



Research Article

MULTIPLE-FACTOR GEOSPATIAL ANALYSIS OF SASQUATCH ENCOUNTER LOCATIONS IN THE BLUE MOUNTAINS

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ABSTRACT. Locations of reported encounters with sasquatch within a geographic area that defines a home range for a sasquatch population may show trends that point to likely areas for future searches. This study involves analysis of several different types of geospatial data over an area that may represent a geographically isolated sasquatch range, in an attempt to predict which specific areas within the range show the greatest potential for field exploration. All data used for this study are freely available to the public from various Internet sources. Software used for this study includes commercial-off-the-shelf (COTS) software, and proprietary software developed specifically for this study. The methodology employed three data parameters: spectral signature, elevation, and rainfall, to potentially narrow the focus of field research by over 94 percent. While not conclusive, the results do suggest that these parameters may have validity as a predictive model.

KEY WORDS: Bigfoot, Landsat, GIS, Washington

INTRODUCTION

Encountering a sasquatch has, up to this point in time, been largely a hit-or-miss proposition. Normally, someone happens to see a sasquatch or its footprints while out hunting, hiking, fishing, driving, or cutting timber in the woods. Sometimes a researcher will follow up with an investigation of the encounter site, and a small expedition may even take place. This is a reactive process, rather than a proactive one. Through analysis of geospatial data, it may be possible to define areas where there is a greater probability of encountering a sasquatch than in other areas. We don't know much about what types of areas sasquatches prefer, but inferences can be made by extrapolating from previous encounter locations. For this study, three

types of geospatial data were used in the extrapolation process: satellite imagery, a digital elevation model, and an average rainfall surface.

DEFINING THE STUDY AREA

It is important that an area defining a probable population be identified, because an arbitrary area of interest can result in a different analytical outcome (O'Sullivan and Unwin, 2003). For example, if the study region included areas that contained vegetation types that were not found universally within the region, such as redwood forest, then analysis results for vegetation would not be valid for areas that contain no redwoods.

The Blue Mountains of northeast Oregon and southeast Washington appear to

potentially contain a relatively geographically isolated population of sasquatch. The reasons for this apparent isolation are probably physical, since the Blue Mountains are bounded by desert to the south and to the northwest, and by Hell's Canyon to the east. Since sasquatch are most commonly associated with moist forested areas, deserts and deep canyons may pose physical barriers to their movement. Although these barriers are probably not insurmountable to a sasquatch, they may serve to inhibit movement and so result in a fairly distinct population (Quammen, 1996). The study area also includes the Wallowa Mountains, which are a sub range of the Blue Mountains.

Locations of encounters were geocoded from descriptions on the Bigfoot Field Researchers Organization (BFRO) web site (www.bfro.net). Besides the relative physical isolation of the Blue Mountains, the 28 encounter locations in the Blue Mountains area from the BFRO site also show geographic isolation from other encounter concentrations in the region (Fig. 1).

DATA

All data used in this study were downloaded free of charge from various Internet sites. The satellite imagery used is from the Enhanced Thematic Mapper (ETM+) sensor aboard the Landsat 7 satellite. The specific imagery used was collected in summer of 2001. Six bands were used: the visible bands (1, 2, and 3), the near-infrared band (4), and the short-wave infrared bands (5 and 7). The individual bands were downloaded from the University of Maryland Global Land Cover Facility (GLCF) web site (<http://glcf.umiacs.umd.edu/data/>).

Digital Elevation Models (DEMs) used in this study were derived from Shuttle Radar Topography Mission (SRTM) 3-arcsecond data downloaded from the USGS EROS Data Center (<http://edc.usgs.gov/>). Rainfall data

was downloaded from the National Atlas web site (<http://nationalatlas.gov/atlasftp.html>).

DATA PRE-PROCESSING

Landsat bands from adjacent path/rows were mosaicked together, without altering pixel values (other than the nominal alteration that results from the nearest-neighbor resampling required to produce an output file). The mosaicked bands were then clipped to the study area boundary.

Individual DEMs were also mosaicked and clipped, using the same procedure as described for the Landsat imagery. Rainfall data were continuous over North America, and so no mosaicking was required. The rainfall raster surface was clipped to the study area boundary.

All data layers were reprojected to the same coordinate system and datum, in this case geographic coordinates and World Geodetic System (WGS) 1984 datum. The results of the pre-processing were eight raster data layers (the six Landsat bands, the DEM, and the rainfall layer), all coincident in space (Fig. 2).

