University of California, Berkeley

Mapping Bigfoot

GIS Analysis for Habitat Suitability and Conservation Planning in Humboldt County

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ESPM 72 Intro to GIS

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Introduction

The existence of **B**igfoot has intrigued humanity for centuries. These towering, seven-foot creatures are notorious for prowling through the wilderness, often startling hikers, construction workers, and campers. In California, particularly, sightings of **B**igfoot have sparked widespread curiosity about their habits and whereabouts. In Humboldt County alone, thousands of reports spanning from 1950 to 2022 attest to their presence, with sightings peaking in both summer and winter seasons. The abundance of data available allows for a comprehensive GIS analysis, providing valuable insights into their navigation patterns and preferred habitats. Leveraging the capabilities of ArcGIS Pro, our dataset includes location points of recent reports, Humboldt County's Digital Elevation Model (DEM) and parcel data, updated US Land Cover data (NLCD 2021), records of historical extreme heat days, and projections for extreme heat days by 2070. This paper is structured into four sections: clustering analysis, assessment of summer versus winter habitat suitability, evaluation of climate change impacts, and identification of optimal parcels for **B**igfoot conservation. Through this research, I aim to assist the Bigfoot Field Researchers Organization (BFRO) in creating a robust conservation strategy.

Clustering Analysis

Method

In an effort to deduce possible **B**igfoot habitat preferences, Spatial Autocorrelation (Global Moran's *I*) tool was used to measure spatial autocorrelation based on sighting points to evaluate navigational tendencies. The data was split into two (winter and summer) to compare seasonal preferences. The Moran's *I* statistic is:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2}$$

ESRI further explains the statistic above, but the main takeaway is that a Moran's *I* closer to +1 indicates positive spatial autocorrelation, and a Moran's *I* closer to -1 indicates negative spatial autocorrelation. A value closer to 0 suggests randomness. In this case, K-nearest neighbors was used as spatial weights to determine the clustering of **B**igfoot. The choice of K=3 is to ensure the capture of local patterns within each cluster and also, the fact that the analysis is only being conducted in one county.

Results

In winter (Figure 1.1), Moran's $I = 0.834$ indicates clustering with high significance (p-value: near 0); whereas in summer (Figure 1.2), Moran's $I = 0.99$ indicates a much denser clustering with high significance (p-value:

near 0). With IDs as input value, a high clustering suggests that **B**igfoot sightings with similar IDs tend to cluster together in space for both seasons, with slight dispersals in the winter. This suggests possible habitat preferences in the summer and slight navigational push in the winter due to cold conditions. The next section explores this. Figure 1.3 map displays winter versus summer clustering analysis.

