

# Unreported Deer Crashes on Iowa Highways

**Final Report**  
**December 2023**



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The preparation of this report was financed in part through funds provided by the Iowa Department of Transportation through its "Second Revised Agreement for the Management of Research Conducted by Iowa State University for the Iowa Department of Transportation" and its amendments.

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### Technical Report Documentation Page

<b>1. Report No.</b> InTrans Project 19-727	<b>2. Government Accession No.</b>	<b>3. Recipient's Catalog No.</b>	
<b>4. Title and Subtitle</b> Unreported Deer Crashes on Iowa Highways		<b>5. Report Date</b> December 2023	
		<b>6. Performing Organization Code</b>	
<b>7. Author(s)</b> John W. Shaw, Inya Nlenanya, and Mallary Allen		<b>8. Performing Organization Report No.</b> InTrans Project 19-727	
<b>9. Performing Organization Name and Address</b> Institute for Transportation Iowa State University 2711 South Loop Drive, Suite 4700 Ames, IA 50010-8664		<b>10. Work Unit No. (TRAIS)</b>	
		<b>11. Contract or Grant No.</b>	
<b>12. Sponsoring Organization Name and Address</b> Iowa Department of Transportation 800 Lincoln Way Ames, IA 50010		<b>13. Type of Report and Period Covered</b> Final Report	
		<b>14. Sponsoring Agency Code</b> TSF-000-0(464)--92-00	
<b>15. Supplementary Notes</b> Visit <a href="https://intrans.iastate.edu">https://intrans.iastate.edu</a> for color pdfs of this and other research reports.			
<b>16. Abstract</b> <p>More than 7,300 crashes involving animals, mainly white-tailed deer, are reported in Iowa each year, accounting for 13.5% of all reported motor vehicle crashes. Previous research indicates that law enforcement reports undercount the actual number of deer crashes, but the extent of this underreporting in Iowa was unknown.</p> <p>To assess the prevalence of unreported deer crashes, this project conducted public surveys of two samples, one recruited through a market research firm and the other recruited through the Iowa Department of Transportation's (DOT's) social media presence. The results indicate that about 40% of deer crashes are not reported to law enforcement and, contrary to the requirements of state law, the severity of the property damage sustained in a crash only weakly affects whether it is reported. The results also suggest that carcass counts substantially undercount deer crashes, with respondents indicating that about 40% of deer run away after the crash, while 20% end up on the road shoulder, and another 17% end up in the ditch, weeds, woods, etc. Respondents also indicated that around 60% of the deer-vehicle crashes in which they were involved occurred on paved two-lane rural highways or unpaved rural roads, about 20% occurred on freeways, and around 20% occurred on urban, suburban, or small-town streets.</p> <p>Mapping of Iowa vehicle-animal crashes that were reported to law enforcement in 2010–2020 indicates that although crashes occur throughout the state, they are most prevalent in southeast and northeast Iowa, on routes that parallel rivers and other waterways, near river crossings, and in the southwestern suburbs of the Des Moines metropolitan area. Animal crashes are less prevalent in northwest and north-central Iowa, except near river crossings. Combinations of high traffic volume and high-quality deer habitat appear to increase the likelihood of motor vehicle crashes involving animals. Fatal vehicle-animal collisions in Iowa often involve motorcycles or loss of control.</p> <p>In addition, this project considered likely deer-vehicle seasons and times of day, reviewed previous research on the potential effectiveness of various countermeasures, assessed methods for automating the collection of deer crash location information, and estimated a recommended value for the comprehensive costs of a typical deer crash.</p>			
<b>17. Key Words</b> deer-vehicle crashes—habitat and crashes—highway safety—road safety—unreported motor vehicle crashes—underreporting—ungulates		<b>18. Distribution Statement</b> No restrictions.	
<b>19. Security Classification (of this report)</b> Unclassified.	<b>20. Security Classification (of this page)</b> Unclassified.	<b>21. No. of Pages</b> 100	<b>22. Price</b> NA





# UNREPORTED DEER CRASHES ON IOWA HIGHWAYS

**Final Report  
December 2023**

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Sponsored by

Iowa Department of Transportation

Preparation of this report was financed in part  
through funds provided by the Iowa Department of Transportation  
through its Research Management Agreement with the  
Institute for Transportation  
(InTrans Project 19-727)

A report from

**Institute for Transportation**

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## **ACKNOWLEDGMENTS**

The authors would like to thank the Iowa Department of Transportation (DOT) for sponsoring this research and the people listed below for participating in the project's Technical Advisory Committee (TAC):

- Shawn Blaesing, Iowa DOT
- Steve Gent, Iowa DOT
- Tyler Harms, Iowa Department of Natural Resources (DNR)
- Angela Poole, Iowa DOT
- Chris Poole, Iowa DOT
- Mary Kay Solberg, Iowa DOT
- Willy Sorenson, Iowa DOT





## EXECUTIVE SUMMARY

More than 7,300 crashes involving animals are reported in Iowa each year, accounting for 13.5% of all reported motor vehicle crashes (Iowa DOT 2023). These crashes occur on roadways of every classification and in all 99 counties of the state. Although it is likely that some of the reported animal crashes involve small mammals, large birds, or domesticated animals such as dogs or cattle, the majority result from collisions with white-tailed deer (*odocoileus virginianus*).

About 96% of Iowa deer crashes are property-damage-only. From 2013 through 2022, an average of 3.2 animal-involved fatal crashes occurred in Iowa each year. Most of these fatalities involved a motorcyclist or all-terrain vehicle (ATV) rider striking the animal, or a motorist who lost control after swerving to avoid the animal.

### Unreported Deer Crashes

Previous research leaves little doubt that law enforcement reports undercount the actual number of deer crashes, both in Iowa and nationally. To assess the prevalence of unreported deer crashes, this project conducted public surveys of two samples, one recruited through Dynata (a major market research firm) and the other recruited through the Iowa Department of Transportation's (DOT's) social media presence.