ATTRIBUTION

In order to perform analysis on the data, the encounter locations had to be attributed with the values from the raster layers. A proprietary Visual Basic algorithm implemented through the Esri ArcGIS software interface was used to perform this task.

Since the Landsat data is of relatively high resolution (30-meter pixel size), it is possible that slight errors in positioning could result in anomalous attribution (Manis, Lowry, and Ramsey, 2001). To mitigate this possibility, a 3 x 3 pixel window was used to average the pixel values surrounding the encounter locations (Fig. 3). This process was iterated for all locations for each Landsat band.

The same iteration process was used to

assign attribution from the DEM and rainfall layers, but, due to the coarser resolution of these layers, no averaging was performed.

ANALYSIS

The attribution process produced a range of values from each data layer for each encounter location. The mean and standard deviation of these values was calculated for each attribute.

Using a parallelepiped classification method in which candidate pixels fall within only one range of values in each dimension (Chen and Lee, 2001), and implemented through proprietary Visual Basic code within the Esri ArcGIS software interface, a new binary surface was produced. The value range used in this case was the mean plus or minus one standard deviation, to further account for any anomalous values. A simplified graphic of this algorithm is shown in Fig. 4.

The resulting raster layer is composed of pixels with one of two possible values, 0 or 1. Pixels with a value of 1 met the classification criteria in every input layer at the pixel location; pixels with a value of 0 did not meet the criteria in one or more layers. Fig. 5 shows the output layer overlaying Landsat band 1.

The output raster layer shows pixels that correspond to locations in the real world where conditions relating to vegetation, elevation, and rainfall are most similar to the average conditions of previous encounters. Specifically, the output layer indicates a preference for mid-elevation ponderosa pine forest. However, as can be seen by the varying “good” pixel density in Fig. 5, these conditions are not distributed evenly throughout the study area. It stands to reason that prime areas for Sasquatch activity will have a higher density of “good” pixels.

To calculate density, it was first necessary to convert “good” pixels to point features, since density functions work on discrete features, rather than continuous raster

surfaces. The actual calculation was done using COTS software performing a kernel density function, in which point events are counted within a moving region of constant radius (O’Sullivan and Unwin, 2003). The output is a raster surface.

As expected, all of the original encounter locations fell within areas having a density above zero. However, three other density surfaces were derived from this original density calculation. One surface contained only areas with pixel densities more than one standard deviation above the mean; the second surface contained only areas with pixel densities more than two standard deviations above the mean; and the third surface contained only areas with pixels densities more than three standard deviations above the mean. These three surfaces, overlain by the original encounter location points, are shown in Fig. 6.

DISCUSSION OF RESULTS

The area containing the highest density of pixels matching the classification criteria is in the west-central portion of the Blue Mountains, as can be deduced from Fig. 6. This area covers about 2831 square kilometers. While still a significant amount of area, it represents only about 5.7 percent of the original study area, thus potentially narrowing the focus of field research by over 94 percent.

How good is the described methodology, using the three data parameters (spectral signature, elevation, and rainfall), as a predictive model? It is difficult to tell, because the number of samples (encounter locations) is very low for a statistical analysis, and because there is much uncertainty about presumed sasquatch habitat requirements. However, one measure of validity would be how effectively the methodology identified “good” areas as defined by existing encounter locations. In Fig. 7, the ratio of the percent of

encounter locations occurring within the boundaries of each successively denser “good” pixel area, divided by the percent of the total study area that each of these areas occupies, is plotted versus the number of standard deviations above the mean that each successively denser “good” pixel area represents. In other words, the graph in Fig. 7 depicts how much more likely it is that an encounter point occurred in an area identified as “good” than at any random point within the study area ($y = 1$). At one standard deviation, it is about 23 percent more likely; at two standard deviations, about 31 percent more likely; at 3 standard deviations (highest density), about 88 percent more likely.

While not conclusive, the graph does suggest that the methodology and parameters used (spectral signature, elevation range, and rainfall amount) have validity as a predictive model.

It is interesting to note that the cluster of original encounter locations in the north-central part of the study area does not fall within an area of significantly high density of pixels matching the classification criteria. Closer examination of the details of these encounters reveals that five of them occurred within a 14-month span in 2000 and early 2001, and two of them occurred within two months in 1992. It is possible that, although the analysis indicates this area’s sasquatch habitat is marginal as it relates to the study criteria, an individual or small group of sasquatch may occasionally occupy the area for a short time and then move on.