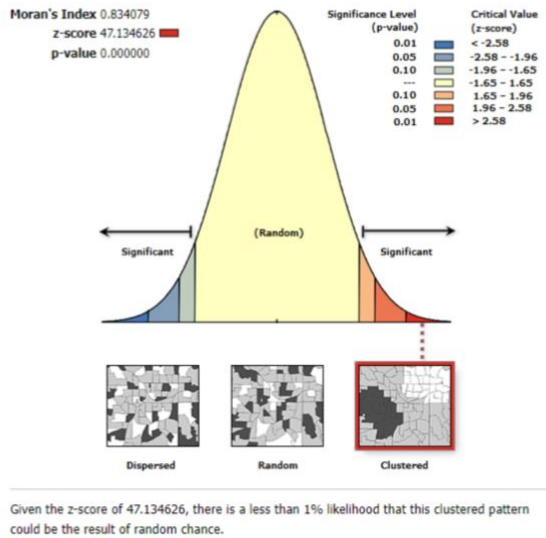


Figure 1.1 Winter Spatial Autocorrelation

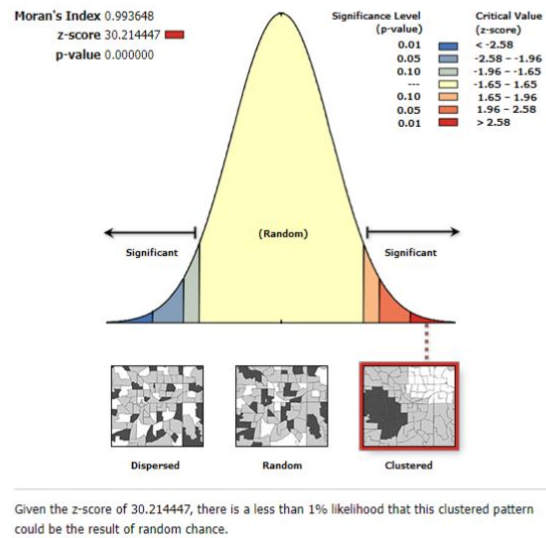
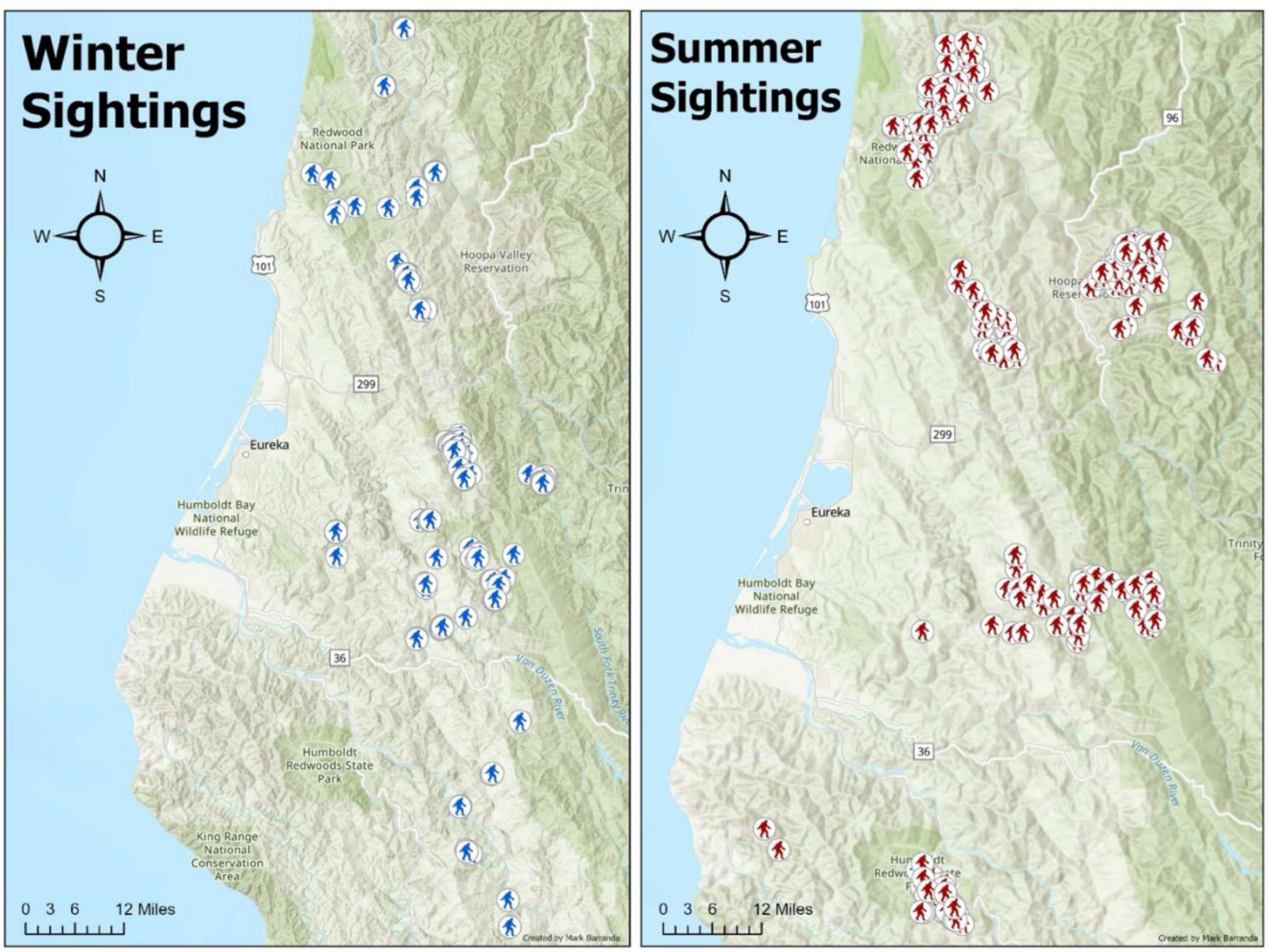


