If it's there, could it be a bear?

Floe Foxon[1]

[1] Department of Data Management and Statistical Analysis, PinneyAssociates – Pittsburgh, USA

Correspondence: ffoxon@pinneyassociates.com

Abstract

It has been suggested that the American black bear (*Ursus americanus*) may be responsible for a significant number of purported sightings of an alleged unknown species of hominid in North America. Previous analyses have identified correlation between 'sasquatch' or 'bigfoot' sightings and black bear populations in the Pacific Northwest using ecological niche models and simple models of expected animal sightings. The present study expands the analysis to the entire US and Canada by regressing sasquatch sightings on bear populations in each state/province while adjusting for human population and land area in a generalized linear model. Sasquatch sightings were statistically significantly associated with bear populations such that, on the average, one 'sighting' is expected for every few hundred bears. Based on statistical considerations, it is likely that many supposed sasquatch are really misidentified known forms. If bigfoot is there, it may be many bears.

Keywords: Black bear; *Ursus americanus*; Sasquatch; Bigfoot; Regression

Introduction

The United States and Canada feature nearly 20 million square kilometers of land, hosting hundreds of mammal species in its woodlands, prairies, boreal forests, and along its coasts (Kays and Wilson, 2009). Proponents of 'hominology' argue that the North American faunal catalogue is incomplete, and that these lands harbor a hominid species as-yet unrecognised by science (Heuvelmans, 1986).

Reported sightings of these alleged animals, variously dubbed 'sasquatch' after West Coast First Nations tradition, 'bigfoot' to Westerners, and the *nomen dubium Gigantopithecus canadensis* (Heaney, 1990), number in the thousands (Bigfoot Field Researchers Organization, 2023). Consequently, this anthrozoological phenomenon has entered popular culture.

Numerous casts and photographs of tracks and footprints attributed to sasquatch have been presented (Napier, 1976, 'Tables'), some apparently featuring primate-like dermal ridge patterns, sweat pores, and sole pads (Cachel, 1985; Krantz, 1983). These have been criticised as hoaxes constructed with modelling clay and the 'latex-and-kerosene expansion method' of preserving details of [human] footprints while greatly increasing their size (Baird, 1989; Bodley, 1988). It has been suggested that features such as 'sweat pores' are casting artefacts such as air bubbles (Freeland and Rowe, 1989).

The 'Patterson-Gimlin film' is a notorious 16 mm motion picture purportedly depicting an unknown hominid over six feet tall in California (Discovery, 2022; Kelsey, 2022; W Munns, 2014). The film apparently was not spliced or edited (B Munns and Meldrum, 2013), but many have noted the imposing likelihood that the film subject is a suited actor.

Genetic and microscopic analyses of supposed hairs, faeces, and other specimens attributed to sasquatch have been variously identified as synthetic fiber (Somer, 1989; Winn, 1991), or material from known forms such as cervids, bovines, and ursids (Bryant and Trevor-Deutsch, 1980; Coltman and Davis, 2005; Federal Bureau of Investigation, 2019; Hart, 2016a,b; Sykes et al., 2014).

Indeed, the American black bear (*Ursus americanus*) has been identified as a likely candidate for many purported sasquatch sightings, since the black bear is a large tetrapod, typically covered with a dark pelage, and is known to ambulate bipedally (Nickell, 2013).

Blight (2005a,b) examined the relationship between sasquatch sightings and black and brown bear (*U. arctos*) populations in the Pacific Northwest (including Alaska, Montana, Oregon, Washington, Northern California, and Idaho) with probabilistic models of expected animal sighting rates. No positive correlation between brown bear population density and sasquatch sighting frequency was not found, suggesting that brown bear misidentification must comprise only a small proportion of all sightings. However, a positive correlation was identified for black bears, which further implicates the black bear in sasquatch 'sightings'. Lozier et al. (2009) compared results from ecological niche models both for sasquatch and for black bears in the Pacific Northwest, noting a high degree of overlap in predicted distributions.

In a previous article titled "If it's real, could it be an eel?", the author used statistical methods to investigate whether large Anguilliformes may account for the related anthrozoological phenomena at Loch Ness (Foxon, 2023a). In the present study, statistical methods are used to investigate whether purported sasquatch sightings may be explained in large part by mistaken identifications of black bears.