CONCLUSIONS AND FUTURE RESEARCH

This study used spectral characteristics of satellite imagery and physical characteristics of the environment in order to indicate areas where future sasquatch field research may be focused in order to maximize chances for success. The results show that geospatial

analysis can be used as a proactive tool in order to achieve this goal. It would be useful to perform the image classifications using other techniques, and to then compare the results.

Some data that are already available may be useful in future geospatial research. For example, it has been suggested that road density, deer population, and old growth forest extents (Pyle, 1995) may influence sasquatch distribution. And, of course, more encounter reports will lead to a greater sample size, which will enable greater accuracy in geospatial, statistical, and biological analysis.

Much biological research on sasquatch behavior, habitat, and food sources needs to be accumulated in order to refine this analysis method. For example, is there a preferred food source, such as a plant species, which can be detected from its spectral signature in satellite imagery, or can it be mapped using field techniques? How big is a sasquatch’s home range? How far do they travel outside this range? These are just a few of the biological questions that must be answered to be able to refine geospatial analysis techniques to achieve greater accuracy.

ACKNOWLEDGEMENTS

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LITERATURE CITED

- Chen Y, and Lee Y (2001) *Geographical Data Acquisition*. New York: Springer-Verlag Wien.
- Manis G, Lowry J, and Ramsey R (2001) Preclassification: An Ecologically Predictive Landform Model. *Gap Analysis Bulletin* 10:11-14.
- O’Sullivan D, and Unwin D (2003) *Geographic Information Analysis*. Hoboken, New Jersey: John Wiley and Sons, Inc.
- Pyle, R (1995) *Where Bigfoot Walks*. New York: Houghton-Mifflin Company.
- Quammen D (1996) *The Song of the Dodo*. New York: Touchstone.