Social media respondents were much more likely to indicate involvement in an unreported crash than those recruited from the Dynata panel. Although some of this appears to be related to more rural driving among the respondents recruited through social media (indicated by substantially greater involvement in crashes on two-lane rural highways), the social media channel appeared to produce a very high degree of self-selection bias: individuals recruited through social media were evidently more likely to participate in the survey if they had been involved in a deer crash than if they had not. Therefore, the Dynata results indicating that about **40%** of deer crashes are not reported to law enforcement appear to provide the more reliable figure.

Surprisingly, the crash reporting rates do not appear to differ much based on the severity of the damage sustained by the crash-involved vehicles. Iowa's \$1,500 threshold for reporting property-damage-only crashes appears to have almost no influence on whether the driver reports the crash to law enforcement.

The results of both surveys suggest that carcass counts very substantially undercount deer crashes. According to the survey participants, about 40% of deer are still alive after the crash and run away. Presumably, the vast majority of these injured deer ultimately die away from the roadside or are taken down by predators. Around 20% of the deer end up on the road shoulder, while another 17% end up in the ditch, weeds, woods, etc.

According to the survey participants, around 60% of the crashes occur on paved two-lane rural highways or unpaved rural roads, about 20% occur on freeways, and around 20% occur on urban, suburban, or small-town streets.

## Crash Locations and Countermeasures

The Iowa DOT is fighting an uphill battle against vehicle-deer crashes, likely driven by growth in the deer population and changes in land use that increase vehicle-deer conflicts. The timing of the annual corn and soy harvests coincides with the start of deer mating season, resulting in abrupt migration of the deer population. Moreover, this disruption coincides with the annual switch to standard time, which shifts the evening commute to sunset—precisely the time of day when deer are most active.

Numerous physical deer crash countermeasures have been explored in the research literature, but only a few appear to be effective:

- Previous research indicates that the most comprehensive way to reduce vehicle-deer crashes would be to remain on daylight savings time for the entire year (Cunningham et al. 2022). This would separate the daily peak of deer activity from the daily peak of motorized traffic. For Iowa, it is mathematically equivalent to switching to Eastern Standard Time year-round.
- Another very cost-effective method for preventing vehicle-deer crashes is to display deer warning messages very selectively on existing dynamic message signs (DMS) (Donaldson and Kweon 2019). These messages can be narrowly targeted to locations and times when deer are likely to be near the roadway, such as forested/riverside areas around dusk and dawn from late October through early December. This selective messaging can be far more salient to motorists than static signs, which are often seen at times when deer are unlikely to be present.
- Combinations of fencing and underpasses or overpasses appear to be the most effective physical deer crash prevention approach. Although costly to retrofit to existing sites, these countermeasures can potentially be implemented incidental to new roadway construction and when bridges over waterways are reconstructed.

Habitat fragmentation potentially contributes to the deer crash problem in Iowa. Numerous roadways include bridges over waterways that are buffered by narrow strips of woods, which in turn adjoin agricultural fields. This puts the three key elements of deer habitat (food, water, and cover) into close proximity. If one element is separated from the others by a roadway, frequent deer crossings can be expected. In very site-specific cases, defragmenting the habitat—for example, by adding a small culvert to bring water to the opposite side of a highway—can potentially reduce the need for deer to cross.

In spite of their widespread use, very little research has been conducted on the effectiveness of DEER CROSSING traffic signs, designated as sign W11-3 in the 2009 *Manual on Uniform Traffic Control Devices* (MUTCD). The few studies that have been completed have all been small-scale efforts that lack the statistical power to demonstrate conclusively whether such signs have an effect on crashes.

## **Deer Crash Detection**

Video surveys from drones or maintenance vehicles appear to be the only feasible means of automating the collection of deer crash location information. Wildlife biologists are currently exploring the potential to automate the process of extracting carcass locations from video data using machine learning techniques. Since many carcasses are promptly scavenged by predators, the reliability of the resulting data will be highly dependent on the frequency of the video data collection. The reliability of the carcass counts is doubtful, given that the survey respondents indicate that about 40% of injured deer remain alive long enough to take cover away from the roadway right-of-way.

## **Deer Crash Costs**

The National Safety Council, Centers for Disease Control and Prevention, and U.S. Department of Transportation all publish recommended values for motor vehicle crash valuation. These recommendations are stratified based on crash severity and endeavor to capture the costs incurred by all payers, including public agencies, health insurers and government healthcare programs, employers, families, and individuals. The direct costs of response and carcass removal are small in relation to those associated with morbidity and mortality, loss of wages and productivity, vehicle repairs, and claims administration.



## INTRODUCTION

More than 7,300 crashes involving animals are reported in Iowa each year, accounting for 13.5% of all reported motor vehicle crashes (Iowa DOT 2023). These crashes occur on roadways of every classification and in all 99 counties of the state. Although it is likely that some of the reported animal crashes involve small mammals, large birds, or domesticated animals such as dogs or cattle, the majority result from collisions with white-tailed deer (*odocoileus virginianus*, Figure 1).



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**Figure 1. White-tailed deer crossing a highway in Michigan**

Previous research leaves little doubt that law enforcement reports undercount the actual number of deer crashes, both in Iowa and nationally. For example, several studies find wide discrepancies between reported crash counts and the number of deer carcasses removed from roadsides by highway maintenance crews (Gkritza et al. 2010, Knapp et al. 2005). Moreover, carcass counts are themselves an undercount of vehicle-deer crashes: when struck by a vehicle, some deer sustain injuries that are not immediately fatal, and these animals tend to move away from the road in search of cover. Not infrequently, deer that die by the roadside are consumed by scavengers before they are discovered by maintenance crews, though this varies with maintenance patrol frequency, local scavenger population levels, and weather (Santos et al. 2016, Santos et al. 2011, Jennelle et al. 2009). And some carcasses are simply left to decompose at the roadside, particularly if traffic is light or the carcass is hidden by weeds or brush.