Figure 1.2 Summer Spatial Autocorrelation



Esri, CGIAR, USGS, California State Parks, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USFWS

Figure 1.3 Distribution of Bigfoot sightings for the data collection periods of 1957 – 2022.

Summer vs Winter Habitat Suitability

Method

The 2021 National Land Cover Database (USGS) provides a rasterized information on land types across the United States. To preserve computing power, the Raster Clip tool was used to manually define the study area of Humboldt County. Next, each visible cluster of **B**igfoot in both Winter and Summer was assigned a polygon (stored as shape file in the geodatabase) before conducting analyses on land cover and terrain slope preferences. Zonal Statistics tool was used to determine Land Cover majority for each polygon as well as average slope (percent rise). In the Digital Elevation Model, the two points used to calculate percent rise represent the start and end of slope (for instance, the top and bottom of a hill, but it can be any two relevant locations).

Results

Figure 2.1 maps suggest that **B**igfoot are more likely to seek habitat in Evergreen Forest or Grassland/ Herbaceous land types in the summer. In the context of elevation, mean slope percent rise ranging from 20% to 32% suggest significant terrain steepness. A higher distribution of mean slope closer to 32% indicate that **B**igfoot are likely to inhabit or be sighted in mountainous or rugged terrains in the summer.

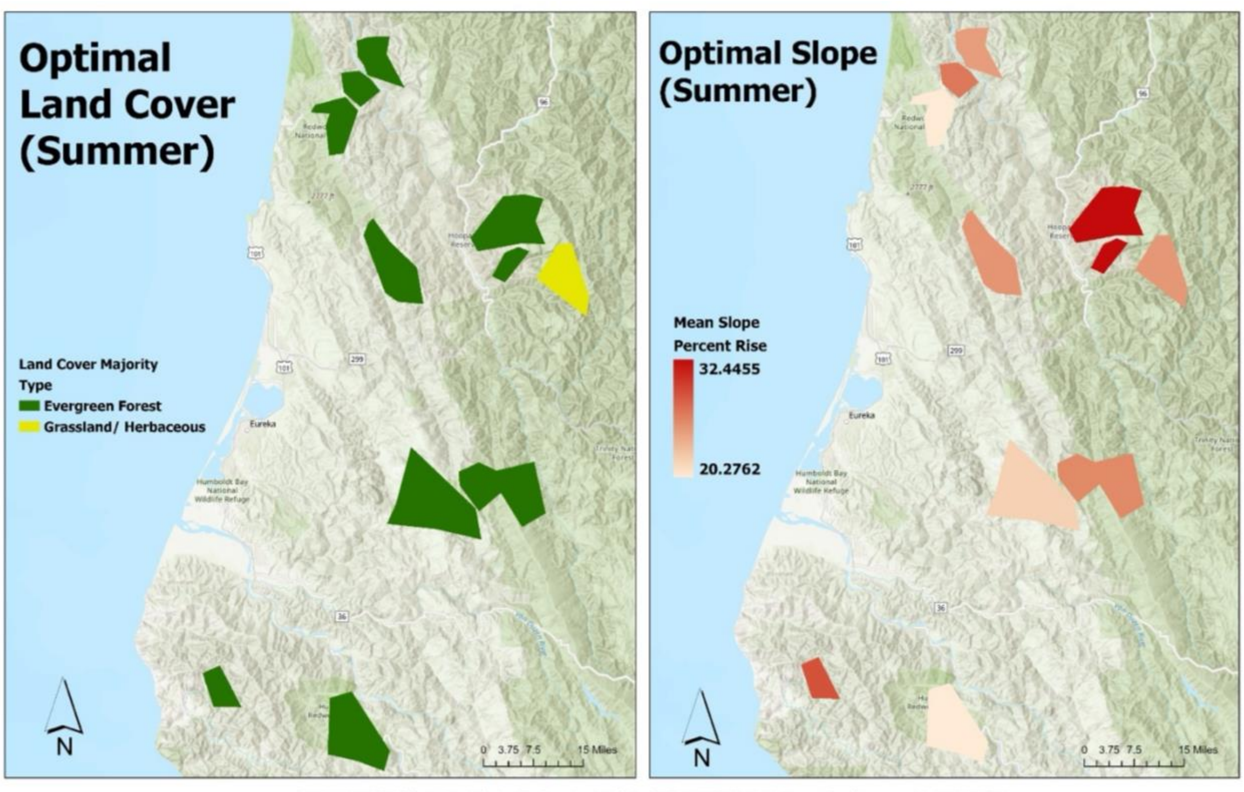


Figure 2.1 Summer Habitat Suitability using Zonal Statistics on NLCD and Slope

Figure 2.2 maps suggest that **B**igfoot are more likely to stay away from grasslands and seek habitat in deciduous, evergreen, or mixed forests in cold weather conditions. The mean slope percent rise expands to ranges 19% to 37% with higher distribution towards the lower range suggesting that **B**igfoot are likely to prefer gentler slopes with some outliers trekking steeper terrains.

