Title and Subtitle: Wildlife-Vehicle Collision Hotspots in Wisconsin
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Abstract: Wisconsin is fifth in the country for wildlife-vehicle collisions, according to State Farm insurance company. These collisions are expensive for both drivers and insurance companies. This report looks at spatial data for wildlife collisions across the state, provided by the Wisconsin Department of Transportation, breaks them down by various factors and identifies hot and cold spots, then attempts to answer why some areas are hot spots for collisions and other areas are not by looking at various possible covariants.

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Disclaimer:
This project relies on data collected by people who do not have the explicit objective to collect data on wildlife-vehicle interactions or collisions. For this reason, data points in the primary dataset are often missing information such as time of collision or roadway name. Due to the volume of data, all other information has had to be assumed to be correct, despite having no method of verification. Where data has been removed or changed, the processes as well as the reasons and logic behind them will be detailed in each individual section. This project does not replace the need for a real in-depth study on wildlife-vehicle interactions in Wisconsin nor a real impact study on possible mitigation efforts.

Chapter 1: Introduction

The purpose of this report is to analyze patterns of wildlife-vehicle collisions across the state of Wisconsin. According to State Farm, Wisconsin is number five in the country for wildlife-vehicle collisions. These can be expensive collisions for the driver and the insurance company, and they are often fatal to the impacted wildlife. This report will identify hot and cold spots on Wisconsin roadways and analyze conditions in Wisconsin that correlate with those hot and cold spots for wildlife-vehicle collisions. Using those conditions, it is this report's hope that mitigation strategies can be suggested to lower the incidence of wildlife-vehicle collisions in this state..

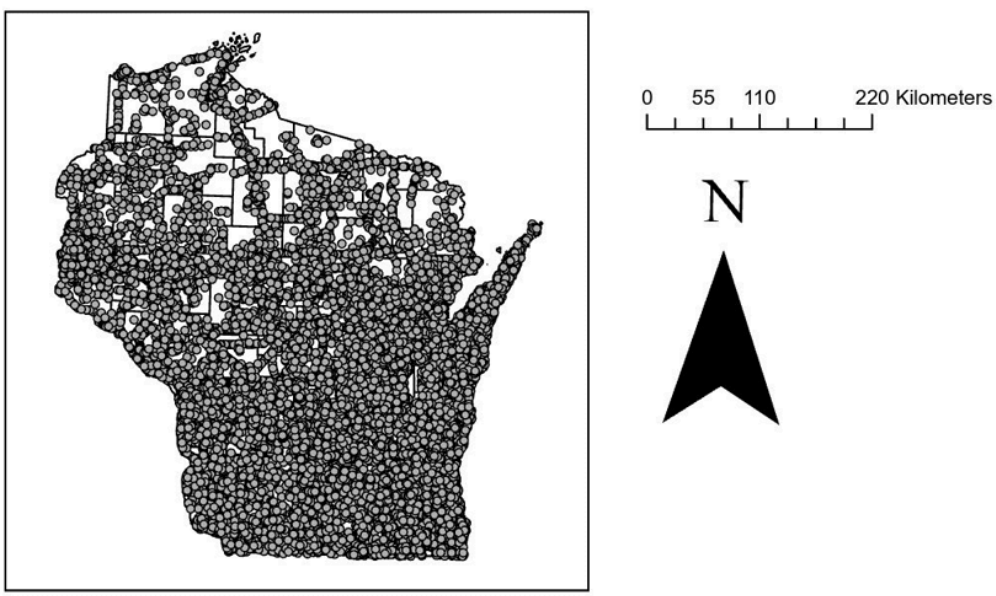
Table 1: Tools and Data:

Design Tools	ArcGIS Pro, Microsoft Excel, Google Docs and Sheets, Adobe Illustrator
Data Management & Analysis Tools	Hotspot Analysis, Merge, Split, .csv to Table, Table to Feature Layer, Spatial Join
Database	.csv files turned into ArcGIS tables
Data Sources	WisDOT Annual Crash Data 2017-2022: WI_Annual_Crash_Data_Flyer.pdf | Powered by Box Major Roadways shapefiles: Major Roads | Wisconsin DNR Open Data Portal County and Local Roadway shapefile: County and Local Roads | Wisconsin DNR Open Data Portal WisDOT Projects: Construction Projects (6 Year) | WisDOT Open Data Land Use/Land Cover: Wiscland 2 | Wisconsin DNR Open Data Portal Remnant Prairies: Roadside Remnant Prairies | WisDOT Open Data Woody Vegetation: Mowing Frequency of Woody Vegetation | WisDOT Open Data Wetlands: Wisconsin Wetland Inventory Geodatabase | Wisconsin DNR Open Data Portal Wisconsin DEM: Wisconsin DEM from LiDAR (Units in Meters) | Wisconsin DNR Open Data Portal WisDOT Traffic Data: WisDOT Traffic Counts

Literature Review	Montana Wildlife & Transportation Partnership: [Montana Wildlife & Transportation Partnership | Montana Department of Transportation (MDT)] State Farm: [New State Farm® data reveals the likelihood of hitting an animal while driving in every state] The Badger Project: [Other states have had success with wildlife bridges, so where are Wisconsin's? - The Badger Project] Environment America: [Wildlife crossings connect small, fractured habitats] Federal Highway Administration Wildlife Crossings Program: [Wildlife Crossings Program | FHWA]

Data Review:
Collision data from WisDOT was organized by year and contained data for all collisions throughout the state for the years 2017-2022 in one Microsoft Excel .csv file. The data was broken up with one sheet corresponding to one year. Before being input into ArcGIS, collisions that did not contain a value in the "animal" columns were taken out, so that only vehicle collisions involving animals were included. The spreadsheets were turned into tables in ArcGIS and then merged into one "collisions" table encompassing all data from 2017-2022. Because this table has latitude and longitude information in it, it could then be turned into a points shapefile: the "master" point layer including all wildlife collisions in Wisconsin from 2017-2022.

Figure 1: map of all collision points



"Road Type" refers to the roadway designation by WisDOT. There are four official designations used in the primary dataset: US Highway, Interstate Highway, State Highway, and County

Highway. All other collisions are thought to be on roadways that do not fall under these designations, and they are labelled under the name “Roads” in this project. More information on “Roads” can be found in Chapter 2: Hot and Cold Spot Analysis.

The “master” point layer was also split up according to the month of the collision date in order to look at any hot or cold spots temporally. These were further broken up by road type. Further in-depth explanation and analysis of the monthly data can be found in Chapter 3: Temporal Analysis.

The most common wildlife code for this collision set was for deer (WisDOT code 101), but Table 2 breaks down all of the animal species involved in collisions in the data set.

Table 2: Animal Species

Species	2017	2018	2019	2020	2021	2022	Total
Bear	167	148	134	136	138	125	848
Turkey	196	164	166	136	137	163	962
Raccoon	165	168	145	137	125	133	873
Opossum	10	11	5	10	9	10	55
Other	339	204	211	182	222	195	1353
Coyote	86	76	88	49	82	42	423
Deer	20669	20916	19119	17247	16918	17014	111883