Accurate estimates of the number of vehicle-animal crashes are desirable for making countermeasure investment decisions. Adjustment factors (correlation factors) can potentially be

applied to law enforcement data or carcass counts to help account for underreporting. For example, Lee et al. (2021) studied a 45 km (28 mile) stretch of Highway 3 in the Canadian Rockies near Crownset Pass, Alberta. They compiled carcass counts from maintenance records and compared them with the results of a meticulous field survey obtained by walking the right-of-way. The resulting correlation factors ranged from 2.1 to 3.5, implying that less than half of all carcasses were known to maintenance crews. The authors surmised that even after applying these adjustments, the results were still an undercount due to carcass removal by large predators such as cougars, coyote, wolves, black bears, and grizzly bears.

Countermeasure investment analyses typically apply different economic valuations for each level of crash severity. At the outset of the study, little was known about the economic value of the unreported crashes. For example, heavy trucks equipped with “bull bars” (grille guards) can potentially strike a deer with little damage to the vehicle. These devices have been prohibited in several countries due to their impacts on pedestrian safety but remain in widespread use in Iowa.

## **Research Objectives**

To learn more about the nature of Iowa deer crashes and the extent of underreporting, four research objectives were identified in collaboration with the research sponsor and technical advisory committee (TAC):

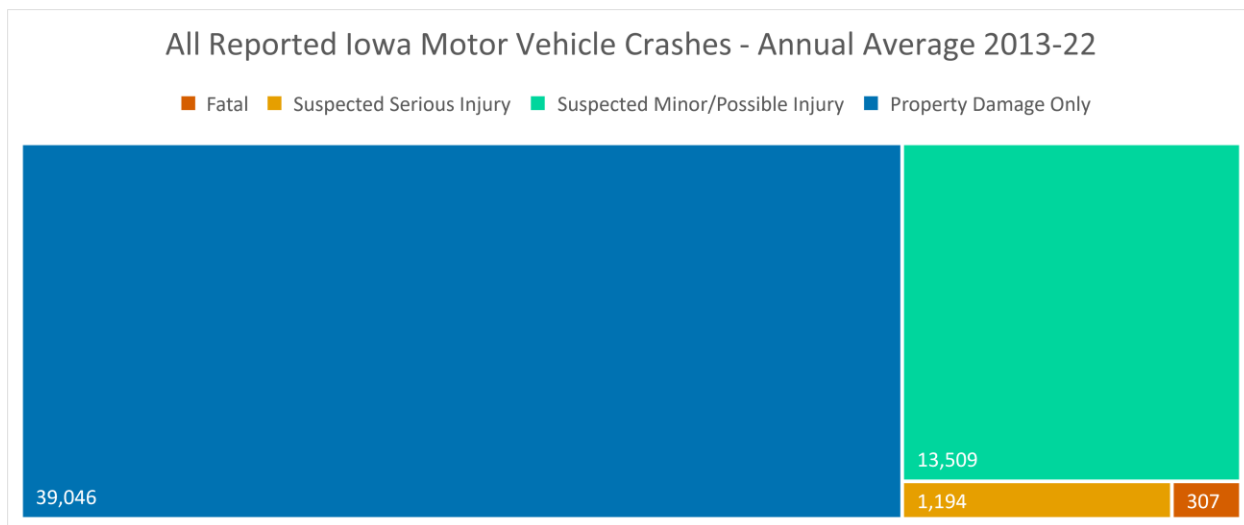
- Develop a general overview of the spatial patterns of Iowa deer crashes using existing data sources
- Explore the prevalence of unreported deer crashes through a survey of people who drive in Iowa
- Develop an estimate of the costs public agencies incur as a result of deer crashes and a recommended value for the comprehensive costs of an average deer crash
- Develop a field data collection methodology that could be applied in the future to document reported and unreported deer crashes

## **Reported Iowa Animal Crashes**

Section 321.266 of the Iowa Code requires motor vehicle crashes to be reported when a human is killed or injured or when there is property damage exceeding \$1,500. The Iowa Crash Analysis Tool (ICAT, Iowa DOT 2023) provides access to many of the details contained in these reports.

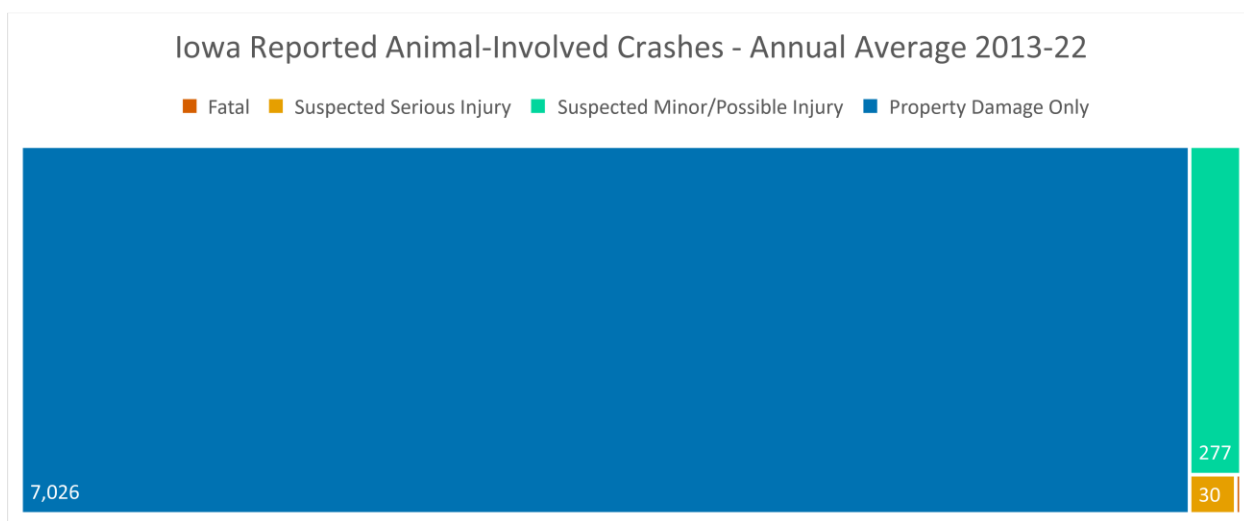
As shown in Figure 2 and Figure 3, over the period from 2013 through 2022 an average of 54,055 motor vehicle crashes were reported each year, of which 7,337 (14%) reportedly involved an animal. The severity of the animal crashes tended to be low, accounting for 1% of fatal crashes, 3% of crashes involving a suspected serious injury, and 2% of crashes involving a suspected minor or possible injury. Overall, 4.2% of the reported vehicle-animal crashes resulted in a human casualty, while 95.8% were reported as property-damage-only.