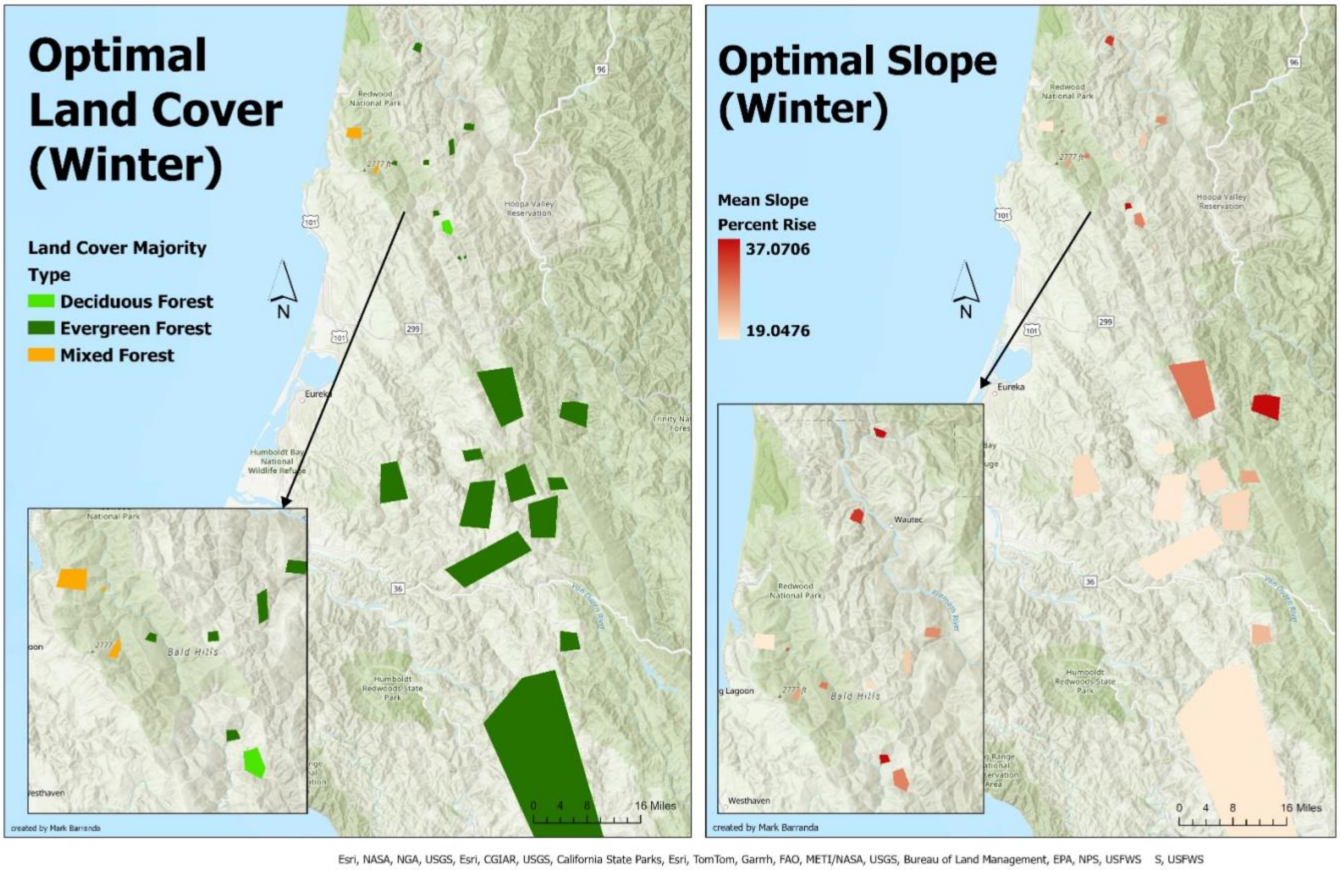


Figure 2.2 Winter Habitat Suitability using Zonal Statistics on NLCD and Slope

Climate Change Assessment

Understanding habitat preferences of **B**igfoot entails the need for assessing the effect of climate conditions on habitat suitability to ensure long term survival of this species. In doing so, GIS analysis of climate trends can offer valuable insights to aid conservation efforts. Before conducting a final analysis on optimal locations for habitat reserves, a simple methodology was used to assess increase in number of extreme heat days by 2070.

Method

Two datasets were used in this method: historical heat days and extreme heat days by 2070. An extreme heat day or warm night is defined as a day in a year when the daily maximum/minimum temperature exceeds the 98th historical percentile of daily maximum/minimum temperatures based on observed historical data from 1961–1990 between April and October. The Raster Calculator tool was used to calculate the percent increase in extreme heat days by 2070. The mathematical formula used was:

((“2070_heat_days” – “historical_heat_days”) / “historical_heat_days”) * 100

Only areas of bigfoot sightings were calculated as these will be serving points for parcel allocations in the next segment. The Zonal Statistics tool was used to calculate the max number of heat days by 2070.

Results

A range between 300% to nearly 1000% indicates a substantial change in frequency of hot weather events which can have implications for habitat suitability and survivability of the **B**igfoot species. For better understanding, this range suggests that an average of 3 extremely hot days today can increase between 9-30 days by 2070.