Figure 2: maps of collisions in each roadway designation type

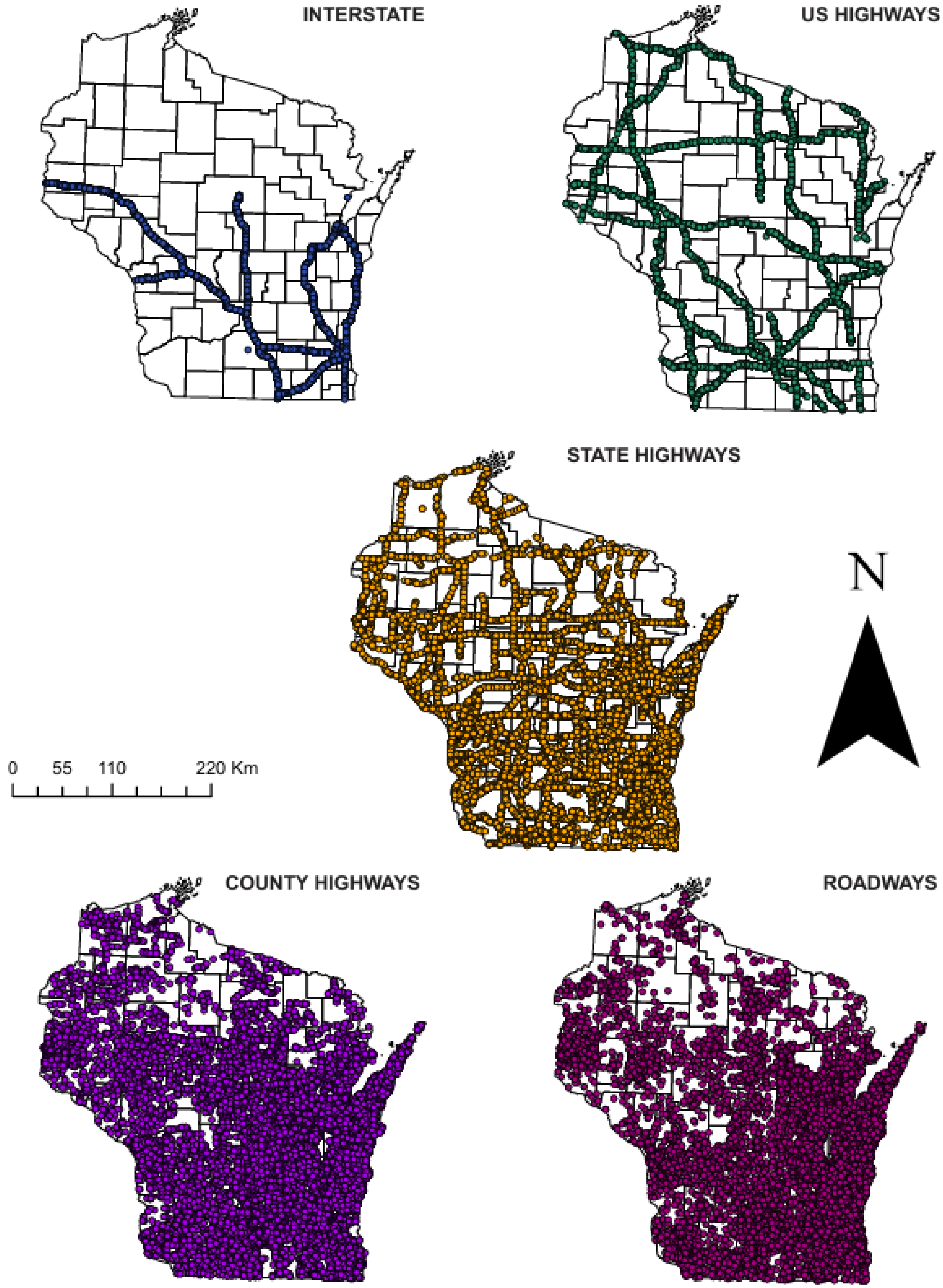
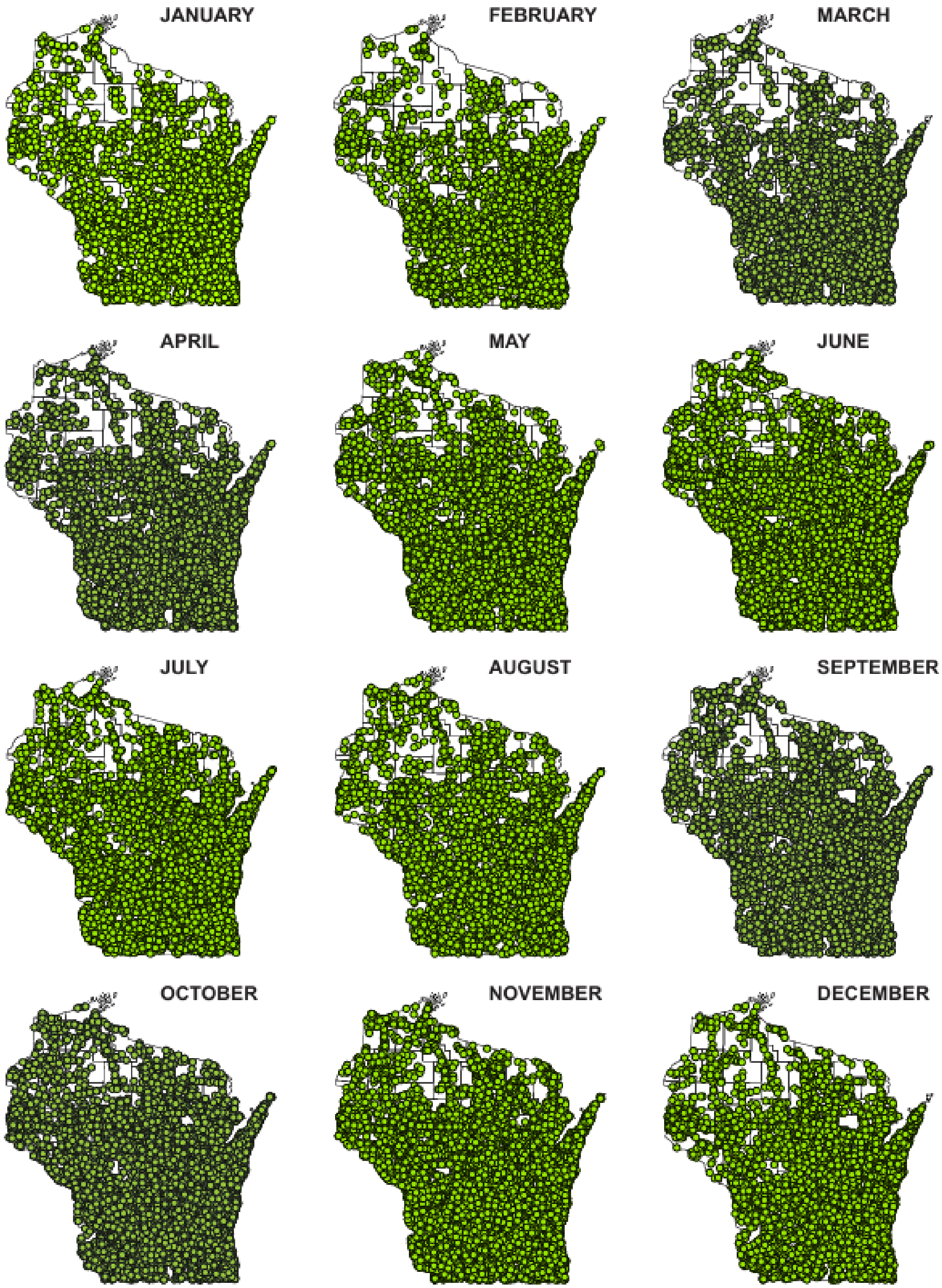


Figure 3: maps of collisions by month (not broken up by road type)



Chapter 2: Hot and Cold Spot Analysis

The most time-consuming portion of this project, and therefore the bulk, is the hot and cold spot analysis of the wildlife-vehicle collision points in Wisconsin. Hot Spot Analysis (Getis Ord Gi*) in ArcGIS requires an input feature class, input field, and then creates an output feature class. The input feature class is easily the collision point layer. However, the "master" point layer did not come with an input field, so one needed to be calculated for it.

Input field should be the field that has the count of what needs to be looked at to distinguish hot and cold spots. For this analysis, decisions had to be made and fields had to be created and calculated for each point feature attribute table. The decision process is detailed below:

How would each point be given a count?

Each point is a discrete set of coordinates on the map, so if a hotspot analysis was run on each pair of coordinates, each coordinate pair would have a count/frequency of 1, meaning each point would either be a hotspot or a cold spot, and there would be no variation.

A hotspot analysis could be run on each roadway by counting the occurrence of names in the dataset. However, a lot of roadways stretch across the state, and they maintain the same name for that stretch. For example, maybe there is a large amount of collisions on one area of Hwy 151 near Fond du Lac, but no collisions on any other section. Using a roadway count would make it look like the entire stretch of 151 from Manitowoc to the Illinois border was a hotspot just because there is a cluster near Fond du Lac.

In the end, the decision was made to combine county and roadway into a field, and record the count of each county/roadway combination incidence in a "COUNT" field. Not only does this split roadways into usable sections, it is also essential for using the county highway data as county highway names are duplicated in each county.

It is also useful to split the data by county because the WisDOT splits their project sections by county, and the hope of this project is to influence WisDOT policy and convince them to include wildlife mitigation efforts into their future projects.