Material and methods

Data

Numbers of sasquatch sighting reports in the US states and Canadian provinces were sourced from the Bigfoot Field Researchers Organization (2023) Geographic Database of Bigfoot/Sasquatch Sightings & Reports. These data consist of eyewitness testimonials, mostly from the second half of the 20th century to the present.

Black bear populations for the US states and Canadian provinces were taken from Hristienko and McDonald (2007), except for Delaware, Hawaii, Illinois, Indiana, Iowa, Kansas, Nebraska, North Dakota, and South Dakota, which have no known breeding populations of black bear and so were coded to zero, and for Alabama (Byington, 2020), Connecticut (Connecticut Department of Energy Environmental Protection, 2020), Kentucky (Estep, 2020), Louisiana (Kemker, 2021), Maryland (Maryland Department of Natural Resources, 2020), Mississippi (Young and Mississippi Department of Wildlife, Fisheries, and Parks, 2021), Missouri (Missouri Department of Conservation, 2021), Nevada (Wildlife Conservation Society, 2020), New Jersey (New Jersey Department of Environmental Protection, 2022), Ohio (Ohio Department of Natural Resources, 2022), Oklahoma (Godfrey, 2021), Rhode Island (McLeish, 2022), and Texas (Rasmussen, 2022), which were sourced variously from state department resources, conservation societies, and biologists and conservationists quoted in media articles. Where ranges were given (e.g., 40–50 bears), the midpoint was taken (i.e., 45 bears).

The latest available human population statistics and land area figures for the US states and Canadian provinces were obtained from the United States Census Bureau (2022, 2023) and Statistics Canada (2022a,b), respectively. A geojson map of the US and Canada was sourced from Cartograhy Vectors (2022).

Analysis

The possible association between sasquatch sighting reports and black bear populations across states and provinces was first investigated by calculating the Pearson correlation coefficient between these two variables in an unadjusted analysis.

Sasquatch sightings are logically a function of the number of people in each state/province available to make a sighting, and the size (land area) of each state/province (because interactions between humans and animals are less likely when each populate an area sparsely). Consequently, models were implemented which investigated the possible association between sightings and bear populations while also adjusting for the potential impact of human population and land area. These were generalized linear fixed-effects regression models which regressed the number of sasquatch sighting reports in each state/province on the black bear population, human population, and land area of each state/province. The models were given by

$$\mathbf{SSR} = \mathbf{X}\beta + \epsilon\,, \tag{1}$$

where **SSR** is the saquatch sighting reports vector, $\mathbf{X}$ is the design matrix of predictors (bear population, human population, and land area), β is the fixed-effect regression coefficients vector, and ϵ is the residuals vector.

Three types of model were implemented. In the simplest model, a Gaussian distribution and identity link function were assumed for the response (sasquatch sightings). The second model assumed a Poisson distribution and the log link function. The third model assumed a Negative Binomial distribution and the log link function. The latter two models are most appropriate for count data, which the sasquatch sightings are. Each of these three models were implemented with and without an intercept, for a total of six models. To counteract the multiple comparisons problem, a bonferroni correction was applied such that the alpha level for

statistical significance was $\alpha = \frac{0.05}{6} = 0.008\dot{3}$. Model fit was assessed by the root mean square error (RMSE; lower is better) and log-likelihood (higher is better). Interaction terms were not statistically significant and/or provided poorer model fits to the data, and so were not included in the final models.

All analyses were performed in Python 3.8.8 with the packages Numpy 1.20.1, Pandas 1.2.4, Scipy 1.6.2, Statsmodels 0.12.2, and Plotly 5.11.0. All code and data are available in the online Supplementary Information (Foxon, 2023c). Statsmodels uses the iteratively reweighted least squares (IRLS) method for generalized linear models to reduce the impact of outliers.

In a previous version of this analysis (Foxon, 2023b), a linear mixed-effects model was implemented assuming a Gaussian distribution and using as the group variable/random intercepts the state/province from which the data originated. However, because only one timepoint is used, these are not repeated subjects. That model was therefore overfitted, and was not considered in the present analyses.

Results

Figure 1 shows choropleth maps for the number of sasquatch sightings, black bear populations, and human populations in the United States and Canada. The human population and sasquatch sighting maps are most similar, which is logical because more people means more potential encounters with any North American species. Both the sasquatch sighting and black bear population maps are strongly coloured in the Pacific Northwest area, though black bears are not prominent in Texas and Florida, where alleged sasquatch sightings have been reported.

