Title
American Beaver Habitat Suitability Tied to Lotic Waters Using Both Nuisance Reports and iNaturalist Crowdsourced Sightings

Journal
Proceedings of the Vertebrate Pest Conference, 31(31)

ISSN
0507-6773

Authors
Mecray, Abrielle
Gass, Nikki
Myers, Madison
et al.

Publication Date
2024

American Beaver Habitat Suitability Tied to Lotic Waters Using Both Nuisance Reports and iNaturalist Crowdsourced Sightings

Abrielle Mecray
Department of Biology, University of Richmond, Richmond, Virginia
Nikki Gass and **Madison Myers**
Biology Department, Providence College, Providence, Rhode Island
Brett Malloy
Malloy Wildlife, Cumberland, Rhode Island
Benjamin Goldfarb
Way Out West, Salida, Colorado
Michael Callahan
Beaver Solutions, Southampton, Massachusetts
Jonathan L. Richardson
Department of Biology, University of Richmond, Virginia

ABSTRACT: Beavers are semi-aquatic rodents that are considered to be pests by humans due to their habit of building dams and the damage they cause to their surrounding ecosystems. Using a program known as NaxEnt, which is a statistical package that can determine the probabilities of species distributions based on surrounding environmental information, we analyzed both nusiance reports of beavers as well as crowdsourced information to create a habitat suitability model. It appears that beavers were most strongly associated with the land cover types of Powerlines/Utility, Non-Forested Wetland, Water-based Recreation, Cropland, and Open Land. Nuisance beavers are negatively correlated with human population density, while iNaturalist beavers were positively correlated. It appears that these models and the workflow for creating them has developed into a suitable base for future research, while also showing the effect that public participation can have on data.

KEY WORDS: beavers, *Castor canadensis*, crowdsourcing, habitat suitability, Massachusetts, MaxEnt

Proceedings, 31st Vertebrate Pest Conference (R. M. Timm and D. M. Woods, Eds.)
Paper No. 31. Published December 20, 2024. 4 pp.

INTRODUCTION

Beavers (*Castor canadensis)* are a common semi-aquatic rodent found throughout North America. While they did suffer from threat of extinction from hunting and the destruction of the environment through the mid-20th century, their populations have recovered, particularly in the Eastern United States, in response to conservation efforts (Cunningham et al. 2006). The habits of beavers and their dams have considerable effects on the surrounding ecosystems, affecting soil, nitrification, and the surrounding flora and fauna, and can positively impact the flora of wetlands (Dee et al. 2018). However, with their increased presence, beavers also come into much closer contact with humans.

Beavers and their dams have caused considerable issues for humans over the years. An often-repeated conundrum considers whether beavers are pests due to their dam-building causing havoc through flooding, and therefore damage to human homes and roads. Some regions have resorted to nuisance trapping to combat the beaver's presence. Conflicts have arisen concerning government management, lethal control, economic cost, and ecological impacts like the loss of wetlands (Yarmey 2020). Looking into nuisance reports and comparing these appearances with various environmental elements can facilitate habitat suitability modeling. Habitat suitability models assign a numerical value to represent the suitability of an environment for a species based on many different variables at once. One method for developing this model is *maximum entropy*, which can be performed using the program Maxent (Phillips et al. 2008), which takes different occurrence points of an organism, and looks for correlations between this appearance and supplied environmental variables (Phillips and Miroslav 2008). The resulting habitat suitability models are also a predictive measure, which display areas that are more suitable for an organism, and therefore where the target organism is more likely to appear. This data can then be utilized in numerous different ways, from conservation efforts (by determining the areas of highest suitability and preserving those), or even for trapping purposes.

For this study, we have taken two datasets that combine not only the importance of professional input, but also public participation. We hypothesized that beaver occurrence would be highly associated with lotic habitats, as well as palustrine wetlands. We also believe that habitat suitability will decrease with elevation and human population density. Additionally, there might be a positive association with forested land cover. Our results can be used to predict the presence of beavers, both currently and in the future, in unsurveyed areas, and provide for more effective beaver management across Eastern North America.