Roads Without Designated Roadway Type

As stated in Chapter 1, collisions that do not occur on the WisDOT designated roadway types (US Highway, Interstate Highway, State Highway, and County Highway) are labelled under the name "Roads" for this project. It was thought that they should not be included based on the methodology for counting collisions for the hotspot analysis. Ostensibly road names can repeat throughout a county without being connected or related spatially. Main Street, for example, is a common street name in villages, towns, and cities. There is a Main St, Poynette, a Main St, Portage, a S Main St, Lodi, and a S Main St, Pardeeville, all in Columbia County, Wisconsin.

However, it was found in the WisDOT collision data that in these instances, street names are given a (1), (2), (3), etc. next to each instance. In the end, roadways were included in the data, but they should be taken with a grain of salt. Human beings do collect this data, and if they mislabel a roadway as “Main Street (1)” when it was really “Main Street (3)”, this project did not go through and verify each instance. Further analysis could be done on roadways that are not highways by possibly counting instances of municipality/road name.

Hotspot Analysis

The Hot Spot Analysis (Getis Ord Gi*) tool was used in ArcGIS to map hot and cold spots of wildlife-vehicle collisions across the state as a whole and on each individual roadway type to look for variation. The results are in Figures 4 and 5.

Figure 5: Statewide Hot and Cold Spots

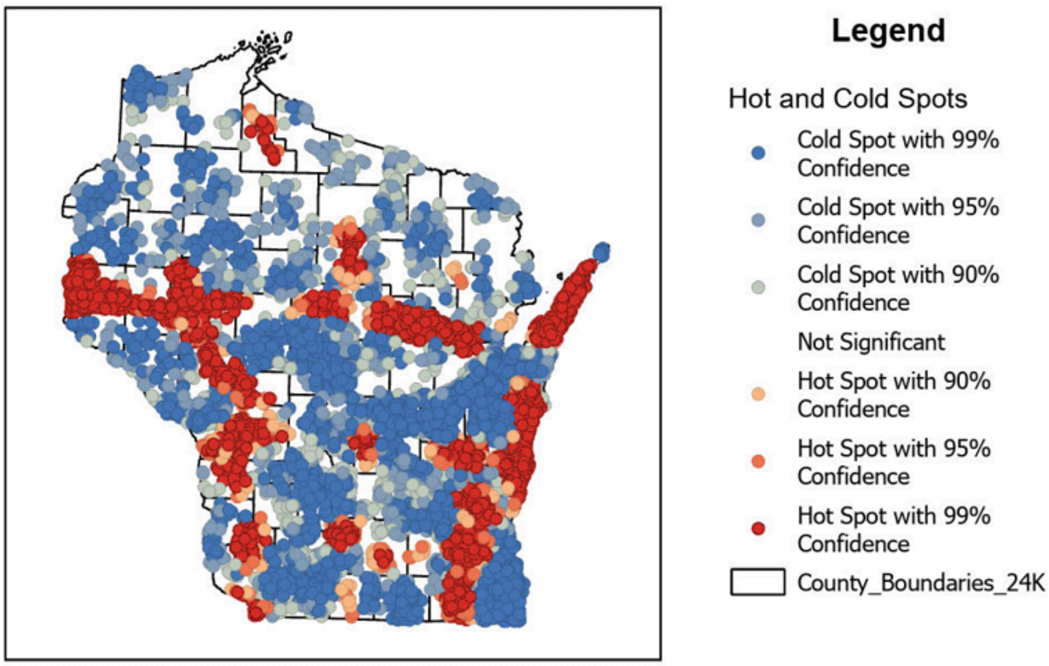
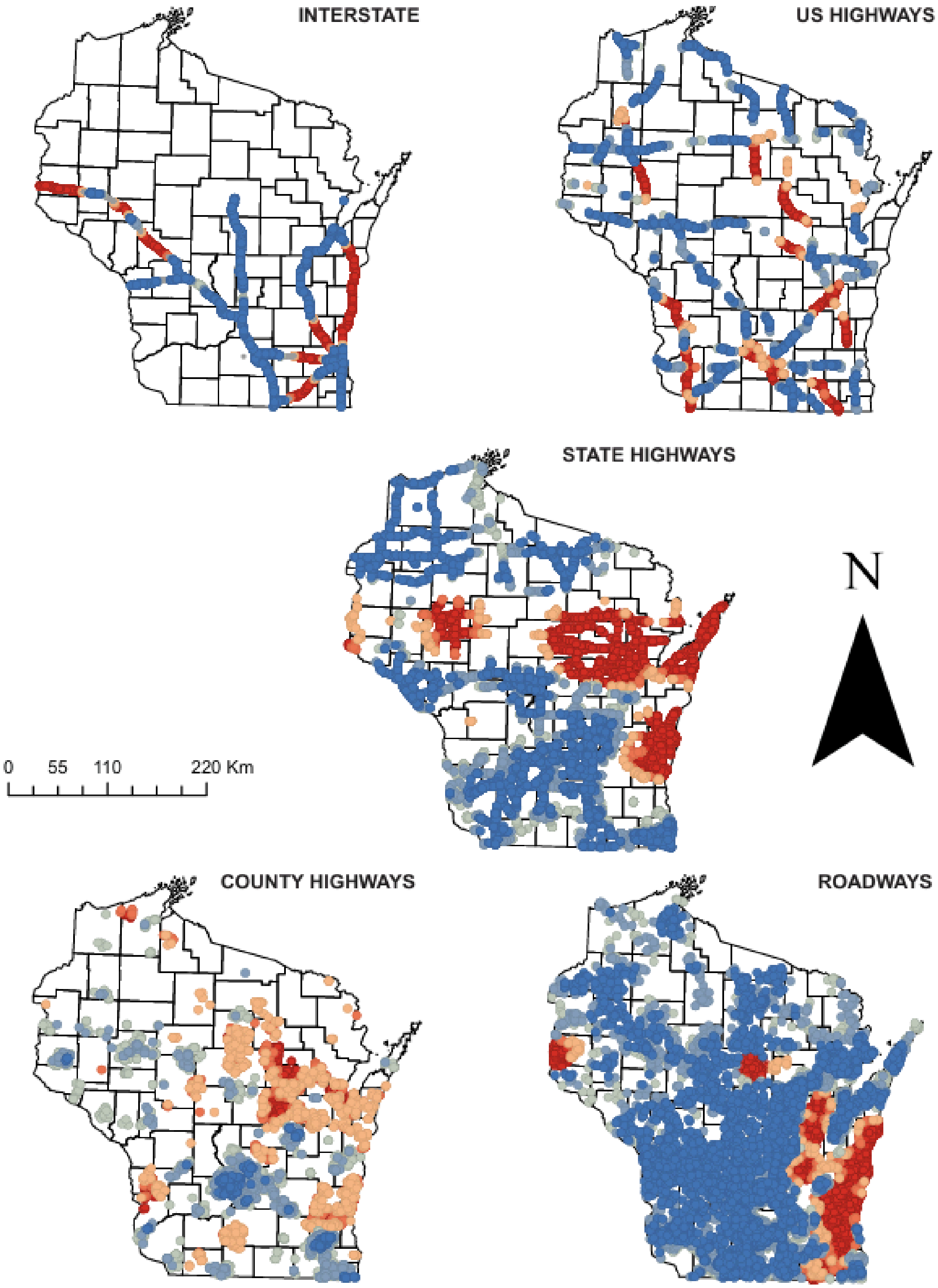


Figure 6: Hot and Cold Spots by Roadway types



Chapter 3: Temporal Analysis

It was proposed, as deer make up a massive majority of the wildlife represented in the data, that there may be a temporal component to these collisions. Deer become extremely active and visible during their rutting season from around September to December. In Wisconsin, they are also driven to activity by the popular gun-deer seasons in November and December. Figure 6 shows that the rut does influence the volume of wildlife-collisions experienced.