In the unadjusted analysis, the Pearson correlation coefficient between number of sasquatch sighting reports and black bear populations in states/provinces was low and statistically non-significant ($\rho = 0.0607$, $p = 0.642$).

Table 1 shows the fit results for the six models. The lowest RMSE was obtained with model 2 (Guassian distribution, identity link, with intercept), while the highest log-likelihood was obtained with model 6 (Negative Binomial distribution, log link, with intercept). Because the sasquatch sightings are count data, model 6 was selected as the primary model, and because model 2 is the easiest to interpret, findings from this model are presented as a sensitivity test.

In the fully adjusted regression analysis with the primary model (highest log-likelihood; model 6), black bear population was significantly associated with sasquatch reports such that, on the average, every 1,000 bear increase in the bear population is associated with a $\sim 2.7\%$ increase in sasquatch sightings (From Table 2, $[(e^{2.7\times10^{-5}} - 1.0) * 100] * 1000 \approx 2.7$). Thus, as black bear populations increase, sasquatch sightings are expected to increase also.

For demonstrative purposes, consider using the primary model with the hypothetical (fictional) state of 'Oklahodahio'. Oklahodahio has a bear population of $13,811$, a human population of $6,056,009$, and a land area of $267,199$ km^2 (these are the averages across all US states and Canadian provinces). In Oklahodahio, the model predicts that there would be ~ 70 sasquatch sightings on record. This equates to $\frac{13811 \text{ bears}}{70 \text{ sightings}} \approx 200$ bears per sasquatch sighting.

As a sensitivity test, in the fully adjusted regression analyis with lowest RMSE (model 2), the black bear population was similarly associated with sasquatch reports with a regression parameter of 1.1×10^{-3}. Thus, on the average, one sasquatch sighting is expected for every ~ 900 black bears in a given state or province

($\frac{1}{1.1\times10^{-3}} \approx 900$). These results are consistent in order of magnitude with the primary model, and with the mixed-effects model in the previous version of this analysis (Foxon, 2023b).

Discussion

The present study regressed reports of sasquatch sightings on black bear (*Ursus americanus*) populations across the US and Canada. A significant positive association was found between sasquatch sightings and black bears such that, after adjusting for human population and land area, one sasquatch sighting is expected for every few hundred bears in a given state or province.

These findings are robust to the model used, are in agreement with the results of previous studies by Blight (2005a) and Lozier et al. (2009), and suggest that many supposed sasquatch sightings in North America are likely misidentified black bears. The present study builds upon previous analyses by expanding the area under consideration from the Pacific Northwest to the entire US and Canada, and by investigating quantitative associations with a generalized linear model.

Limitations include potential residual confounding by effects such as homeless populations and hunters who may also be misidentified, as well as mismatching years in the data (e.g., while the bulk of the black bear population estimates were for 2001, others were more recent). Notably, sasquatch sightings have been reported in states with no known breeding black bear populations. Although this may be interpreted as evidence for the existence of an unknown hominid in North America, it is also explained by misidentifiation of other animals (including humans), among other possibilities.

In conclusion, if bigfoot is there, it may be many bears.

Fundings

This work was not supported by any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest disclosure

The author declares that they have no financial conflicts of interest in relation to the content of the article.

Data, script, code, and supplementary information availability

Data and code are available online: https://doi.org/10.17605/OSF.IO/AV3G2

References

Baird D (1989). Sasquatch Footprints: A Proposed Method of Fabrication. *Cryptozoology* 8, 43–46.

Bigfoot Field Researchers Organization (2023). Geographic Database of Bigfoot/Sasquatch Sightings & Reports. https://bfro.net/GDB/.

Blight EA (2005a). Relationships between the American Black Bear Population and the Bigfoot Phenomenon. blightinvestigations.freeservers.com/bigfootblackbearpaper.pdf. *Blight Investigations*.

Blight EA (2005b). Relationships between the American Brown Bear Population and the Bigfoot Phenomenon. blightinvestigations.freeservers.com/bigfootbrownbearpaper.pdf. *Blight Investigations*.

Bodley JH (1988). Sasquatch Footprints: Can Dermal Ridges be Faked? *Northwest science.* 62.

Bryant VM and B Trevor-Deutsch (1980). Analysis of Feces and Hair Suspected to Be of Sasquatch Origin. In: *Manlike Monsters on Trial: Early Records and Modern Evidence*. Ed. by Halpin MM and Ames MM. Vancouver and London: University of British Columbia Press. Chap. 21, pp. 291–300.