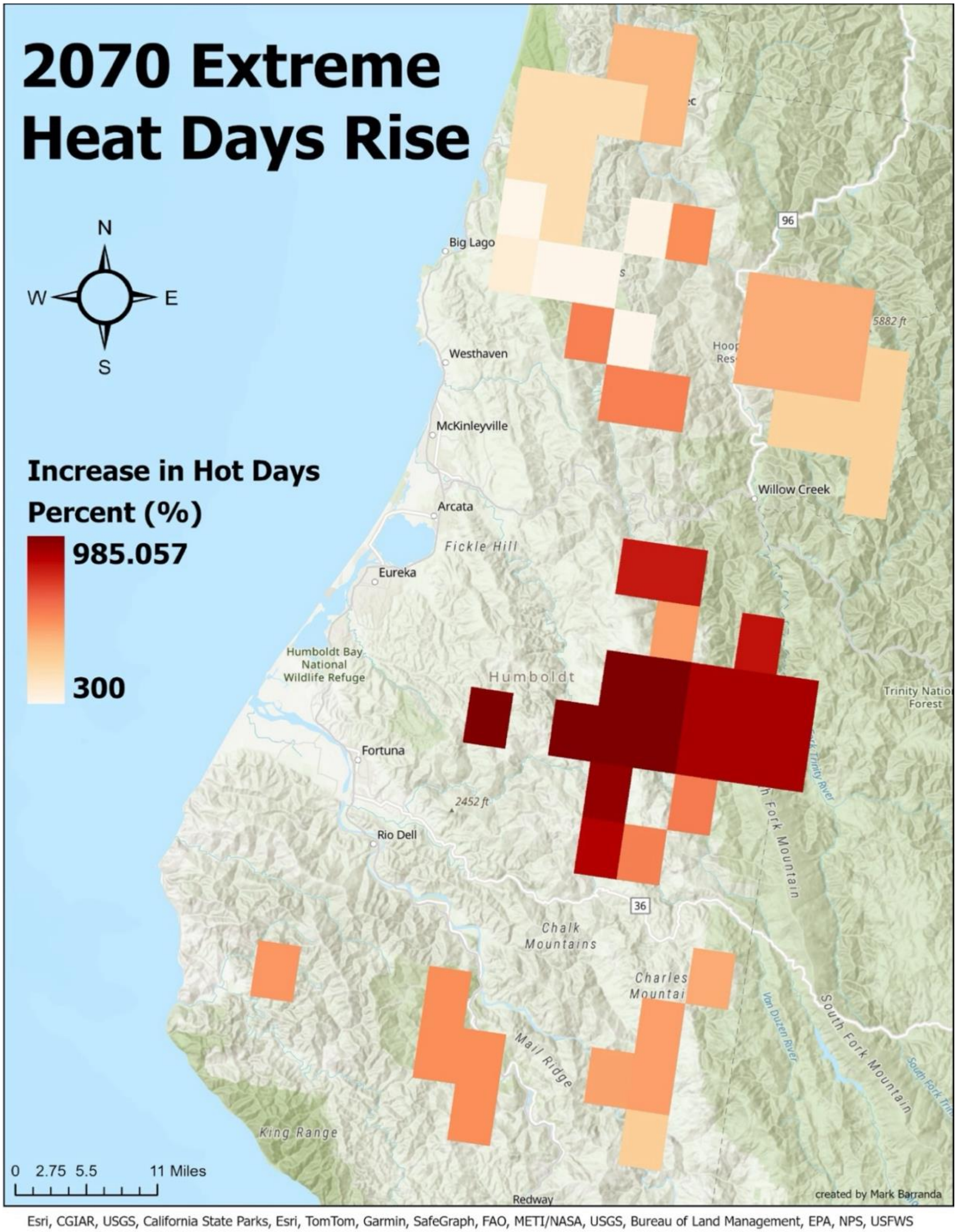


Figure 3 2070 Extreme Heat Days Rise

Understanding the consequences of such increase is crucial for mitigation efforts to address challenges posed by extreme heat day increase posed by climate change.

Optimal Parcels for Bigfoot Conservation

Methods

This final analysis is cumulative of the previous methodologies, with the addition of privately owned parcel dataset, to determine the best parcels for conservation by BFRO. This segment utilized tools such as Spatial Join, Reclassify, Raster to Polygon, Create Layer by Selected Features, and Combine to create a scoring system across various attributes. For instance, a score of 1 was assigned to Deciduous, Evergreen, Mixed Forest and Grasslands and 0 to other land covers. Extreme heat days range was partitioned into 6 equal intervals for scoring with 1 referring to highest projected number of extreme heat days (> 900%) and 6 the lowest (< 320%). In addition, an extra field was added to the parcel attribute table which has calculated **B**igfoot sightings per parcel cost. A high "**B**igfoot sighting per parcel cost" value indicates that a parcel has a relatively high number of Bigfoot sightings compared to its cost. These parcels may be considered valuable for conservation efforts due to the density of sightings relative to the cost of acquisition or conservation.