Figure 6: Counts of Wildlife by Month

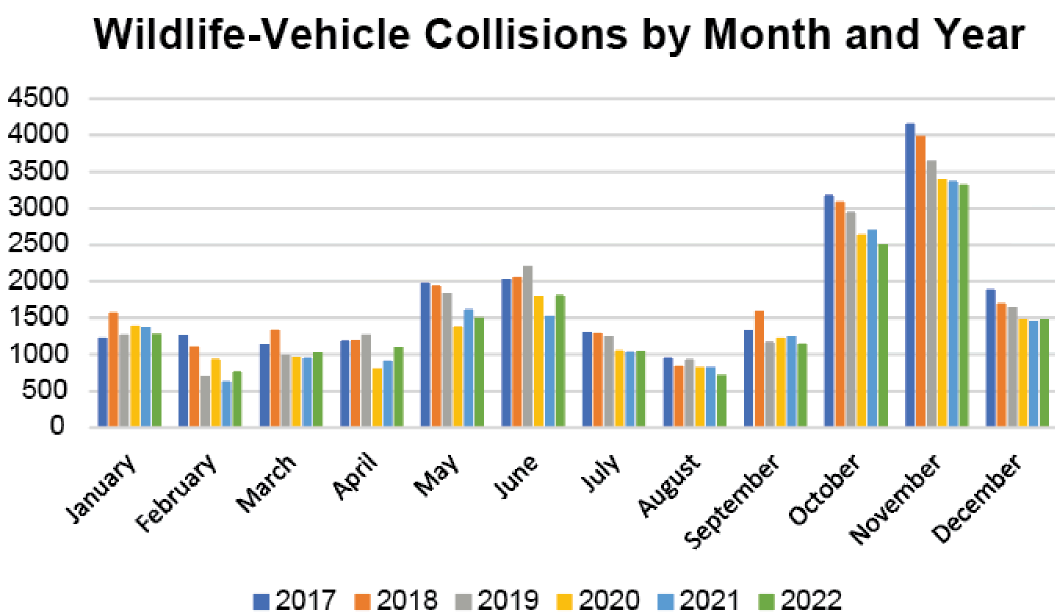
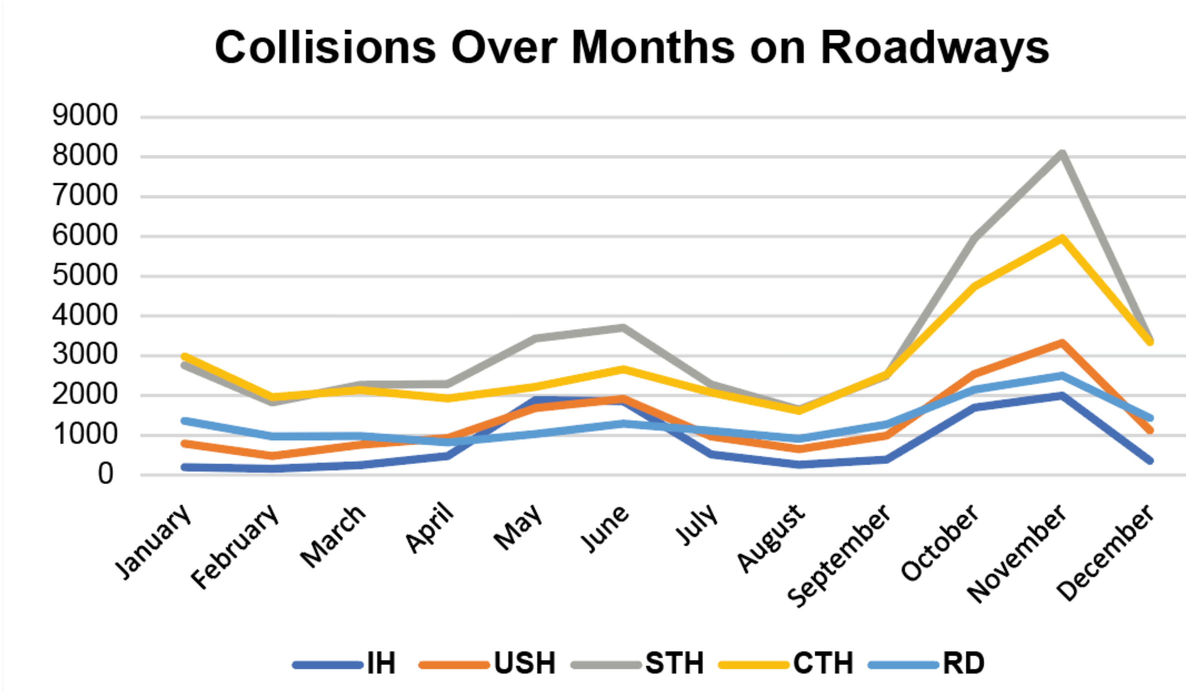


Figure 7 looks a little closer at a breakdown of monthly collisions for all of the years, divided up by roadway type. Every roadway type sees an increase in collisions during October and November with the most increase happening on the state and county highway systems.

Figure 7: Collisions Over Months on Highway Systems



Hotspot Analysis

The same methodology for the statewide hotspot analysis in Chapter 2 was used, however the datasets used were the extracted “roadway type” datasets: US Highway, Interstate Highway, State Highway, and County Highway. These datasets were further split up by the month the collision occurred in.

For this analysis, Interstate and US Highway data were combined.