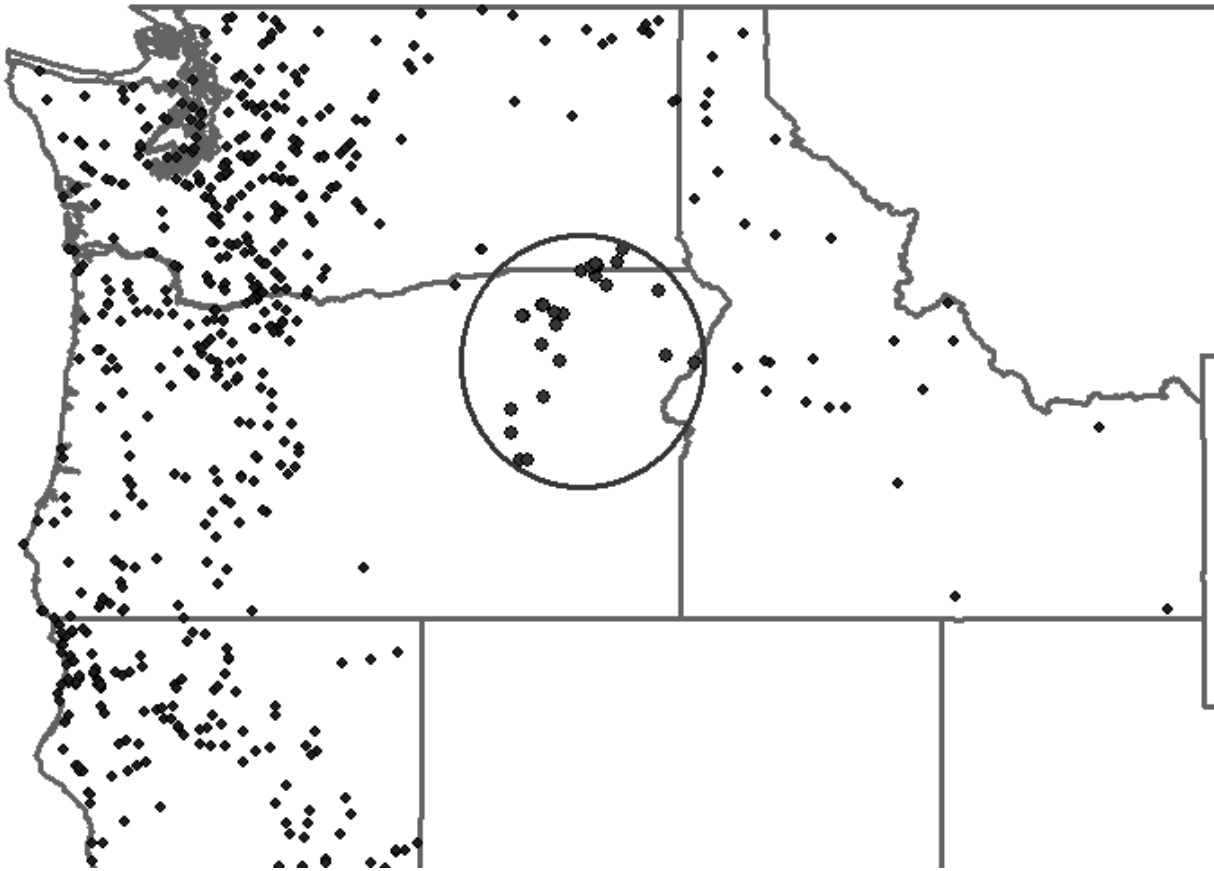


Figure 1. Encounter locations in the Blue Mountains are relatively isolated.