A

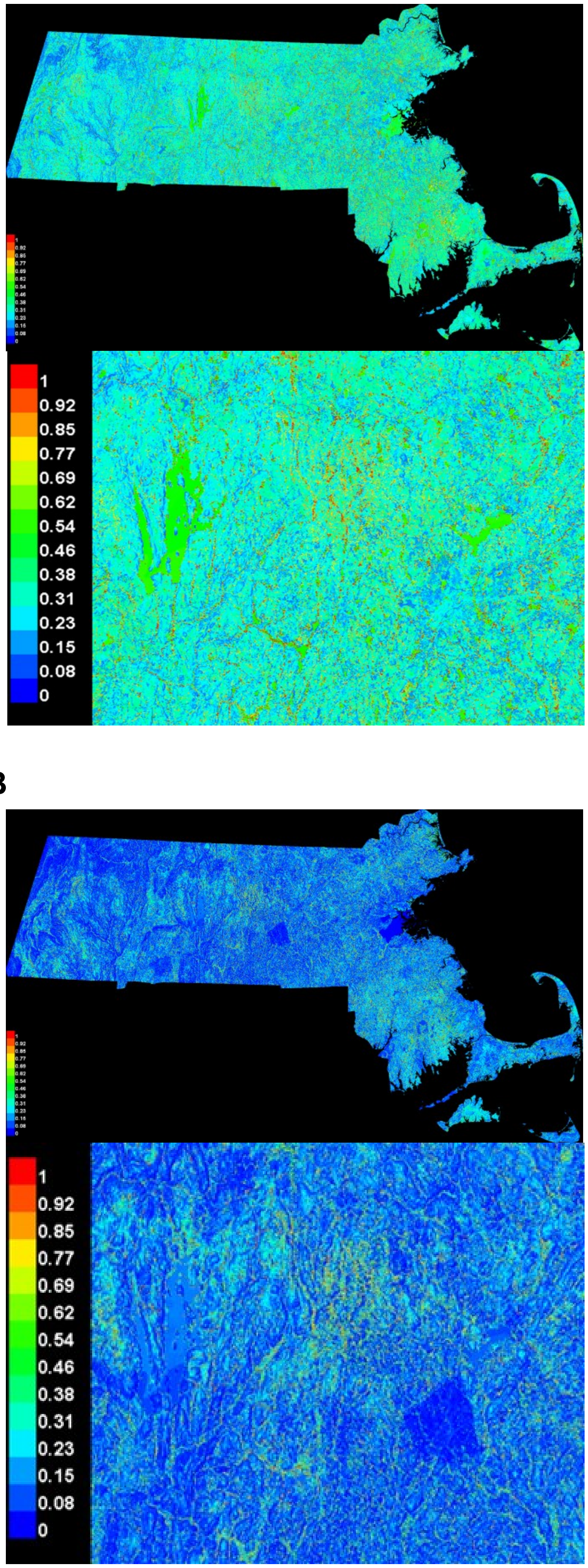

Figure 1. Habitat Suitability Models. A) iNaturalist and B) Nuisance, including subsections with high suitability areas. Warmer colors represent high suitability, while cooler colors represent a low suitability.

METHODS

Beaver locations were obtained from two sources: iNaturalist crowdsourced observations, and beaver nuisance reports collected by Mike Callahan of Beaver Solutions. The iNaturalist points were further filtered into a 'research-grade' category, which confirmed *C. canadensis* sightings with photographs (iNaturalist community). This data provided the coordinates of confirmed beaver sightings, from which MaxEnt could then extrapolate further likelihood of beaver sightings, which in conjunction with other environmental factors, would create the suitability model.

GIS layers were provided by MassGIS and the National Wetlands Inventory and included elevation, slope, land cover, road cover, and population density. The GIS layer determining aquatic habitats were labeled 'hydroarc' for rivers and 'hydropoly' for lakes. Using these layers, we generated two models known as 'iNaturalist' and 'Nuisance'.

We have taken the two data sets and run them through Maxent to create more comprehensive views about the distribution of beavers and also figure out the variables that affect them most. Currently, these models cover the state of Massachusetts, but we believe there is potential to expand the range or specify other areas, given the GIS layers utilized.

The GIS layers and data points were loaded into ArcGIS, in which each variable had its own layer. Therefore, there was one individual layer for elevation, slope, type of land cover, road cover, rivers, and lakes, as well as an additional layer containing the coordinate points of the beaver sightings. Each individual layer was converted into an ascii file to be processed by MaxEnt. MaxEnt then combined these files, and by correlating between the environmental layers and the point distribution of the beavers, was able to output a suitability model.

This included analysis of the percent contribution of each landscape variable, allowing us to determine how much each environmental factor affected the beavers. This process also calculated how much categorical elements, like certain types of land cover, contributed to the model. Maxent also individually displays contribution of variables such as different land types.