Figure 8: Interstate and US Highways by Month

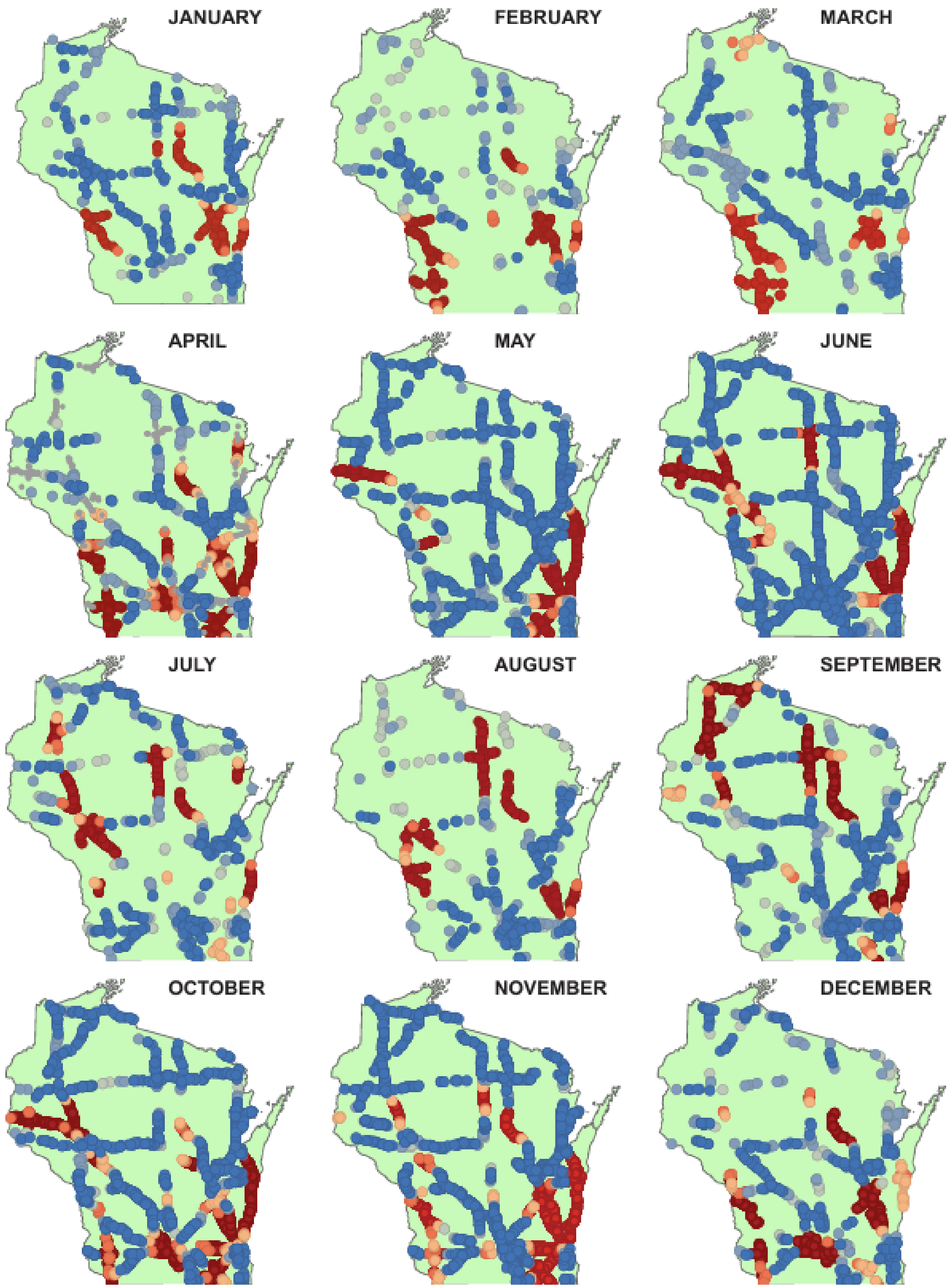


Figure 9: State Highways by Month

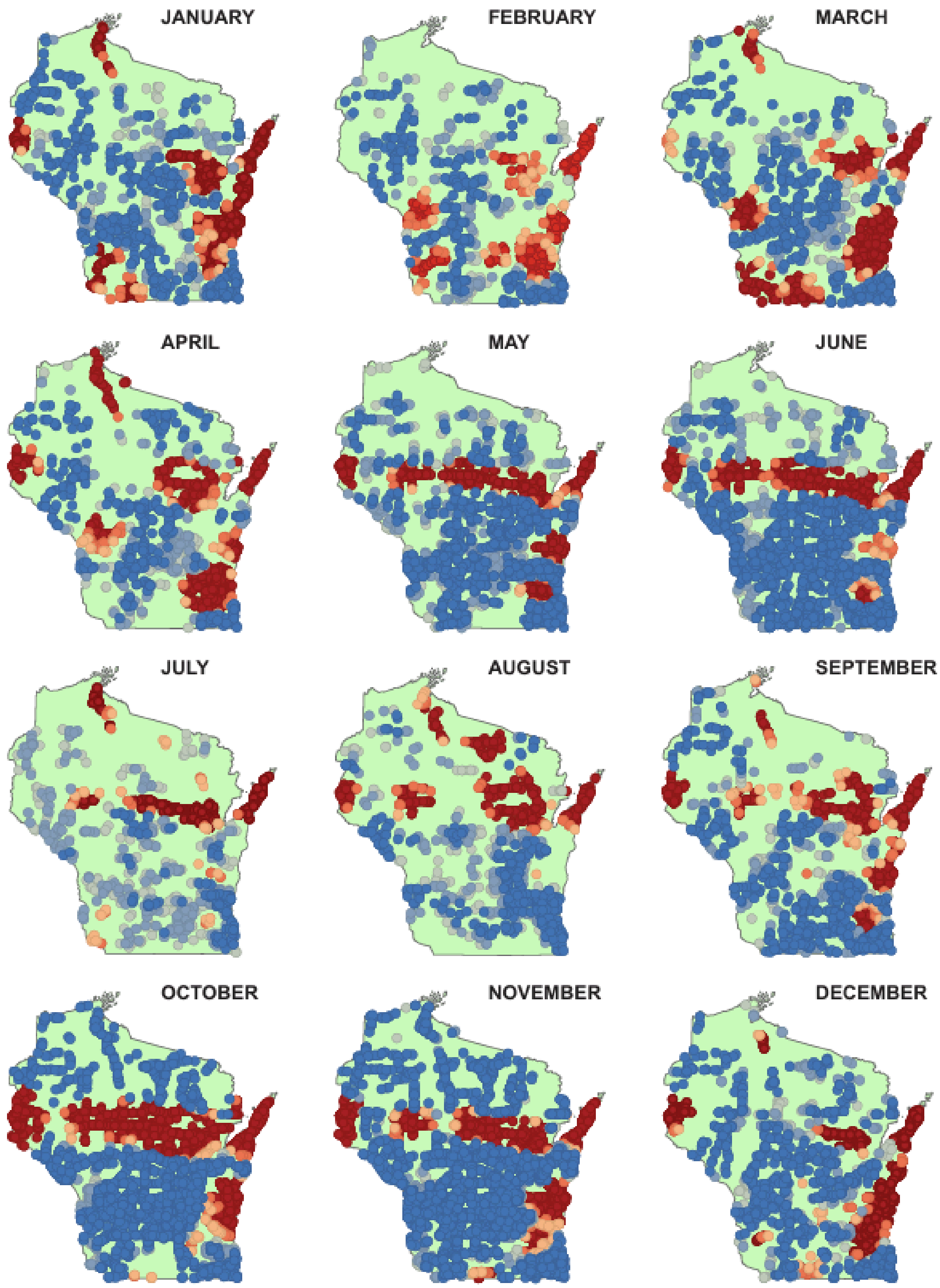


Figure 10: County Highways by Month

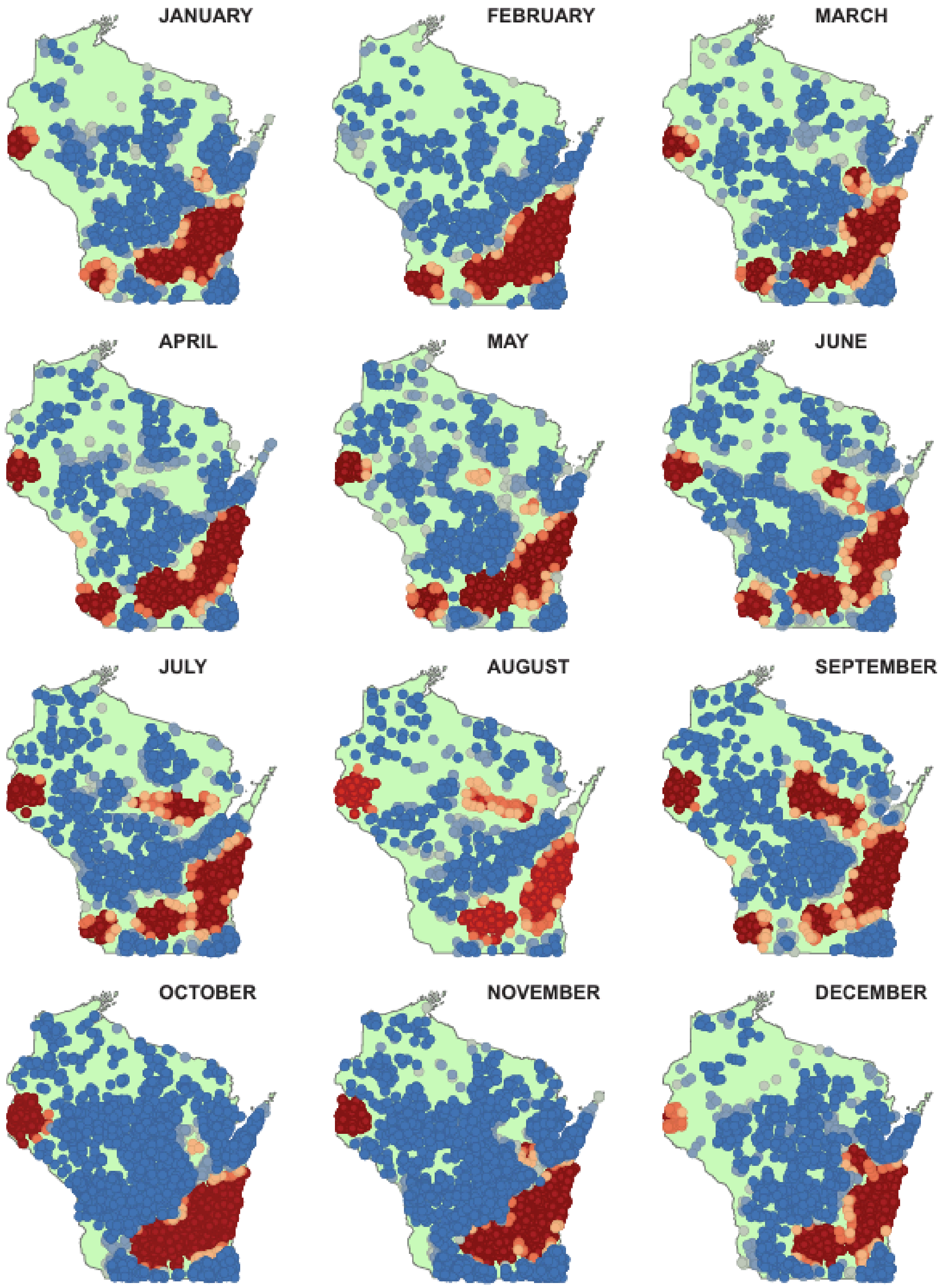
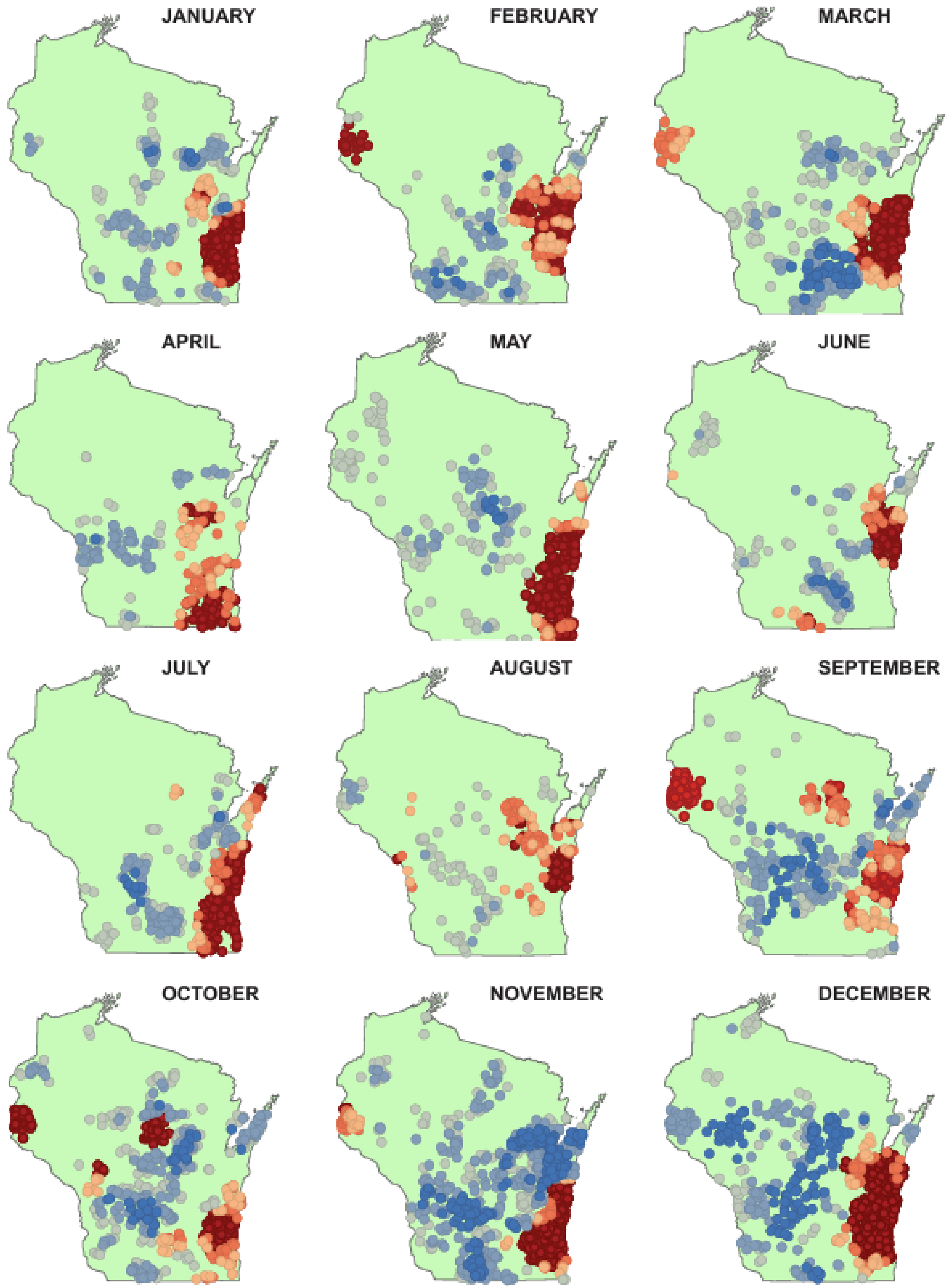