Results

Table A. Ideal Parcels for Bigfoot Reservation

ID	Cost	Count	ID	Cost	Count	ID	Cost	Count
10341	263228.79	4	12048	260810.82	3	12929	470357.28	10
10343	349485.92	3	12049	261715	3	14121	413339.64	6
10423	388021.26	5	12050	352966.56	4	14552	907177.33	3
10616	373513.09	3	12099	363495.94	3	17824	771968.53	3
11249	198062.84	3	12104	610154.67	3	21762	261552.16	23
11511	119433.08	4	12106	120814.66	3	21794	194043.45	3
11512	124948.55	5	12111	628363.9	9	21806	99465.45	3
11520	83922.27	3	12113	506830.48	6	46040	253018.8	3
11523	680202.29	5	12114	1007024.16	4	66864	381670.91	9
11577	624136.4	4	12115	459306.11	4	68689	533460.9	3
12116	101921.16	5	71456	538294.9	9			

The table above displays all the parcels where bigfoot sighting is greater than 2 (yellow shaded). This was manually defined to be ideal parcels, not optimal. Optimal parcels are determined by higher counts per parcel cost which was calculated in the attribute table. The rest of the parcels with just **B**igfoot sightings were included in the map overlaying scored regions to provide wider insights on alternative parcel allocation options. Figure 4 map displays the final result for the best possible parcels to purchase based on Bigfoot habitat suitability and cost.