ICAT

**Figure 2. Annual average number and severity of all reported Iowa motor vehicle crashes, 2013–2022**



ICAT

**Figure 3. Annual average number and severity of reported Iowa animal-involved crashes, 2013–2022**

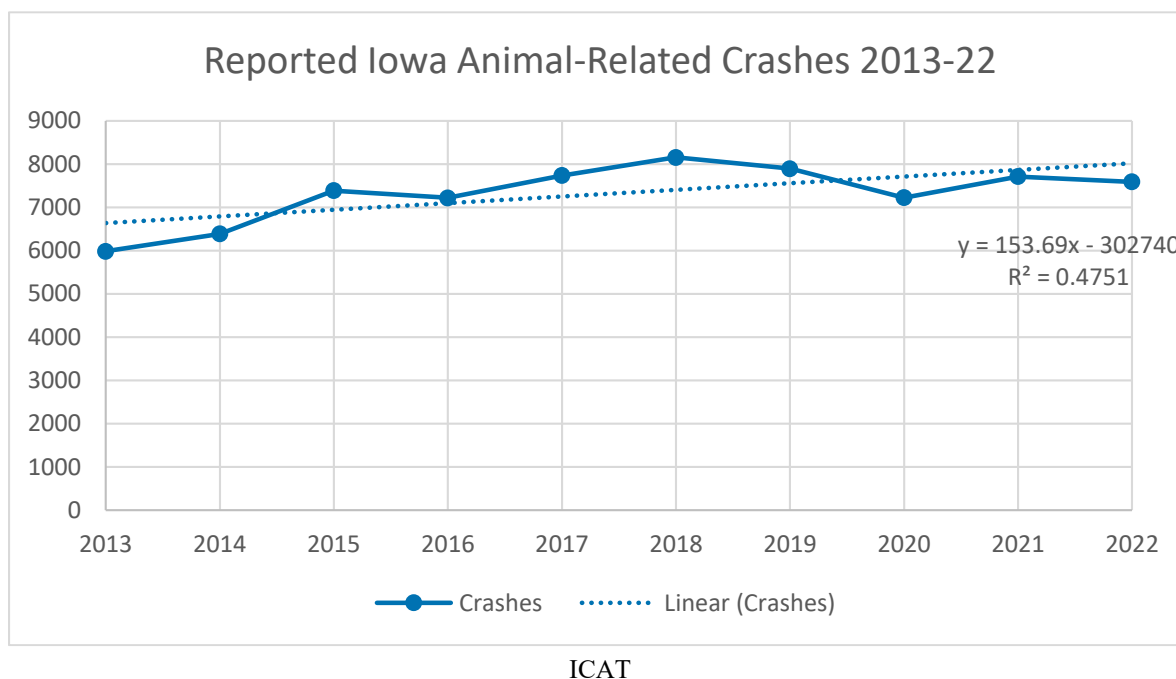
### *Human Fatalities*

From 2013 through 2022 a total of 34 animal-involved crashes fatal to a human were reported in Iowa, an average of 3.4 per year. Two-thirds of the fatalities (23 cases) involved a motorcycle, and one case involved an all-terrain vehicle (ATV). Among the remaining 10 cases, 5 reportedly involved a motor vehicle that swerved or lost control, perhaps while attempting to avoid striking the animal.

