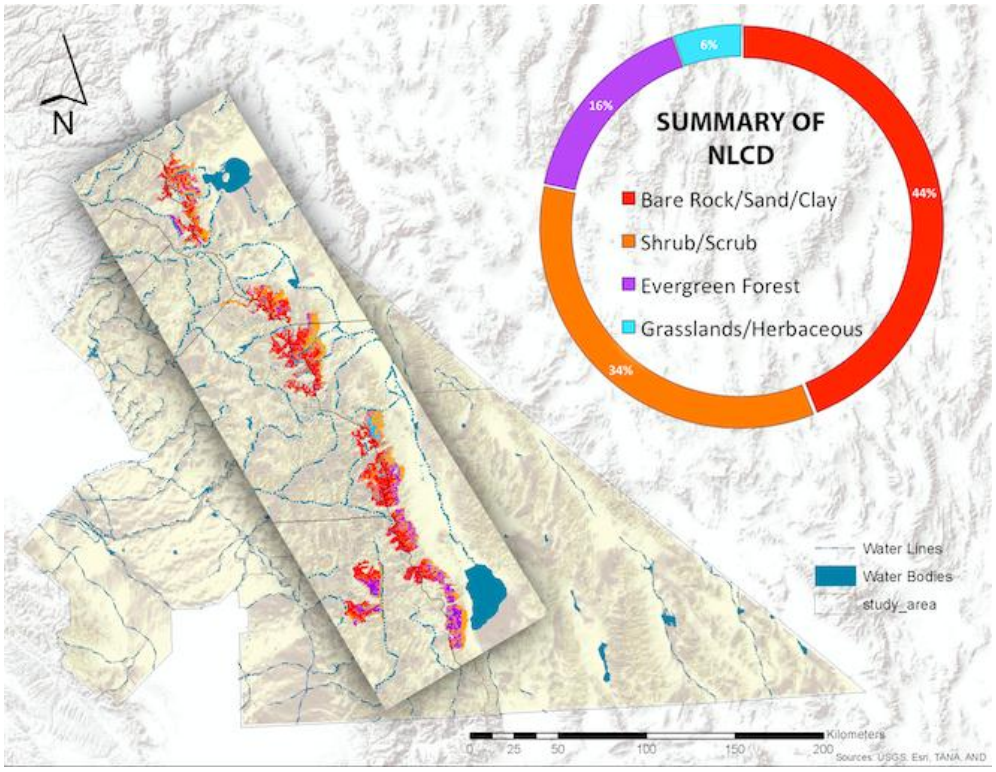


Figure 5: Land Covers

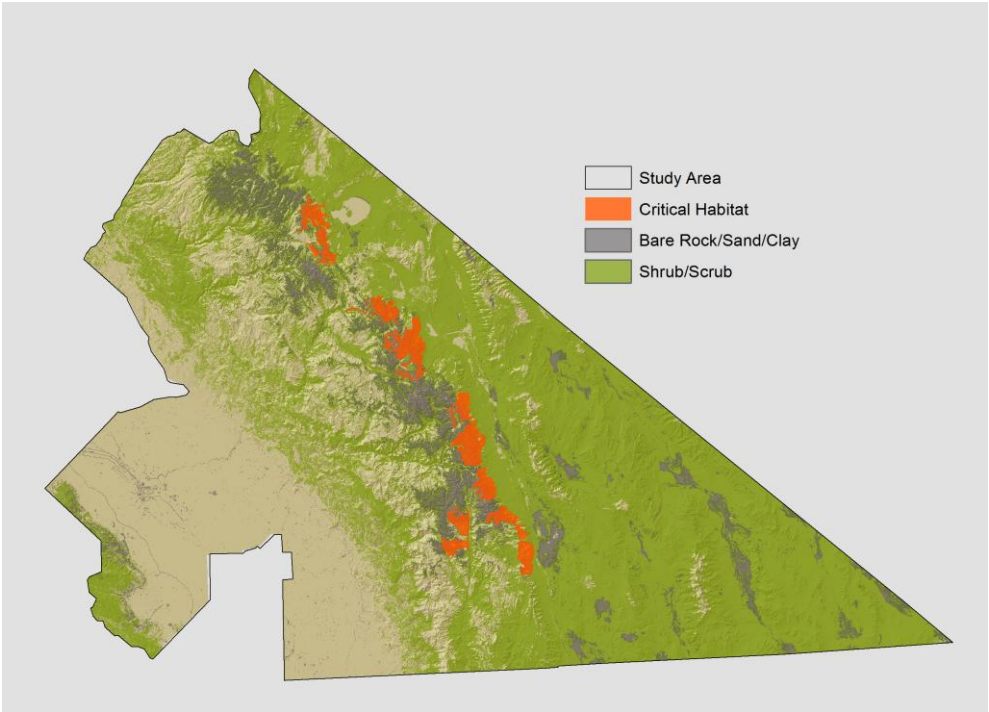


Figure 6: Analyzed Land Covers

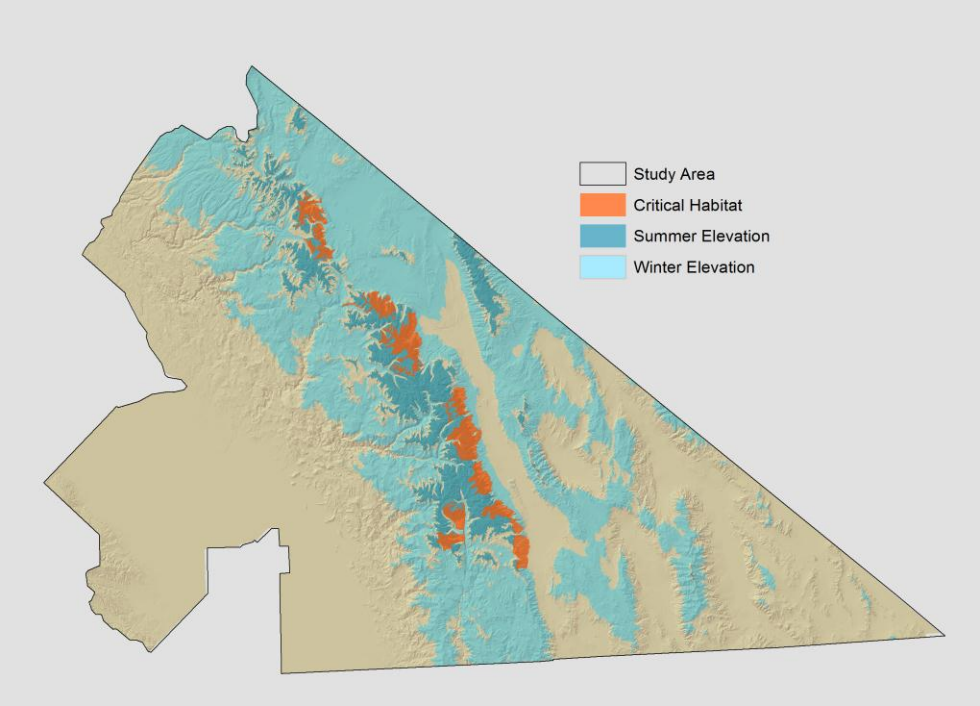


Figure 7: Seasonal Elevation

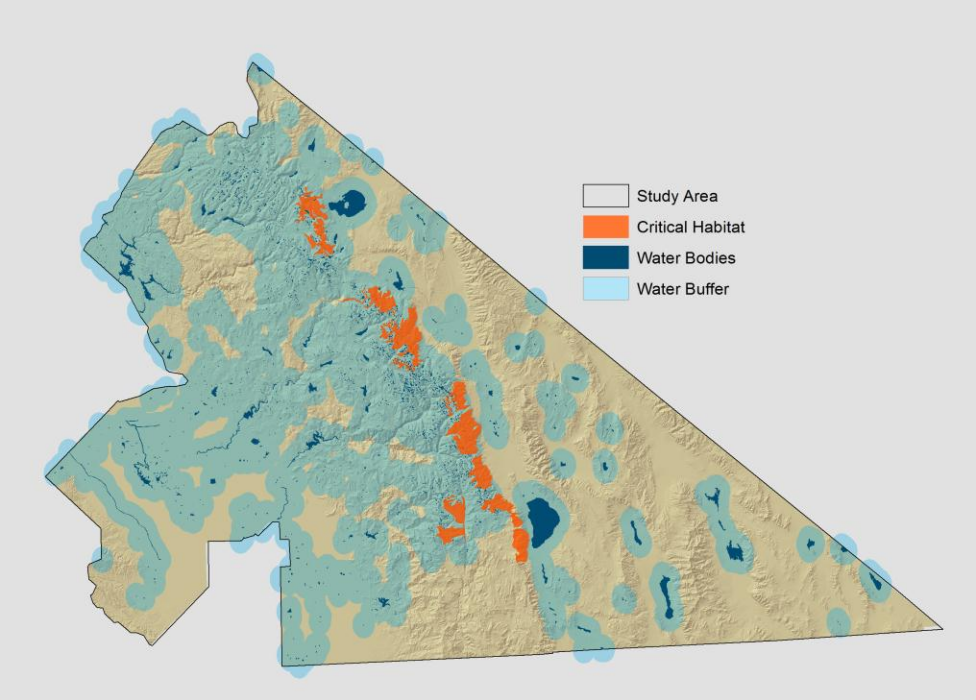


Figure 8: Buffered water sources

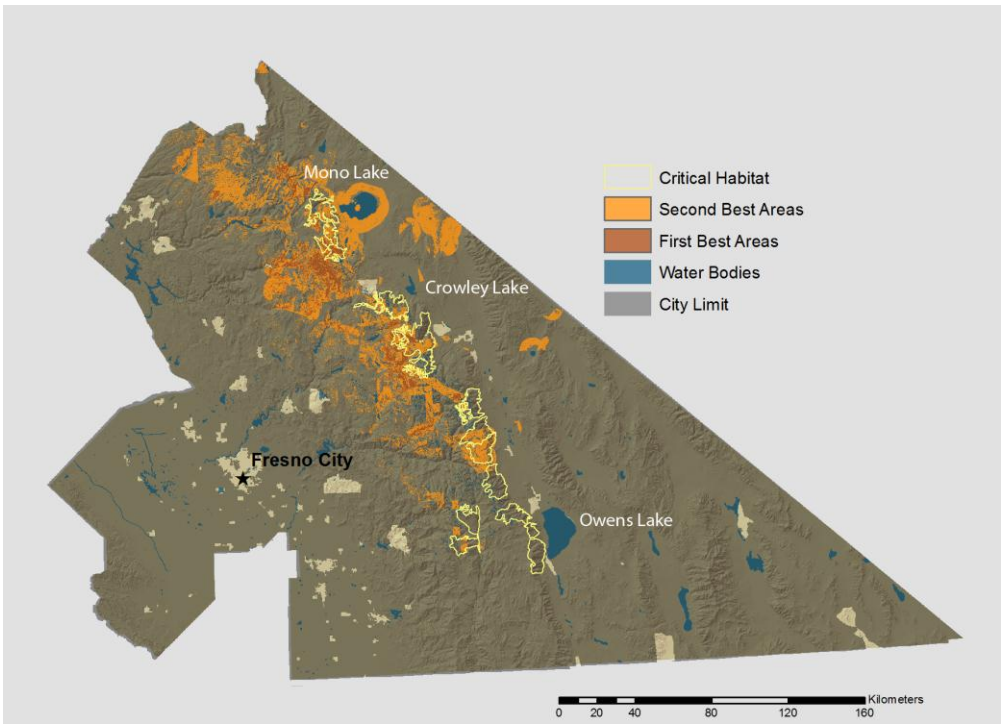


Figure 9: Suitable Areas

Discussion

Even though the suitability classification for the bighorn sheep's habitats needed a number of parameters for the assessment, the ones taken into account for the consideration in this study namely; temperature; precipitation; and elevation, however could yield a reliable result. In particular, when taken the vegetation types.

Limitations of this study mainly found to be concerning with the aspects of the data. Firstly, all data needed were obtained from the secondary sources of which some of them may be obsolete (out of date). Moreover, NED data are quite huge, mosaicking them from many files requires a lot of time. NLCD is another limitation. It is about the projection issues. A clipped NLCD does not rotate to the right position as projected.

Shortcomings are also found in this analysis. Some data are stored in a huge file which makes it difficult to transfer all data via email or cloud computing. Moreover, some data which is processed and analyzed by older version of ArcMap cannot be absolutely opened in a newer version. This makes it waste the time and all data need to be redone again and again in older version.

Suggestions from working on this research, in order to get the best results, are: (1) the project is supposed to be evaluated to figure out what kinds of data needed, and look up data as fast as possible; (2) If there is no data available, requesting data will be necessary; (3) verify date of the entire data and try to find in the adjoining period; and (4) planning time schedule after finishing the analysis for proofreading, editing and preparing for presentation.

Bibliography

A complete list of reference materials used for your project. Please use Turabian-style citations.

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