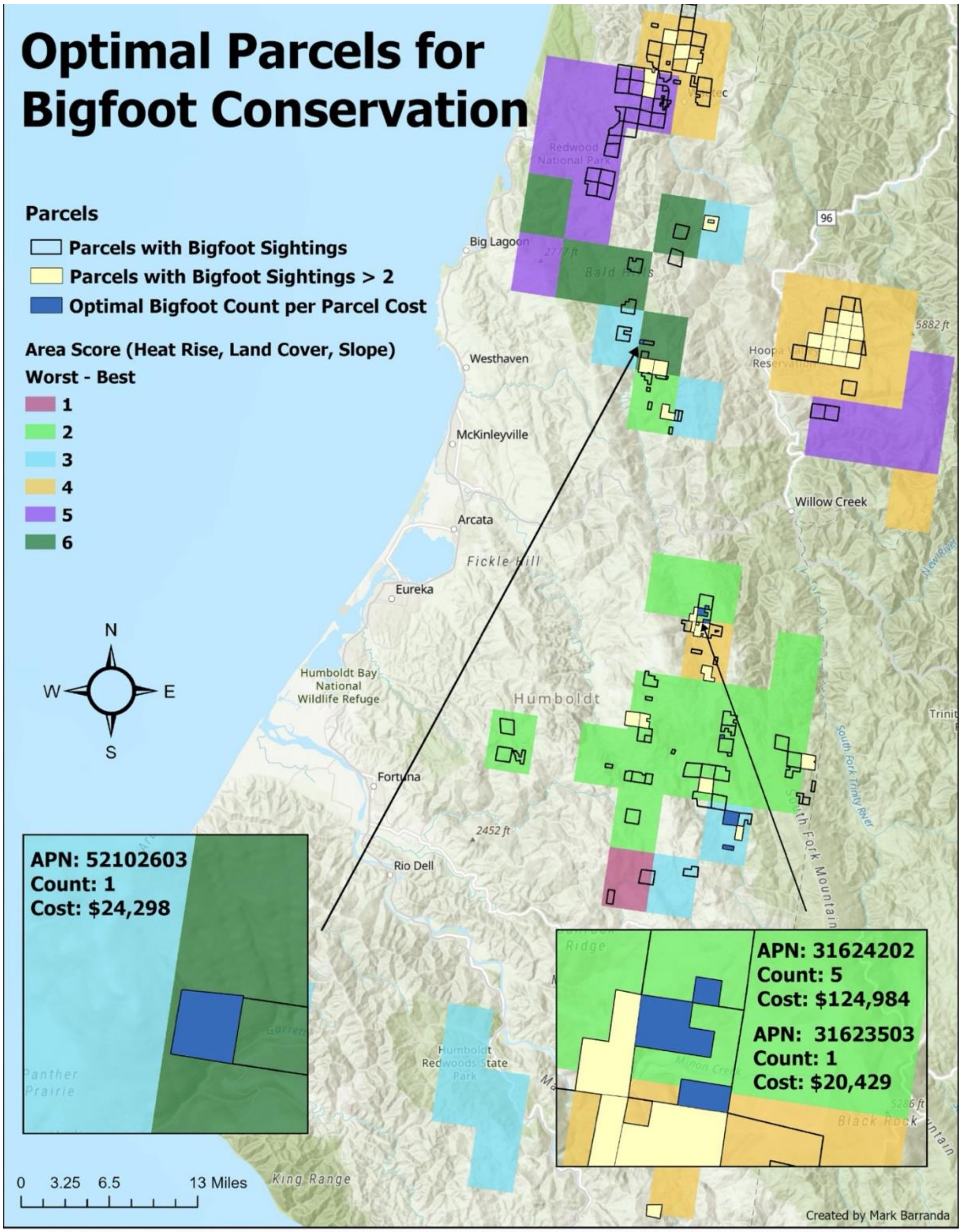


Figure 4 Optimal Parcels for Bigfoot Conservation

Limitations

While this analysis effectively used ArcGIS Pro to provide valuable insights into **B**igfoot habitat suitability as well as suggestions for conservation efforts, it is important to address some limitations of relying on human reports and limited data attributes. First, this analysis only assumes the whereabouts and navigational behavior of **B**igfoot based on sighting reports by hikers and campers. This may lead to what's called "contagion bias" or "observer bias" where individuals' reports are influenced by actions of others, leading to a clustering of certain findings. In this case, people may visit the same area where **B**igfoot are sighted, leading to a concentration of findings in certain area. Next, one important piece of data that was not included in this analysis is the roads data. Although these creatures are often sighted in steep mountains and are likely intelligent enough (thanks to their attribution to apes) to cross a busy road and suffer an injury, roads can increase human presence and activity in natural areas. These creatures may be sensitive to human noises, and so mapping roads may assist in implementing measures to minimize human disturbance.

Conclusion

In conclusion, this GIS analysis offers valuable insights into Bigfoot habitat suitability and provides suggestions for conservation efforts based on geographic information and sighting reports. Through spatial autocorrelation analysis and habitat suitability assessments, we