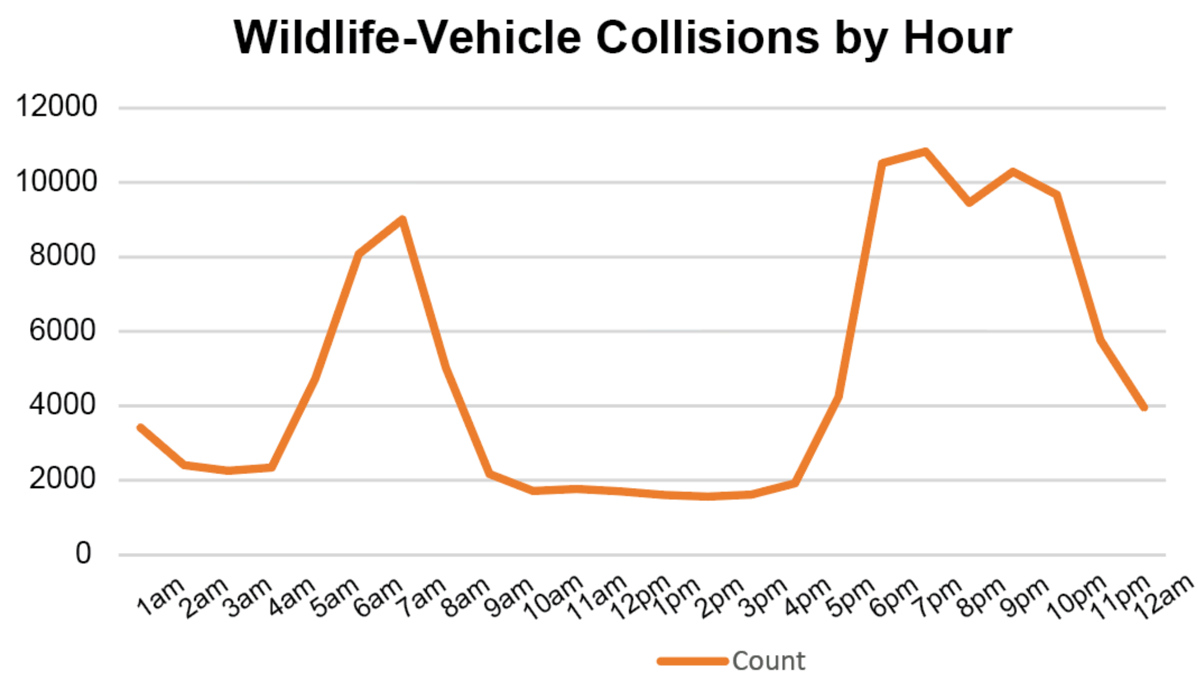
Figure 11: Roads by Month



One Final Temporal Analysis

The final temporal breakdown run on the data was by hour. This was based on several theories. First, collisions would be more prominent during rush hour. This seems to nicely coincide with the data, and with the second theory that collisions would be more prominent before and after dawn and dusk, when visibility is lessened. For most of the year, this proves true, and this may account for a decrease in collisions during the summer months, when the hours are extended. The third theory was proven to be not true, and that was that there would be a spike in collisions around bar-closing time. Figure 12 charts the results. A hot spot analysis of this data (broken down by hour) was not run due to time constraints, please see Chapter 5: Further Research.

Figure 12. Wildlife-Vehicle Collisions by Hour



It should also be noted that the Wisconsin DOT did not have time information for every collision in the dataset. When time was not available, the value was put in as 999. These values were not usable for the analysis by hour, so they were removed from this analysis. Please see the table below for a breakdown on the values removed from each year.

Table 3: Time Values Removed

	2017	2018	2019	2020	2021	2022
999 time value	0	4	46	108	99	96

Chapter 4: Covariant Analysis

A few covariates were proposed to analyze in relation to the hot and cold spots found throughout the state: topology, surrounding land cover, proximity to remnant prairies, proximity to wetlands, and traffic volume.

Topology

Slope was used to measure topology. It was derived from the Wisconsin DNR DEM at a 10 meter resolution. A few thoughts went into looking at slope as a covariant. First, it was theorized that wildlife might be more likely to run across a road if the slope surrounding the road was flat. For example, if a roadway has equally flat fields on either side of it, a raccoon might simply continue in a straight line across it, rather than find a way around it. Second, it was theorized that in areas where the road is surrounded by cliffs or steep slopes, wildlife might use the road to travel along as a least-cost-path alternative to traversing slopes.

A zonal statistics analysis was used that found the mean slope for a 0.5 kilometer buffer around each hotspot is 13.821. Using the same analysis, the mean for cold spots is 11.476. These means are not significantly different. Please see Chapter 5: Further Research.

Surrounding Landcover Type

Wiscland 2, land cover raster file, was used to look at land cover surrounding hot and cold spots to see if there was any correlation there. It was suggested that forest and agricultural lands might be large drivers in wildlife movement. Not enough was done on these two land cover types, please see Chapter 5: Further Research.

There is not an apparent correlation with hotspots and forest or agricultural land, which shot down two prevailing theories: that wildlife were hit while crossing the road from one area of forest or one agricultural field to another. A statistical analysis was run on the land cover types that do coincide with hot and cold spots, which is laid out in Table 4 and Table 5. Cold spots and hot spots occur in nearly identical numbers within each of the land cover types.