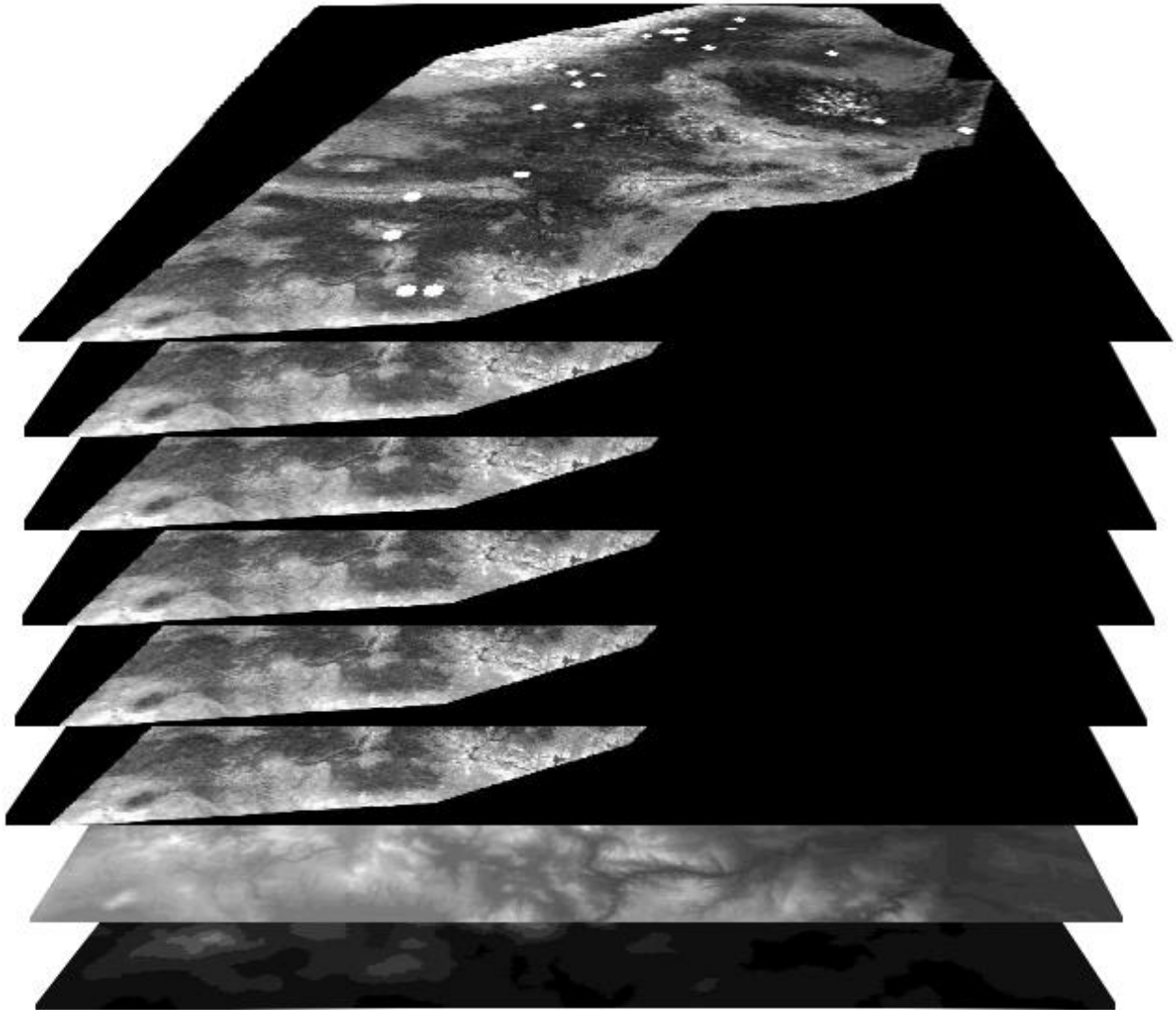


Figure 2. The eight spatially coincident raster data layers, with the 28 encounter locations shown on top as white dots.

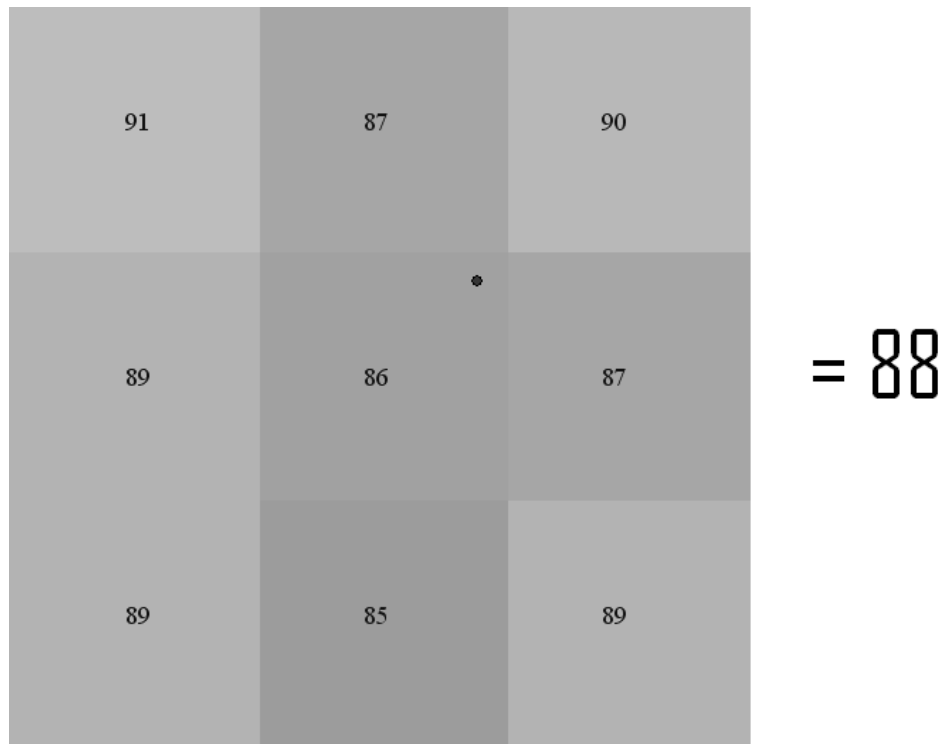


Figure 3. 3 x 3 pixel window averaging for an encounter location (black dot).