identified clustering patterns and seasonal preferences of Bigfoot sightings, highlighting potential habitat preferences and navigational tendencies. Additionally, assessing the impact of climate change on habitat suitability revealed significant increases in extreme heat days by 2070, emphasizing the need for proactive conservation measures to address the challenges posed by changing climate conditions. The identification of optimal parcels for conservation, considering habitat suitability and cost-effectiveness, further informs conservation planning efforts for Bigfoot habitats. However, it's crucial to acknowledge the limitations of this analysis, including potential biases in sighting reports and the absence of roads data, which may affect the accuracy and generalization of the findings. Addressing these limitations and integrating additional data sources can enhance the robustness and effectiveness of conservation strategies aimed at preserving the habitat of this elusive species.

Bibliography

"National Land Cover Database Active." *National Land Cover Database | U.S. Geological Survey*, www.usgs.gov/centers/eros/science/national-land-cover-database. Accessed 9 May 2024.

"Raster Calculator (Spatial Analyst)." Raster Calculator (Spatial Analyst)-ArcGIS Pro | Documentation, pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/raster-calculator.htm. Accessed 9 May 2024.

Weisberger, Mindy. "Closest Living Relative of Extinct 'Bigfoot' Found." LiveScience, Purch, 13 Nov. 2019, www.livescience.com/gigantopithecus-bigfoot-orangutan-cousin.html.