Table 4: Hot Spot Land Cover Statistics

Land Code	Grid Code	Frequency	Percent
Urban/Developed	1000	1374	40.89286
Agriculture	2000	579	17.23214
Grassland	3000	759	22.58929
Forest	4000	320	9.52381
Water	5000	2	0.059524
Wetland	6000	321	9.553571

Barren	7000	2	0.059524
Shrubland	8000	3	0.089286

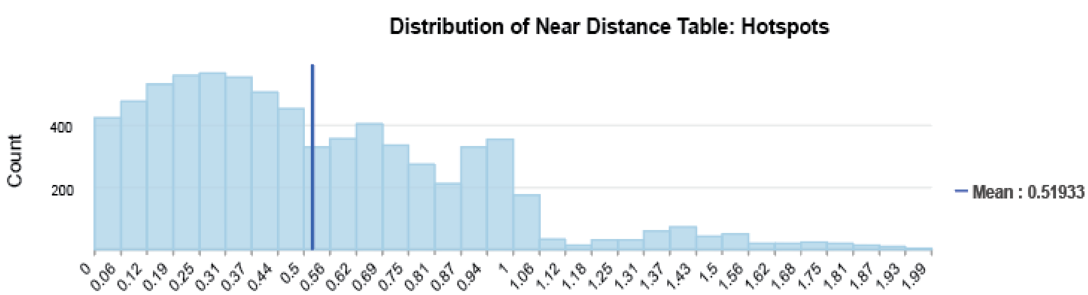
Table 5: Cold Spot Land Cover Statistics

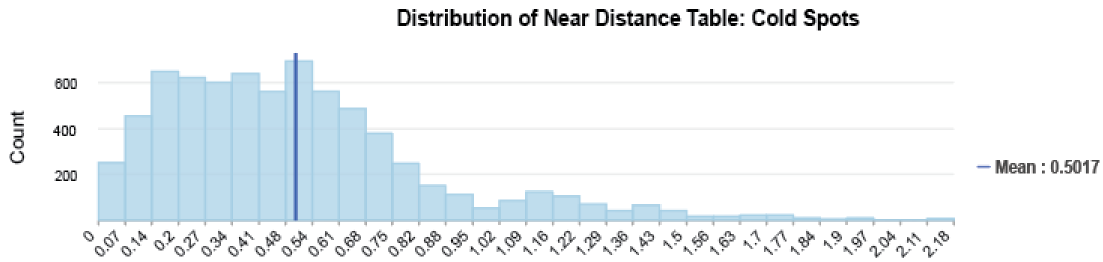
Land Code	Grid Code	Frequency	Percent
Urban/Developed	1000	1379	38.23122
Agriculture	2000	670	18.57499
Grassland	3000	745	20.65428
Forest	4000	396	10.97865
Water	5000	11	0.304963
Wetland	6000	405	11.22817
Barren	7000	1	0.027724

Remnant Prairies and Woody Vegetation

As a part of the land cover analysis, shapefiles from WisDOT containing mowing information on woody vegetation and remnant prairies were looked at extremely briefly to see if there was any kind of correlation. Figure 15 shows the histograms for a Generate Near Table analysis. Both hotspots and cold spots around the state are an average of 0.5 kilometers from a remnant prairie. There are actually more cold spots near remnant prairies. Please see Chapter 5: Further Research for more information on woody vegetation.

Figure 13: Remnant Prairie Analysis



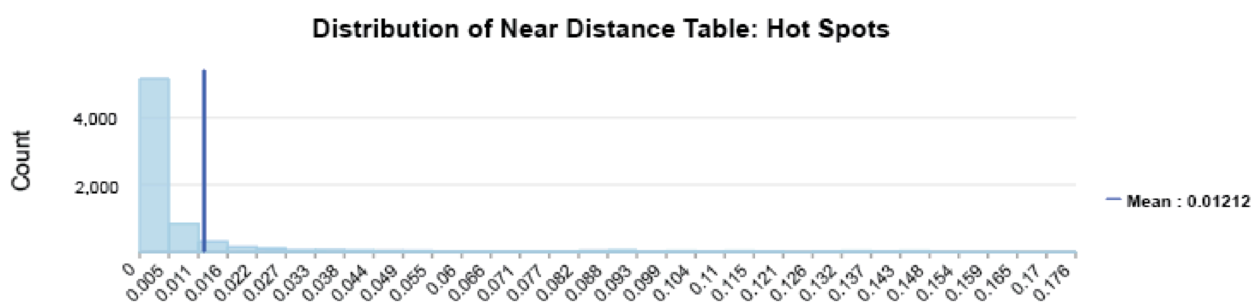


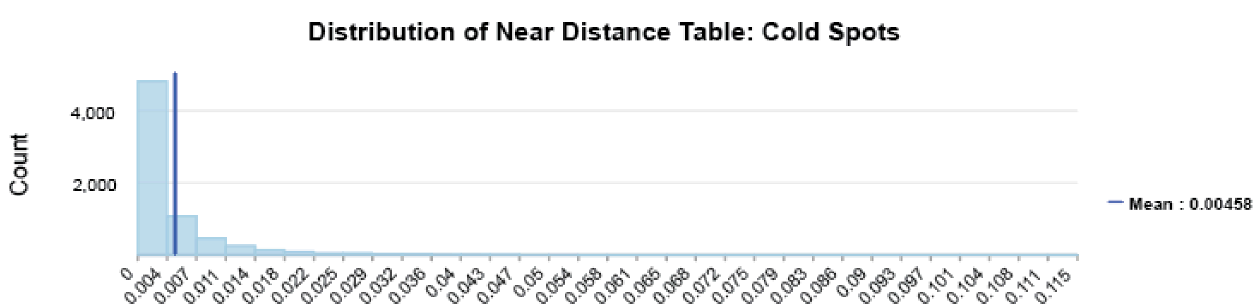
Proximity to Wetlands

There were two theories for looking at wetland proximity to hot and cold spots. First, it was theorized that wetlands represent a high-cost-route, and so walking along a roadway might be preferable to wildlife than walking in a wetland. In this case, there should be a positive correlation between wetland proximity and hotspots.

The second theory was that wildlife that don't make their homes in wetlands might avoid wetlands. This leads to the conclusion that they would not be crossing roads to get from one area of wetland to another. They theoretically would avoid them altogether, meaning there should be a positive correlation between wetland proximity and cold spots.

Figure 14: Wetland Proximity Analysis

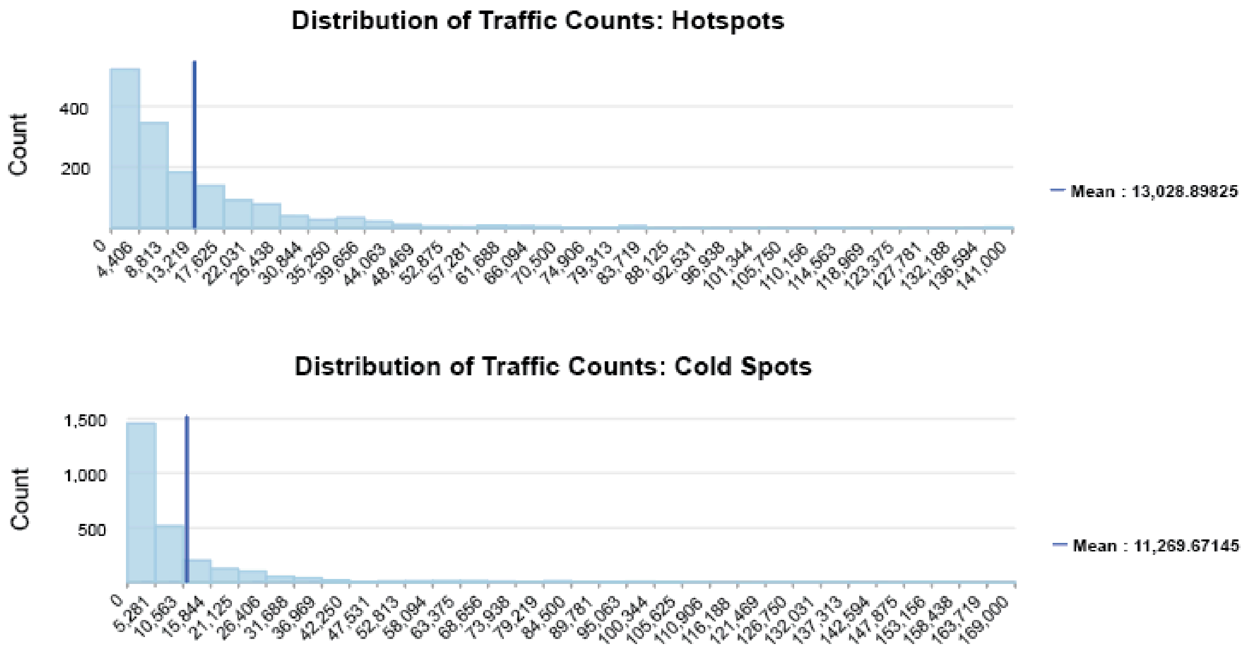




While cold spots are on average closer to wetlands than hotspots, there is no significant difference between the two distributions to suggest they may correlate.