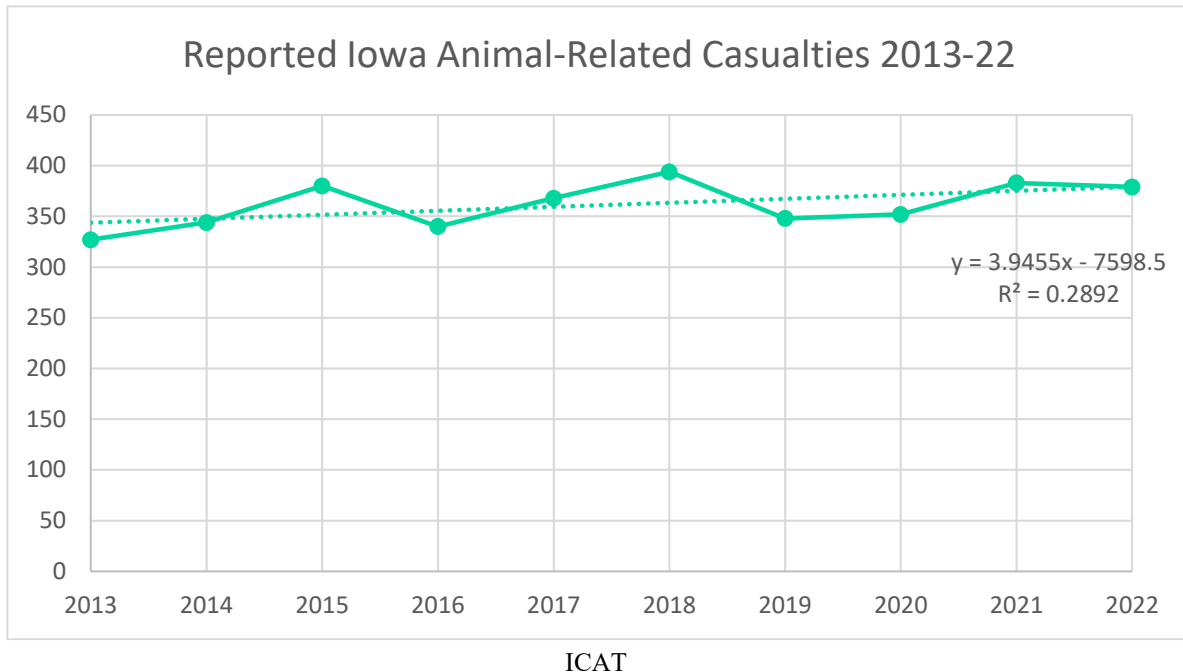
The fatalities occurred mainly in eastern, southern, and central Iowa. They were widely dispersed geographically, occurring in the following counties: Allamakee, Black Hawk, Bremer, Cherokee, Chickasaw, Clayton, Clinton (2), Dallas (2), Davis, Decatur, Delaware, Des Moines, Dubuque, Fremont, Greene, Jackson, Johnson, Jones, Hardin, Keokuk, Lee, Louisa, Mahaska, Muscatine, Polk, Ringgold, Scott, Tama (2), Washington, Wayne, and Webster.

### *Trends*

As shown in Figure 4, the number of animal-involved crashes reported by Iowa law enforcement agencies has been increasing over time. According to the law enforcement reports, from 2013 through 2022 animal-related collisions resulted in an average of 362 human casualties each year, with the numbers slowly increasing over time (Figure 5). These included 3.4 fatalities, 33.7 suspected serious or incapacitating injuries, 144.9 suspected minor or non-incapacitating injuries, 170.0 possible injuries (complaint of pain or injury), and 9.5 injuries of unknown severity. It is likely that these numbers underrepresent the actual number of nonfatal injuries due to medical problems that were not evident to the responding law enforcement officers, not disclosed by people involved in the crash, or not recognized until hours or days after the crash.



**Figure 4. Annual variation in number of reported Iowa animal-related crashes, 2013–2022**

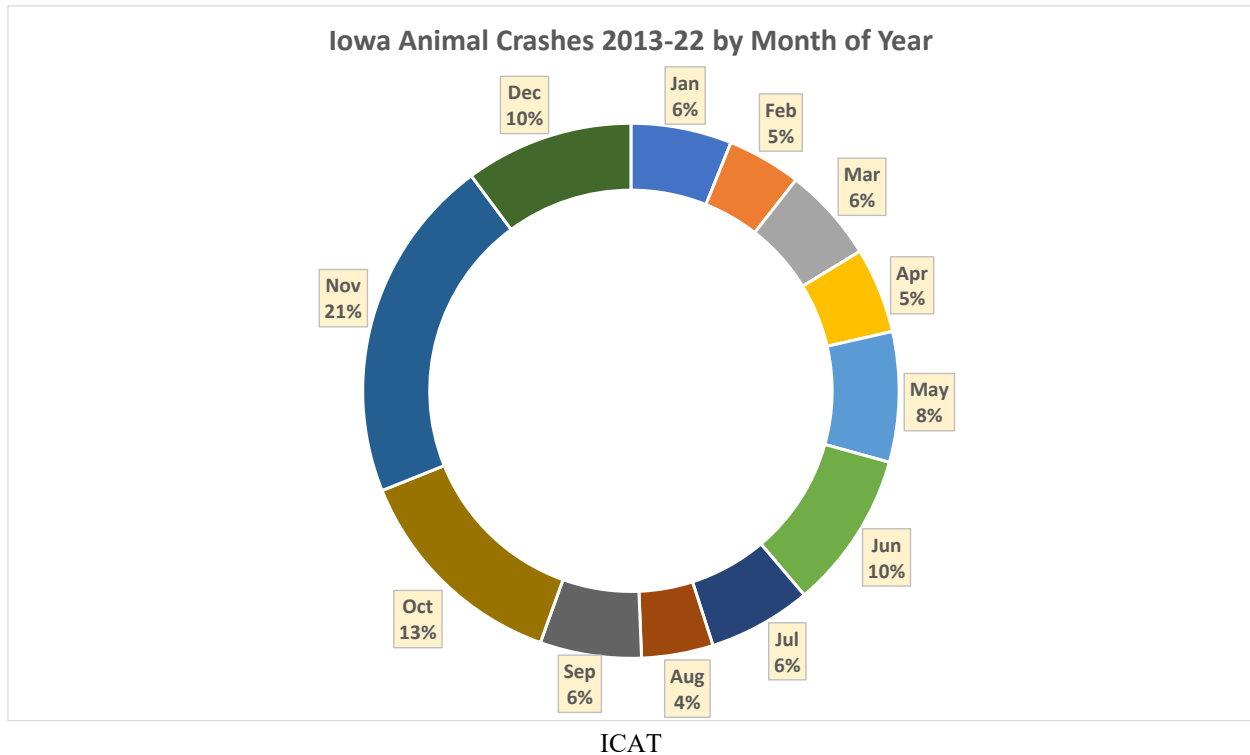


**Figure 5. Annual variation in number of casualties attributed to animal-related crashes reported by Iowa law enforcement agencies, 2013–2022**

Although there are gradual upward trends in the animal crash counts and casualty counts, there are also considerable year-to-year fluctuations. Over the period from 2013 through 2022, the number of fatalities attributed to animal-involved collisions ranged from 0 to 5 per year, while the total number of casualties ranged from 327 to 394 according to the law enforcement data. Random variations and factors such as weather and herd size probably contribute to these fluctuations.