RESULTS

The habitat suitability model generated by MaxEnt is in Figure 1, demonstrating the areas with higher predicted probability for finding beavers, and therefore, likely, higher suitability areas for them. The presence of beavers was negatively associated with elevation (though this had very little actual contribution to either model), as well as slope, but unexpectedly, corresponded more positively in the iNaturalist model with human population density (Figure 2). Therefore, Maxent saw areas with *more* humans as *more* suitable for beavers, which appears paradoxical. In contrast, the nuisance models showed suitability decrease as human population density increased.

Using MaxEnt's output, we then determined the 5 highest contributing types for each model and averaged them. These land cover types were: Powerlines/Utility, Non-Forested Wetland, Water-based Recreation, Cropland, and Open Land. Forested Wetlands were also considered a major contributor and were ranked 6th (Figures 2 and 3).

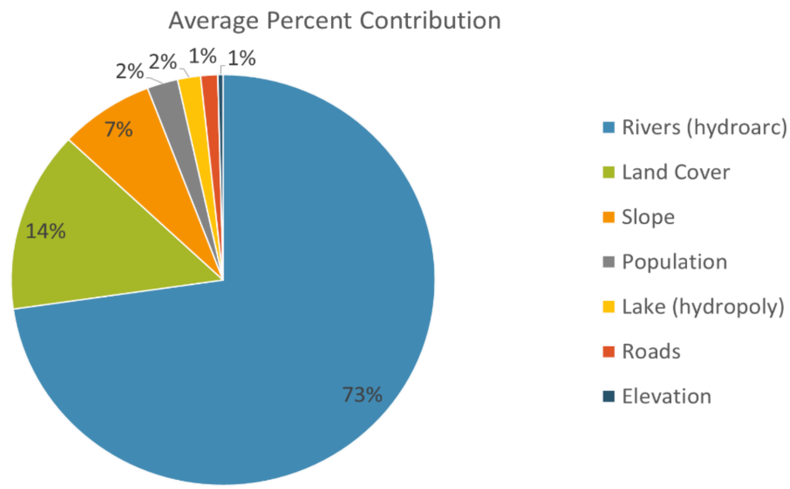

Figure 2. Average percentage contribution across both models showed that riverine habitats and land cover correlated most closely with the presence of beavers, averaging a 73% contribution to the models. The next two highest contributions were land cover at 14% and slope at 7%. The contribution of all other values (population, 'hydropoly' lakes, roads, elevation) was no more than 2% for each.

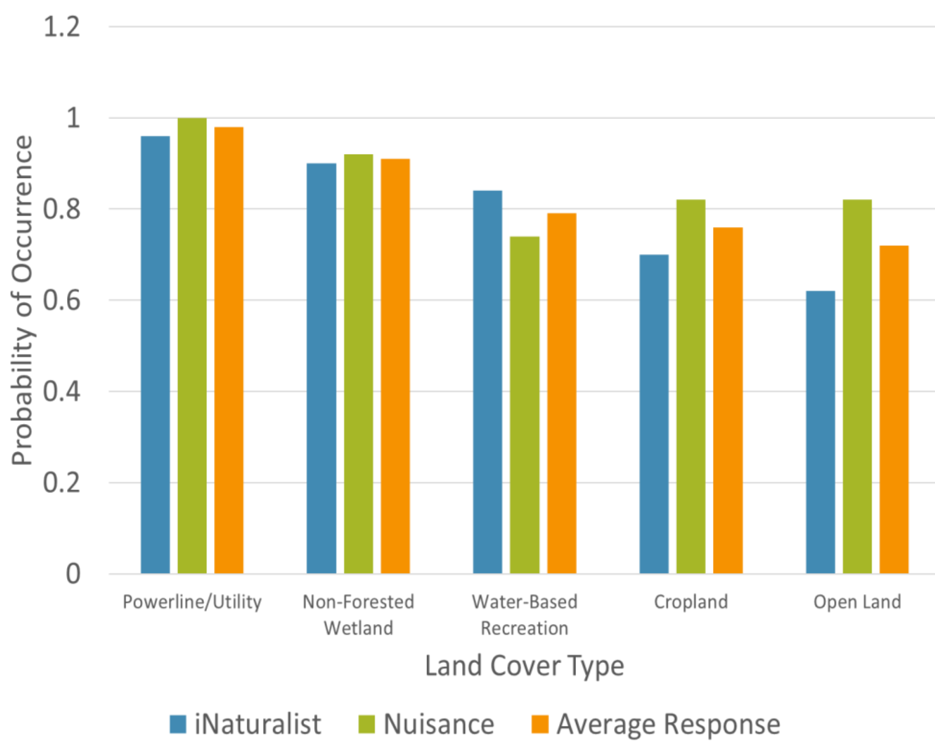

Figure 3. Probability of occurrence based on land cover type. Includes the values for both models, as well as their average.