Byington P (2020). Black bears, our state mammal, are returning to Alabama. https://web.archive.org/web/20201118023021/https://bhamnow.com/2020/11/17/black-bears-our-state-mammal-are-returning-to-alabama-see-how-these-cubs-will-help-us/.

Cachel S (1985). Sole Pads and Dermatoglyphics of the Elk Wallow Footprints. *Cryptozoology* 4, 45–54.

Cartograhy Vectors (2022). Combined US & Canada with States & Provinces. https://web.archive.org/web/20221128141742/https://cartographyvectors.com/map/793-combined-us-canada-with-states-provinces.

Coltman D and C Davis (2005). Molecular cryptozoology meets the Sasquatch. *Trends in Ecology & Evolution* 21, 60–61. https://doi.org/10.1016/j.tree.2005.11.010.

Connecticut Department of Energy Environmental Protection (2020). Black Bear. https://web.archive.org/web/20201025000704/https://portal.ct.gov/DEEP/Wildlife/Fact-Sheets/Black-Bear.

Discovery (2022). Expedition Bigfoot Season 3 Episode 13 - A Massive Discovery. https://web.archive.org/web/20221007103940/https://www.travelchannel.com/shows/expedition-bigfoot.

Estep B (2020). Did you hear the one about a bear that crashed through a restaurant window in KY? hhttps://web.archive.org/web/20201112215057/https://www.kentucky.com/news/state/kentucky/article245987510.html.

Federal Bureau of Investigation (2019). FBI Records: The Vault - Bigfoot Part 01 of 01. https://web.archive.org/web/20191220161650/https://vault.fbi.gov/bigfoot/bigfoot-part-01-of-01/view.

Foxon F (2023a). If it's real, could it be an eel? *bioRxiv*. https://doi.org/10.1101/2023.01.07.523085.

— (2023b). If it's there, could it be a bear? (Version 1). *bioRxiv*. https://doi.org/10.1101/2023.01.14.524058.

— (2023c). Supplemental materials for paper: If it's there, could it be a bear? https://doi.org/10.17605/OSF.IO/AV3G2.

Freeland D and W Rowe (1989). Alleged pore structure in Sasquatch (Bigfoot) footprints. *Skeptical Inquirer* 13, 273–276.

Godfrey E (2021). Black Bear Killed in Norman after Attempts to Tranquilize it Failed. https://web.archive.org/web/20210524011532/https://eu.oklahoman.com/story/news/2021/05/20/bear-oklahoma-killed-norman-wildlife-officials/5184594001/.

Hart HV (2016a). DNA as Evidence for the Existence of Relict Hominoids. *Relict Hominoid Inquiry* 5, 8–31.

— (2016b). Not Finding Bigfoot in DNA. *The Journal of Cryptozoology* 4, 39–51.

Heaney M (1990). A More Appropriate Procedure for Naming Sasquatch. *Cryptozoology* 9, 52–56.

Heuvelmans B (1986). Annotated Checklist of Apparently Unknown Animals With Which Cryptozoology is Concerned. *Cryptozoology* 5, 1–26.

Hristienko H and JE McDonald (2007). Going into the 21st century: a perspective on trends and controversies in the management of the American black bear. *Ursus* 18, 72–88. https://doi.org/10.2192/1537-6176(2007)18[72:GITSCA]2.0.CO;2.

Kays RW and DE Wilson (2009). *Mammals of North America*. Princeton University Press. https://doi.org/10.1515/9781400833504.

Kelsey P (2022). A Forensic Analysis of the Patterson-Gimlin Film. https://web.archive.org/web/20221211054745/https://adventuresinrediscovery.com/2022/06/13/a-forensic-analysis-of-the-patterson-gimlin-film/.

Kemker A (2021). Louisiana Black bears keep multiplying, making encounter more likely. https://web.archive.org/web/20210922173225/https://www.fox8live.com/2021/05/08/louisiana-black-bears-keep-multiplying-making-encounter-more-likely/.

Krantz GS (1983). Anatomy and Dermatoglyphics of Three Sasquatch Footprints. *Cryptozoology* 2, 53–81.

Lozier J, P Aniello, and M Hickerson (2009). Predicting the distribution of Sasquatch in western North America: anything goes with ecological niche modelling. https://doi.org/10.1111/j.1365-2699.2009.02152.x.