### Seasonal Variation in Animal Crashes

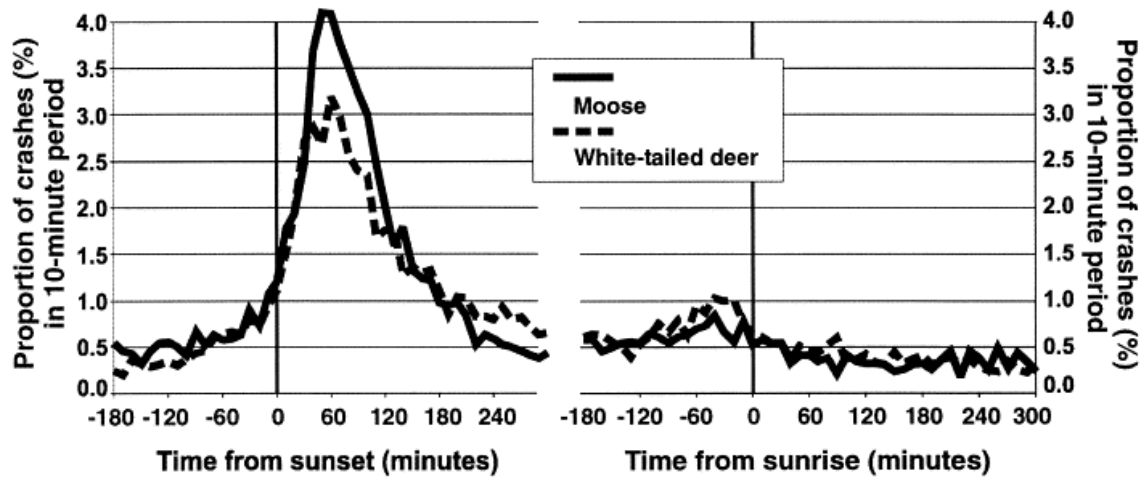
As shown in Figure 6, reported Iowa animal crashes show a strong seasonal pattern. About 44% of the annual totals occur in the months of October, November, and December, the deer mating season. More than a fifth of annual crashes occur in the month of November. A secondary peak occurs in the late spring.



**Figure 6. Seasonal pattern of Iowa animal crashes, 2013–2022**

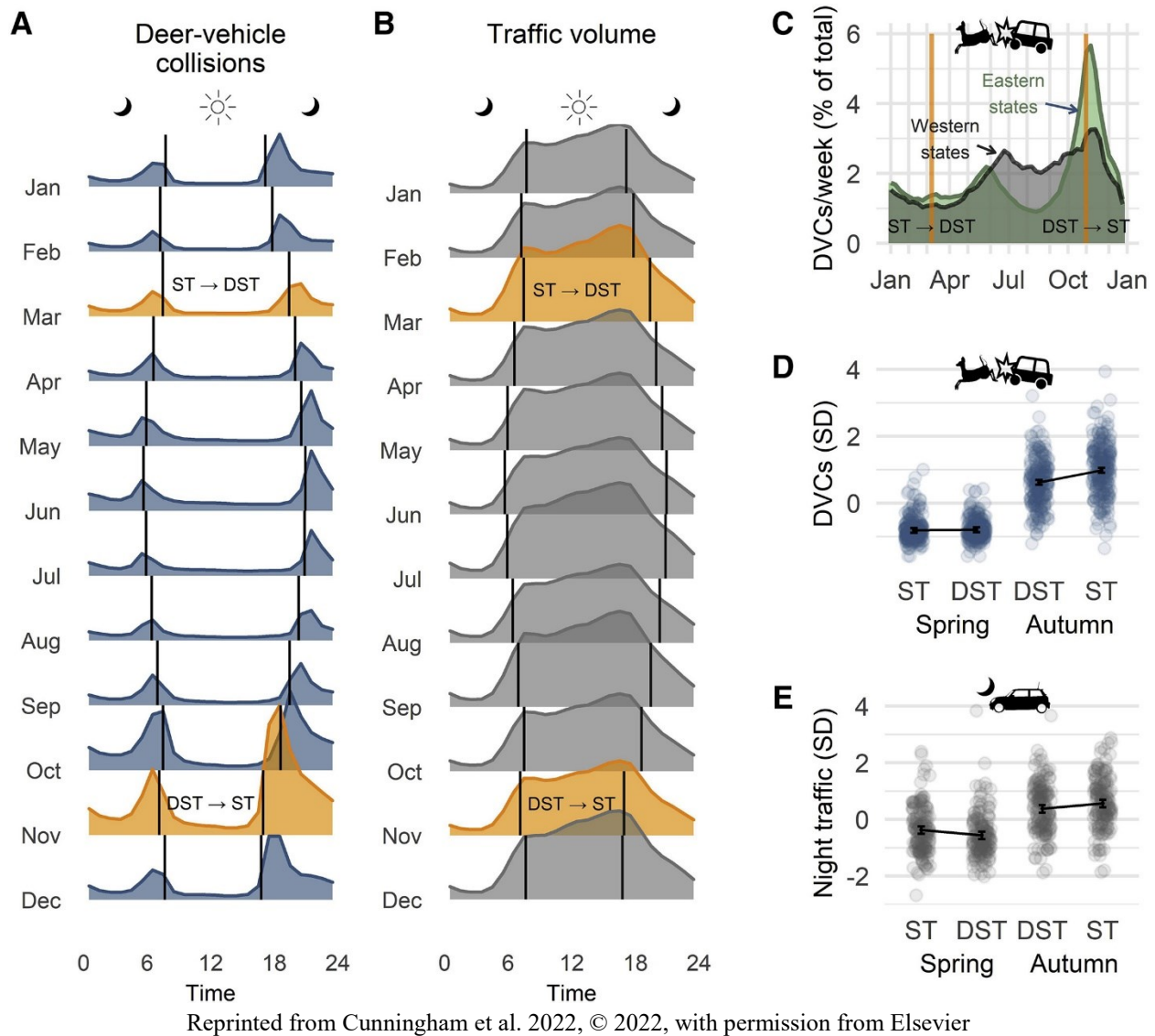
### **Diurnal Patterns of Deer Crashes**