Traffic Volume
The previous variables relied completely on wildlife behavior. Traffic volume relies completely on human/vehicle behavior. For this analysis, traffic counts from WisDOT were used and spatially joined with roadways to analyze whether or not there was a correlation between hot and cold spots and traffic volume. Roadway segments were then selected within 10 meters of hotspots and within 10 meters of cold spots. Figure 17 shows the histograms.

Figure 15: Traffic Volume Analysis



Please see Chapter 5: Further Research.

Chapter 5: Further Research

The goal of this project was to complete the hotspot analysis, analyze the possible causes, and propose mitigation strategies for implementation. This goal was not fully achieved, so instead of this chapter being about mitigation strategies for the areas with increased wildlife-vehicle collisions around the state, this chapter will outline some ideas for further research into the subject.

Hourly Analysis

This project did not have a chance to analyze collisions broken down by hour for a hotspot analysis. While it is theorized that there is a correlation between rush hour times and collisions or dawn and dusk times and collisions, this could be further tested by breaking out collisions by date and then by hour and correlating them with the sunrise and sunset times.

Monthly Analysis

The monthly analysis could have been further expanded on, as well. This project looked at hotspots by road designation type, then further broken down by month. A covariate analysis should be run on each month to look for a few obvious things. First, it should be looked at whether or not collisions occur near farmland at key agricultural moments throughout the year. Second, deer movement patterns throughout the state should be looked at to see if they coincide with any hotspots.

Finally, it was proposed that wildlife collisions might increase during the heavy tourist months in Wisconsin. According to the monthly breakdown, there actually seems to be a dip in the summer months. However, it would be interesting to look at popular tourist areas in Wisconsin and see whether or not they coincide with hotspots in heavy tourist months.

Slope Analysis

While zonal statistics did not return evidence that slope is a contributing factor to hot or cold spots, further in-depth research should be done. The means were calculated for all hot and cold spot buffer areas. More individual data should be looked at to more closely compare certain hotspots with their nearest cold spots. It's also possible slope plays a role in multivariable interactions.

Land Cover Analysis

As referenced in Chapter 4: Covariant Analysis, WisDOT has a shapefile that records mowing schedules and frequency for woody vegetation types along highways. This file contains four separate woody vegetation types but no key to identify what each number refers to, so no analysis was done on it for this project. Further analysis should be done on roadside vegetation and whether or not certain plant species correlate with either hot or cold spots for wildlife-vehicle collisions. Even further analysis could look at roadside Endangered Species Act (ESA) plant buffers along roadways and wildlife habitats that are possibly split by roadways.

Traffic Volume
In Chapter 4: Covariant Analysis, basic traffic count data from WisDOT was analyzed to determine whether or not there was a correlation with hot and cold spots. Further research could be done on many other aspects of this that were beyond the timeframe of this project. First, traffic volume is looked at in this project as a count. Analysis of traffic counts should be done to identify areas where traffic count might be higher than the surrounding area, and comparison can be made to the hotspots in this project.

Second, speed limits and road widths should be analyzed. Both of those variables might give wildlife less time to safely cross a road before a vehicle comes. In addition to that, median widths on the interstates should be looked at to see if they correspond with the string of hotspots along I-90, for essentially the same reason, but adding that wildlife might go to medians as part of their habitat cycles.

Third, road density was not analyzed. Perhaps the large hot spot area on the eastern side of the state correlates with an increased density of roadways. It might also correlate with a sudden decreased density in roadways, where the city is more dense than the suburbs, and more collisions occur in the suburbs.

Population Centers
Population was not studied at all in this project, and it is perhaps a glaring hole in it. There are multiple hotspot areas that seem to exist in a buffer around cities in the state, however, no city or county population data was analyzed to see if there was any correlation between, for example, census tract population data and hotspots surrounding a city. No analysis was done on the proximity of hot and cold spots to large population centers, and this should certainly be further researched.

Multivariable Analyses
In Chapter 4: Covariant Analysis, each variable was analyzed in isolation. However, each variable does not exist in the world in isolation. Further research should be done on the way these variables interact together and whether or not a combination of these variables correlate with hot or cold spots in this project. It is probable that a combination of proximity to population center, traffic count, and land cover type might be the key to identifying areas that are hot spots instead of cold spots. Roadway density in concert with more varied land cover type might also explain the increase in collisions in the suburbs.

Chapter 6: Literature Review

This project was inspired by a comment made on the number of deer that die each year at an intersection in Rhinelander, where the person said a wildlife crossing should be. That comment inspired a lot of research into wildlife crossing research and implementation and efficacy.

Western United States: Montana

Many states in the western half of the United States boast about wildlife crossings. Washington has a multi-million dollar crossing across I-90 near Snoqualmie Pass, a very popular route for traversing the Cascade Mountains. The Flathead Reservation in Montana has a similar large, grass-covered crossing over US-93. However, those are only the flashy crossings. Researching the Flathead wildlife crossing leads to a project done by the Montana Department of Fish and Wildlife in accord with the Montana Department of Transportation to fix their rating at the number one state in the country for wildlife-vehicle collisions, called the Montana Wildlife and Transportation Partnership, founded in 2018. This partnership led to the creation of many wildlife crossings along US-93; most of them culverts and other crossings under the road, hardly noticeable to the people driving.

Montana Wildlife & Transportation Partnership. (n.d.). Montana Wildlife & Transportation Partnership | Montana Department of Transportation (MDT). Montana Department of Transportation. https://www.mdt.mt.gov/pubinvolve/mwt/

Closer to Home: Wisconsin

Rankings then had to be pulled to find where Wisconsin fell. It's impossible to drive out of the cities in Wisconsin and not see at least one animal killed on the side of the road. According to State Farm insurance, who has a stake in knowing the probability of wildlife-vehicle collisions in every state, WIsconsin ranks as number five out of fifty, meaning it is a pretty large problem in this state.

State Farm. (2023). New State Farm® data reveals the likelihood of hitting an animal while driving in every state.
https://www.statefarm.com/simple-insights/auto-and-vehicles/animal-collision-data

So, is Wisconsin doing anything about this? This is a question that has actually been asked before in an article in the Badger Project from 2022. The answer is no. In the article, a spokesperson for the WIsconsin DNR is quoted as saying wildlife crossings are "not feasible" for Wisconsin, and "wouldn't be effective in 'significantly' reducing deer collisions". WisDOT does install "fencing to try and funnel deer under bridges and away from high-traffic areas" (Johnson, 2022).

Johnson, P. (2022, October 5). Other states have had success with wildlife bridges, so where are Wisconsin's? The Badger Project.
https://thebadgerproject.org/2022/10/05/other-states-have-had-success-with-wildlife-bridges-so-where-are-wisconsins/

Why It Matters
The most effective answer to why wildlife crossings matter is that they can help prevent collisions that are costly for both drivers and insurance companies. According to Environment America, wildlife crossings can also connect wildlife habitat areas previously broken up by roadways.

Environment America. (n.d.). Wildlife crossings connect small, fractured habitats. https://environmentamerica.org/articles/wildlife-crossings-connect-small-fractured-habitats/

Grants
Federal grant programs were started in 2021 for states to put in wildlife crossings through the Federal Highway Administration (FHWA). According to the website, as of 2024, the FHWA "is performing studies and developing several deliverables to advance the state of the practice for wildlife crossings to reduce wildlife vehicle collisions (WVCs) and improve habitat connectivity" (Federal Highway Administration, 2024).

Federal Highway Administration. (2024). Wildlife Crossings Program | FHWA. U.S. Department of Transportation. https://highways.dot.gov/wildlife-crossings-program