Maryland Department of Natural Resources (2020). Black Bear Management in Maryland. https://web.archive.org/web/20200927173010/https://dnr.maryland.gov/wildlife/Pages/hunt_trap/BlackBear.aspx.

McLeish T (2022). Despite Perceptions, Black Bear Numbers Remain Low. https://web.archive.org/web/20220703002356/https://ecori.org/2021-5-11-despite-perceptions-bear-numbers-in-rhode-island-remain-low/.

Missouri Department of Conservation (2021). Missouri Black Bear Project. https://web.archive.org/web/20200614144348/https://research.mdc.mo.gov/project/missouri-black-bear-project.

Munns B and J Meldrum (2013). Analysis Integrity of the Patterson-Gimlin Film Image. *The Relict Hominoid Inquiry* 2, 41–80.

Munns W (2014). *When Roger Met Patty*. Self-published: CreateSpace.

Napier J (1976). *Bigfoot - The Yeti and Sasquatch in Myth and Reality*. Sphere Books Ltd.

New Jersey Department of Environmental Protection (2022). Black Bear Biology and Behavior. https://web.archive.org/web/20221116034644/https://dep.nj.gov/njfw/bears/black-bear-biology-and-behavior/.

Nickell J (2013). Bigfoot Lookalikes: Tracking Hairy Man-Beasts. *Skeptical Inquirer* 37.

Ohio Department of Natural Resources (2022). Nuisance Species: Bears. https://web.archive.org/web/20220706224512/https://ohiodnr.gov/discover-and-learn/safety-conservation/wildlife-management/nuisance-wildlife/nuisance-bears.

Rasmussen C (2022). Are there Bears in Texas? https://web.archive.org/web/20221214212624/https://a-z-animals.com/blog/are-there-bears-in-texas/.

Somer L (1989). Morphological Analysis of Possible Sasquatch Hair Recovered from the Blue Mountains of Washington State. *Sasquatch Evidence: Scientific and Social Implications Symposium. Eight Annual Meeting, International Society of Cryptozoology, June 24-25, 1989, Washington State University, Pullman, Washington*.

Statistics Canada (2022a). Land and Freshwater Area, by Province and Territory. https://web.archive.org/web/20220612012229/https://www150.statcan.gc.ca/n1/pub/11-402-x/2010000/chap/geo/tbl/tbl07-eng.htm.

— (2022b). Population and Dwelling Counts: Canada, Provinces and Territories. https://web.archive.org/web/20220209134802/https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=9810000101.

Sykes BC, RA Mullis, C Hagenmuller, TW Melton, and M Sartori (2014). Genetic analysis of hair samples attributed to yeti, bigfoot and other anomalous primates. *Proceedings of the Royal Society B: Biological Sciences* 281, 20140161. https://doi.org/10.1098/rspb.2014.0161.

United States Census Bureau (2022). State Area Measurements and Internal Point Coordinates. https://web.archive.org/web/20220430094104/https://www.census.gov/geographies/reference-files/2010/geo/state-area.html.

— (2023). State Population Totals and Components of Change: 2020-2022. https://web.archive.org/web/20230110074310/https://www.census.gov/data/tables/time-series/demo/popest/2020s-state-total.html.

Wildlife Conservation Society (2020). Absent for 80 Years, Bears Once More Roam the Eastern Sierra Nevada Mountains and Great Basin. https://web.archive.org/web/20201024224203/https://measures.wcs.org/Metric-Details/m/37.

Winn EB (1991). Physical and Morphological Analysis of Samples of Fiber Purported to be Sasquatch Hair. *Cryptozoology* 10, 55–65.

Young B and Mississippi Department of Wildlife, Fisheries, and Parks (2021). Black Bears in Mississippi: Past and Present. https://web.archive.org/web/20211022214444/https://www.mdwfp.com/wildlife-hunting/black-bear-program/black-bears-in-ms.aspx.

Figure 1. Choropleth maps for sasquatch reports, black bear (*Ursus americanus*) populations, and human populations in the United States and Canada.