Distinctive time-of-day patterns are evident in deer crash data. As shown in Figure 7, previous research has identified a sharp peak in crashes involving white-tailed deer in the two hours after sunset and a secondary peak in the hour before sunrise (Haikonen and Summala 2001, Cunningham et al. 2022). This is particularly troublesome in November, when the peak of the deer mating season coincides with the annual switch to standard time, resulting in sunset in central Iowa at approximately 5:00 PM, the peak of the evening commute (Figure 8). Cunningham et al. (2022) estimate that national implementation of year-round daylight savings time would avoid \$1.2 billion of deer crash costs each year, prevent 33 human deaths and 2,054 human injuries, and prevent the deaths of nearly 37,000 deer.



Reprinted from Haikonen and Summala 2001, © 2001, with permission from Elsevier

**Figure 7. Temporal distributions of moose and white-tailed deer crashes**



**Figure 8. Close correlation between peak commuting hours and peak deer activity in November and December, resulting in thousands of deer crashes that could be prevented by delaying the switch from daylight savings time (DST) to standard time (ST)**

### Fate of Deer Carcasses

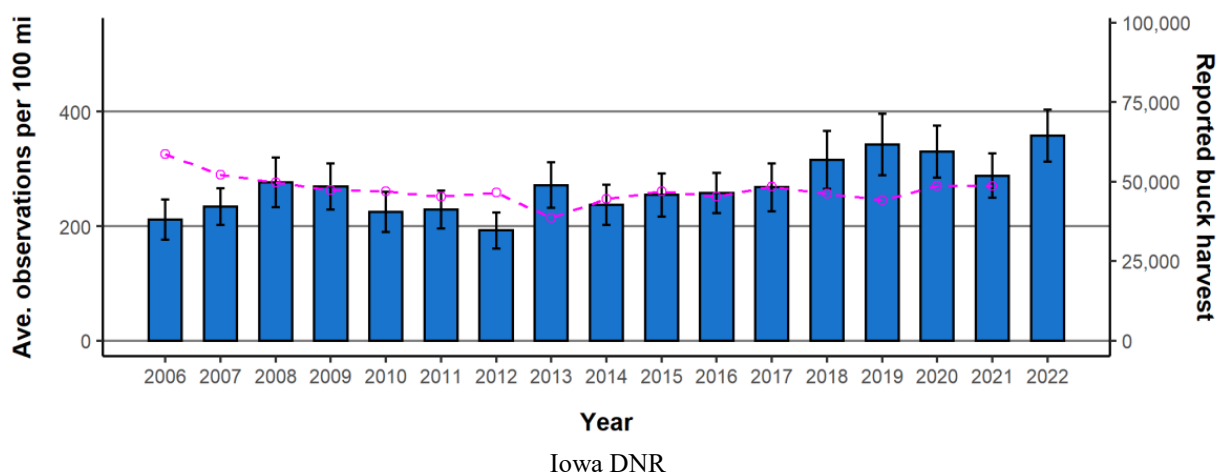
When a deer is struck by a motor vehicle, various things can happen to the carcass. Some carcasses are removed for disposal, and a few are harvested by drivers. Others may be left in ditches or dragged to tall roadside grass. These informal methods of disposal potentially contribute to the spread of chronic wasting disease (Jennelle et al. 2009), which is known to be present in 12 counties in Iowa as of 2022 (Iowa DNR 2022a).

Abandoned carcasses are usually targeted by scavenger animals (Jennelle et al. 2009). A study conducted in southwest Wisconsin identified 14 Midwestern species of mammals that scavenge

deer carcasses, such as raccoons, opossum, foxes, otters, skunks, and coyote, along with domesticated dogs and cats. The study also identified 14 species of avian scavengers, notably crows, turkey vultures, and red-tailed hawks. Consumption and decomposition of the flesh from the carcass takes 3 to 15 weeks depending on ambient temperatures.

## Deer Population and Hunting

The effects of winter weather and disease can result in substantial year-to-year fluctuations in wildlife populations. To assess these changes, each spring the Iowa Department of Natural Resources (DNR) conducts wildlife counts by traveling thousands of miles of unpaved east-west roads at approximately 18 latitudes of the state. The results are reported in terms of animal observations per 100 miles traveled. Results from the 2022 Iowa Spring Spotlight Survey indicate that while the deer population dipped in 2021, it rebounded in 2022 (Figure 9).