DISCUSSION

The percent contribution corresponded with our beliefs that beavers would be closely associated with lotic and wetland habitats. However, the effects of human population density were unexpected, as the iNaturalist and Nuisance models contradicted each other. In the iNaturalist model, suitability was positively associated with the presence of humans. We believe that the reason for this is because of the crowdsourced nature of the beaver points. Many of the reports occur from points alongside areas where people are engaging in recreation. Also, the suitability of these iNaturalist points is contingent on their interaction and observation *by humans directly*, and therefore it makes sense that the more human presence that is in an area, the more likely humans and beavers are to cross paths. The nuisance data provides different results, likely because these points are all from occurrences of pest control. Again, they are reliant on the fact that humans are being directly impacted by the beaver's presence, but in this case on much rarer occasions and likely more remote due to the nature of the locations of most power lines.

For *both* models, the highest contributing type of land cover towards beaver sightings was Power Lines/Utility. In the case of the nuisance data, this is due to many of the nuisance reports being from power companies (M. Callahan, pers. commun., Beaver Solutions). In the iNaturalist model, this could be explained by beavers being encountered where more humans are, and therefore where more power lines could be dispersed, as these would be connected closely to human civilization. Suitability also corresponded with Non-Forested (and, less strongly, Forested) Wetlands, which was expected. However, water-based recreational areas were also a large part of the iNaturalist model. Because the observations are crowd-sourced, they correspond with areas where both humans and beavers would spend time, and therefore are more likely to cross paths. Finally, cropland and open land are largely associated with Nuisance beavers. The cropland is likely due to the beavers being reported as pests by farmers, while the open land could be due to a number of different factors, including where and when rivers are present (as, again, lotic habitats were the highest determining factor in creating these models.

CONCLUSION

The nuisance-based and iNaturalist habitat suitability models are both influenced by human activity. For nuisance cases especially, the beavers will only be reported when they are directly causing issues for humans, and human infrastructure. Therefore, they are more closely associated with power lines and infrastructure that is vulnerable to their activities. A similar observation can be made when using the iNaturalist data. In this case, beavers appear to be more prevalent in wetlands near human population centers and recreational bodies of water.

We are considering combining the inputs of both models to form a more comprehensive view of beaver habitat suitability and human interactions. We have also developed and are currently analyzing two more models that create different distinctions for aquatic habitats. Instead of using the hydroarc and hydropoly layers from MassGIS, we use a GIS layer created by the National Wetlands Inventory. This model makes distinctions between streams, rivers, marine and freshwater habitats, ponds, streams, and types of wetlands. We believe that these will allow for greater nuance in determining the presence of beavers and adding another layer of complexity when comparing the results of all four models.

Our process has promising results for future works. The workflow can be utilized for other organisms and purposes, from trapping to conservation, including modeling areas vulnerable to any pest species of interest. We have also been looking into using this modeling workflow for other pests, like rats, and measuring the likelihood of zoonotic diseases coming into contact with urban human populations. Overall, we've established an effective method, and have made strides in including both professional and public knowledge in predicting the suitability for beavers, and hopefully more organisms in the future.

LITERATURE CITED

Cunningham, J. M., A. J. K. Calhoun, and W. E. Glanz. 2006. Patterns of beaver colonization and wetland change in Acadia National Park. Northeastern Naturalist, 13(4), 583-596. http://www.jstor.org/stable/4130992

Dee, S., A. Korol, C. Ahn, C. J. A. Lee, and M. Means. 2018. Patterns of vegetation and soil properties in a beaver-created wetland located on the coastal plain of Virginia. Landscape and Ecological Engineering 14:209-219.

iNaturalist Community. Observations of American beaver (*Castor canadensis*) from Massachusetts. Exported from https://www.inaturalist.org Nov. 16, 2023.

Phillips, S. J., and M. Dudík. 2008. Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. Ecography 31(2):161-175.

Phillips, S. J., M. Dudík, and R. Schapire. [Internet] Maxent software for modeling species niches and distributions (Version 3.4.1). Available from http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed Nov. 10, 2024.10.

Pollock, M. M., G. Lewallen, K. Woodruff, C. E. Jordan, and J. M. Castro, editors. 2015. The beaver restoration guidebook: working with beaver to restore streams, wetlands, and floodplains. Version 1.02. U. S. Fish and Wildlife Service, Portland, OR. 189 pp. Online at: http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp

Yarmey, N. T., and G. A. Hood. 2020. Resident perceptions of human-beaver conflict in a rural landscape in Alberta, Canada. Human-Wildlife Interactions 14(3):476-486.