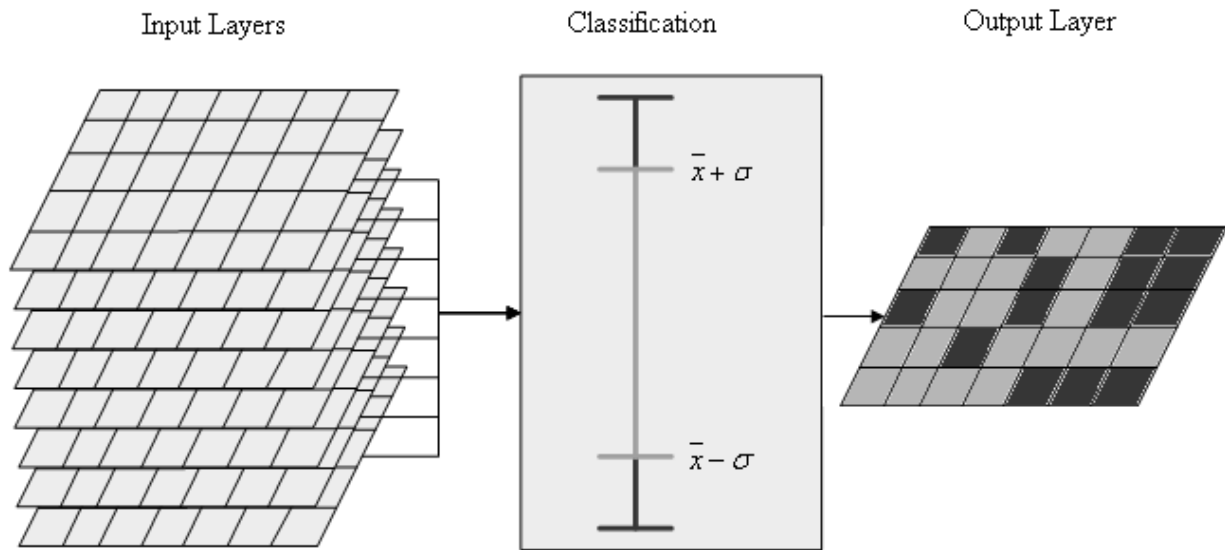


Figure 4. Classification to select pixels that match criteria.