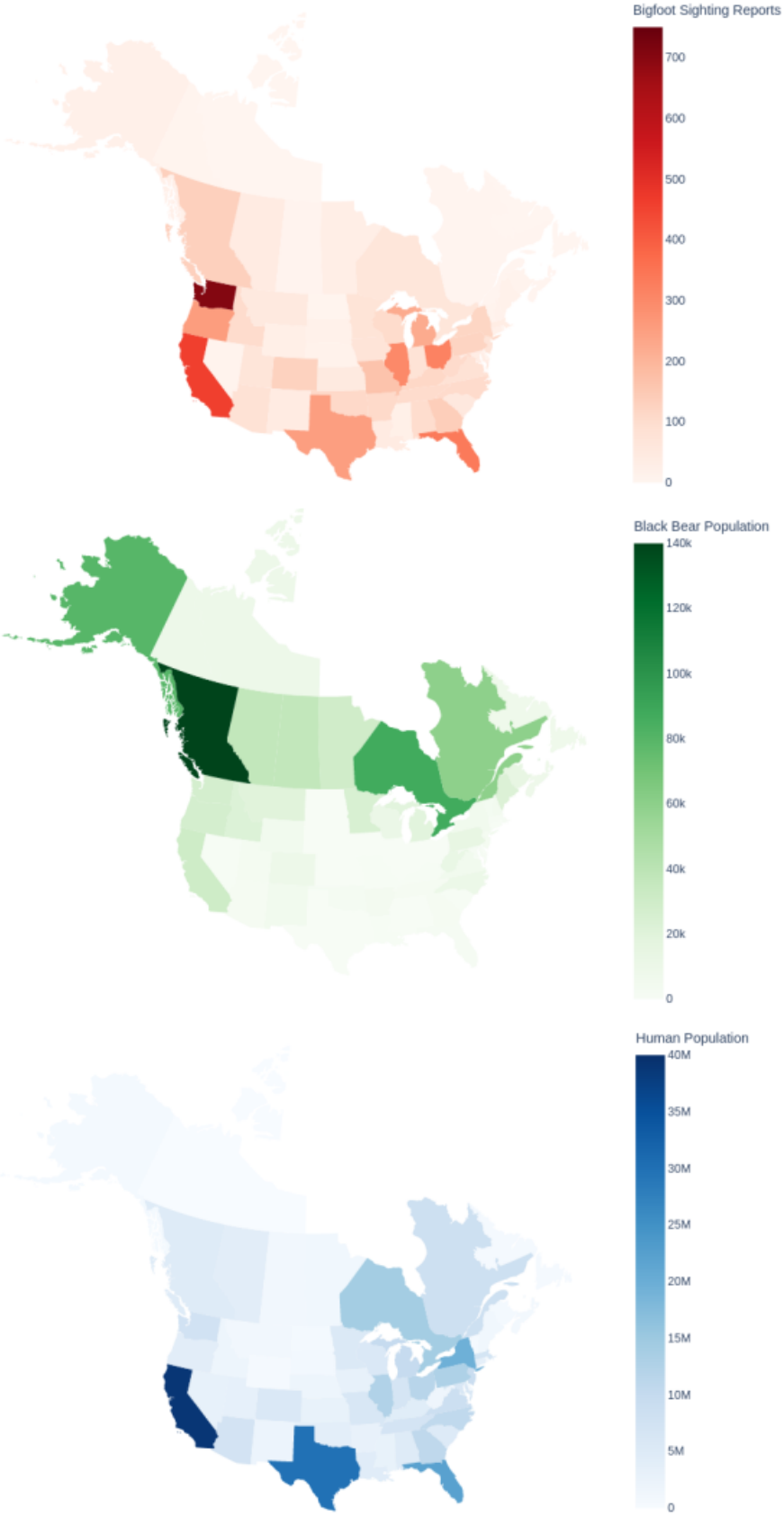

Table 1. Regression Models and Fits

Model No.	Distribution	Link Function	Intercept	Log-Likelihood	RMSE
1	Gaussian	Identity	No	-365.4	96.7
2	Gaussian	Identity	Yes	-362.9	92.7
3	Poisson	Log	No	-12589.5	176.2
4	Poisson	Log	Yes	-2162.7	102.5
5	Neg. Bin.	Log	No	-435.7	2.4×10^{9}
6	Neg. Bin.	Log	Yes	-319.5	402.1

Table 2. Regression Model 6 Parameters

Variable	Regression Coefficient $\pm$ Standard Error
Intercept	3.9 ± 0.2 **
Black Bear Population	$(2.7 \pm 0.8) \times 10^{-5}$ *
Human Population	$(1.2 \pm 0.2) \times 10^{-7}$ **
Land Area (km^2)	$(-2.7 \pm 0.6) \times 10^{-6}$ **

* $p < \frac{0.05}{6}$, ** $p < 0.0001$