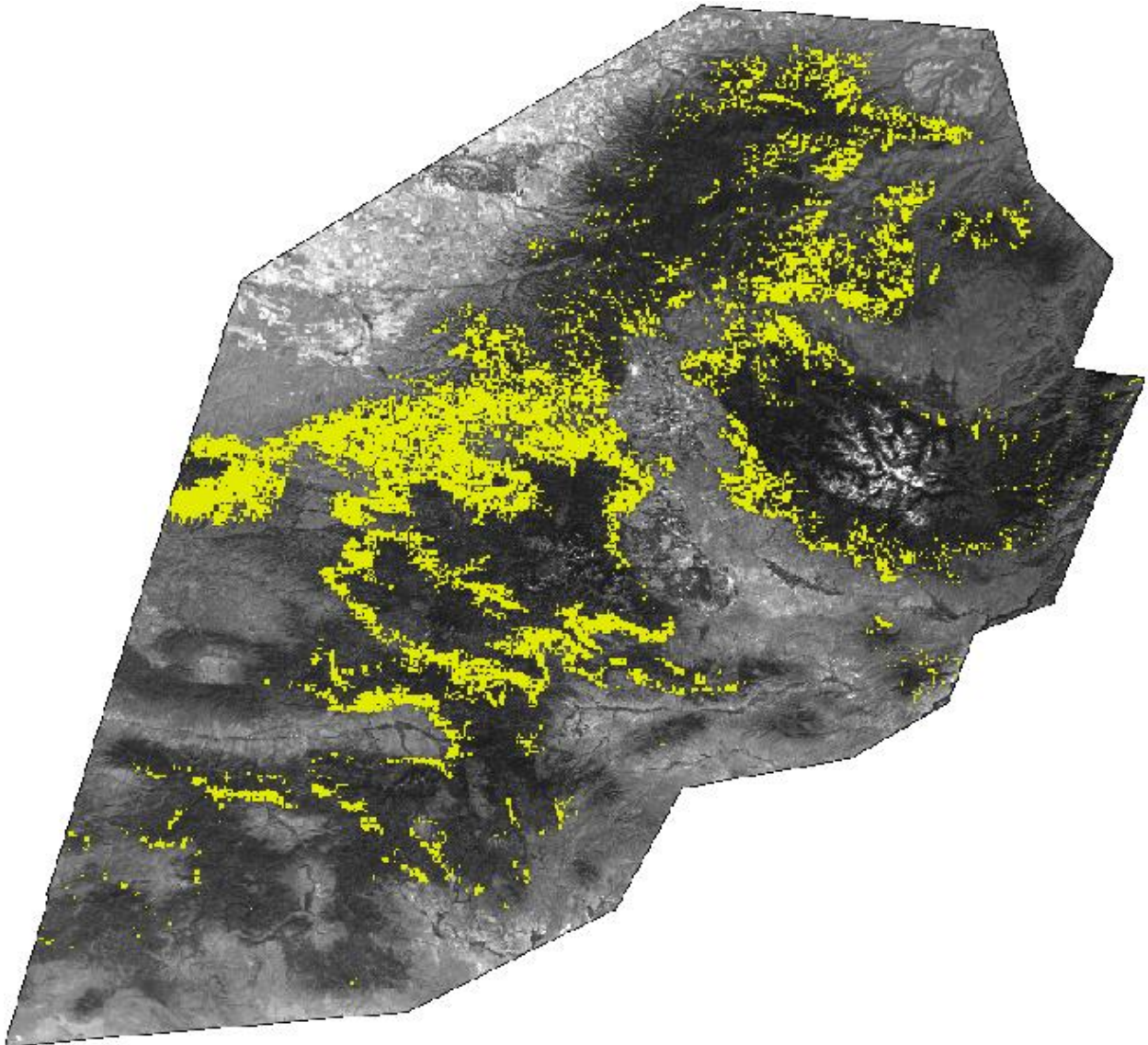


Figure 5. Output of classification. Pixels with a value of 1 are shown in yellow; pixels with a value of 0 have been made transparent.

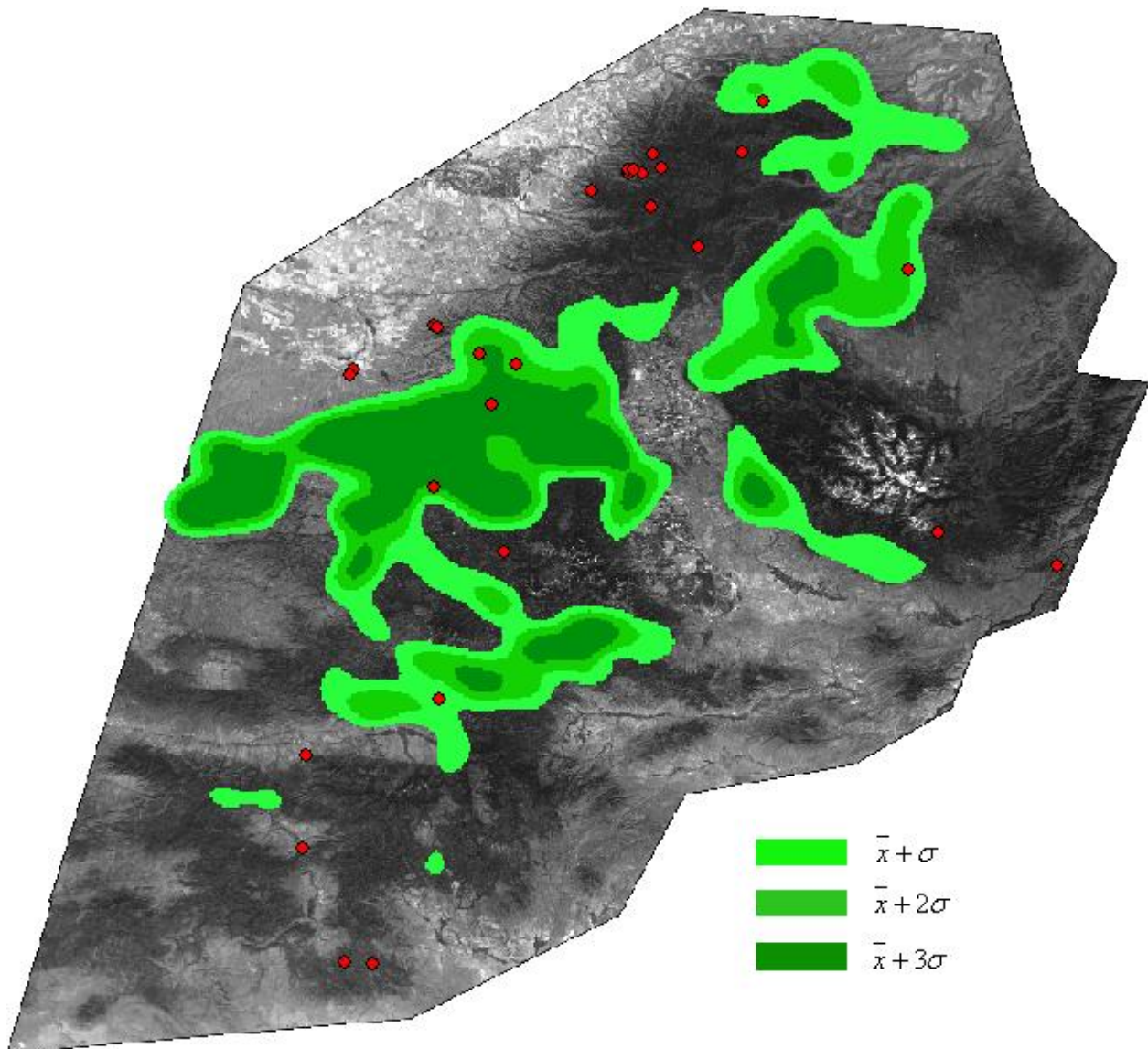


Figure 6. Areas with progressively higher densities of pixels matching the classification criteria.

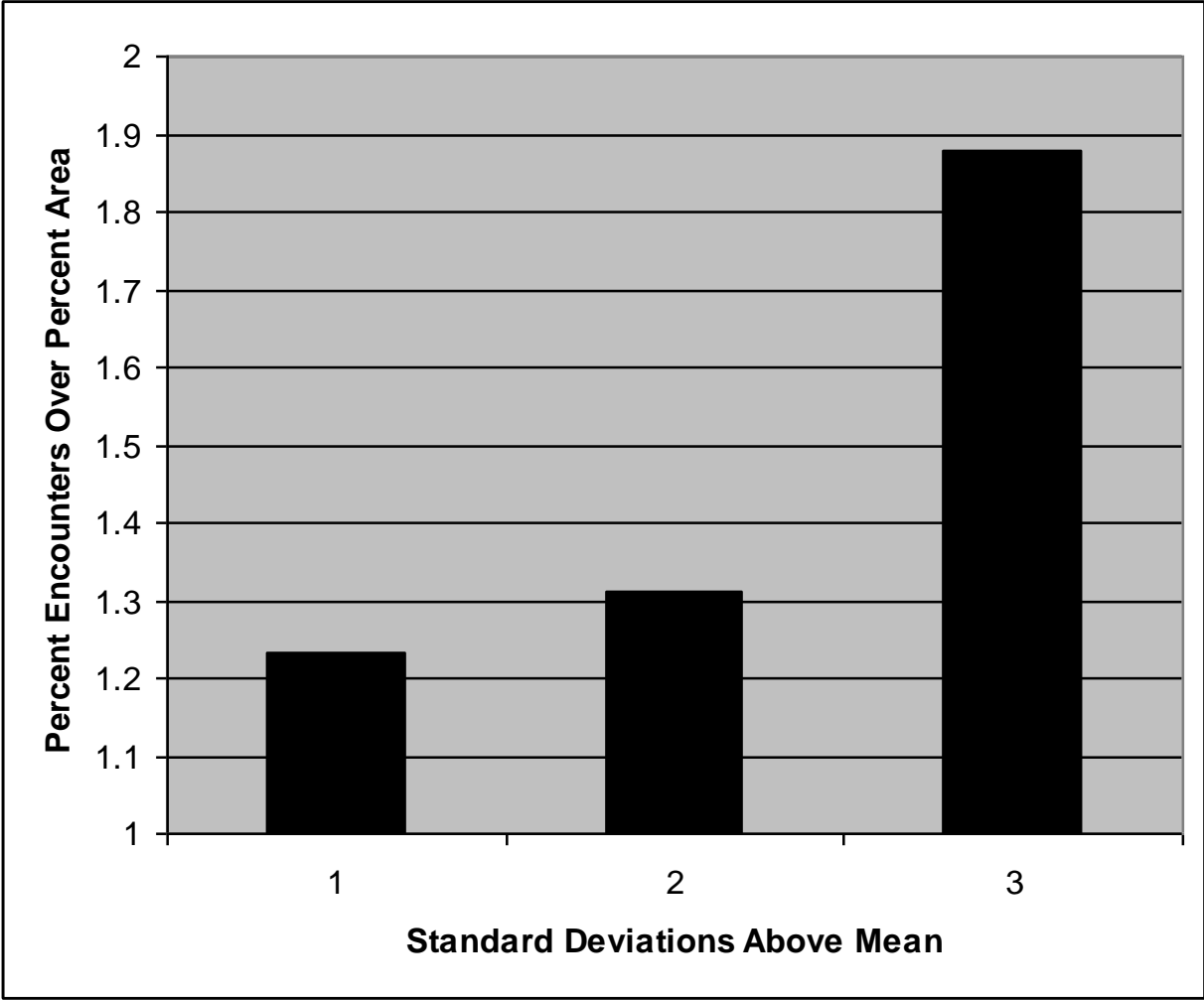


Figure 7. The graph shows a correlation between successively denser “good” pixel areas and the ratio of percent of total encounters to percent of total study area represented by each successively denser “good” pixel area.