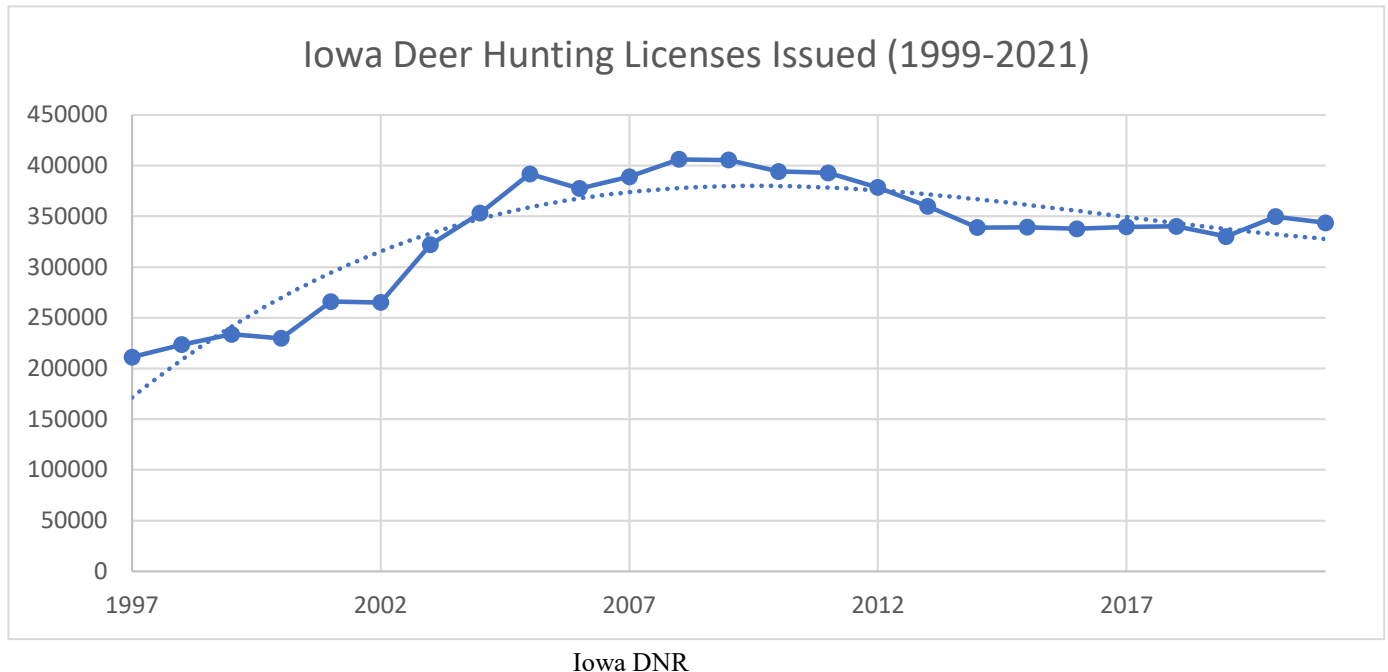
**Figure 9. Average number of deer observations per 100 miles of road traveled (blue bars) and Iowa-reported buck harvest (dashed pink line) from the 2022 Iowa Spring Spotlight Survey**

A long-term upward trend in the deer population is evident in the field survey results. This could be one factor in the increasing numbers of deer crashes reported by law enforcement. In addition, several areas of the state are experiencing suburbanization, which fragments deer habitat and increases road mileage with potential for deer-vehicle contact.

As illustrated in Figure 10, the 2022 Iowa Spring Spotlight Survey's highest deer population densities were observed in northeast Iowa (particularly Clayton and Allamakee Counties, which are heavily forested), the counties just north of the Missouri state line, Jackson and Des Moines Counties along the Mississippi River, and the counties immediately west and south of the Des Moines metropolitan area. In general, deer population densities were lowest in northwest Iowa and the counties along the Missouri River.







**Figure 11. Number of Iowa paid hunting license holders, 1999–2021**

## Deer Crash Countermeasures

There is an extensive body of research related to the prevention of vehicle-wildlife crashes, which can be motivated by the desire to avoid human casualties, reduce property damage, or protect rare species. Crashes involving large animals such as moose, elk, caribou, bears, and bison are of particular importance in areas where these animals are prevalent.

As a subset of this broader literature, numerous vehicle-deer crash countermeasures have been proposed. Separate literature reviews by Hedlund et al. (2004) and Knapp et al. (2004) considered the then-available evidence for the effectiveness of these countermeasures. Both authors reached similar conclusions. Hedlund et al. (2004) provided the following summary:

*The only widely accepted method with solid evidence of effectiveness is well-designed and maintained fencing, combined with underpasses or overpasses [see Figure 12] as appropriate. Herd reduction is controversial but can be effective. Deer whistles appear useless. Roadside reflectors appear to have little long-term effect, although additional well-designed evaluations are needed before firm conclusions can be drawn. Both temporary passive signs and active signs appear promising in specific situations, but considerable research is required to evaluate long-term driver response and to improve and test deer detection technology for active signs. Other methods using advanced technology require substantial additional research and evaluation.*



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**Figure 12. Wildlife overpasses (left) and underpasses (right) are a proven countermeasure for deer crashes**

### *Deer Warning Signs*

Only four studies exploring the crash reduction effectiveness of conventional or slightly modified deer warning signs were found. All studies were small-scale deployments that added signs at 1 to 35 sites. Three studies on rural highways were consistent in showing slight reductions in vehicle-deer crashes when signs were added, but due to the small number and high year-to-year variability of crashes at these sites, none of the reductions were statistically significant. The fourth study, conducted in an urban area, showed stronger benefits. Results from the studies can be summarized as follows:

- Pojar et al. (1975) installed a pair of animated deer crossing signs at a single site in Colorado that had a history of frequent deer crashes. Using a sign animation method typical for the era, each sign incorporated four sets of neon tubes outlining the shape of a deer, which flashed in series to suggest the animal bounding across the roadway (Figure 13). The electronics were turned on and off in alternate weeks of 1972 and 1973. Vehicle-deer crashes were recorded by local law enforcement and natural resources officers, traffic speeds were monitored with electromagnetic loops, and the frequency of deer crossings of the highway was estimated based on manual observations from aircraft. Traffic speeds declined by 3 mph when the animated sign was in use. A total of 44 deer were killed in weeks the signs were off, while 40 were killed in weeks the signs were on. After adjusting for variations in the estimated frequency of deer crossing the highway, Pojar et al. (1975) concluded that there was no difference in the number of vehicle-deer collisions when the signs were on.



Pojar et al. 1975

**Figure 13. Animated neon deer crossing sign used experimentally by Pojar et al. (1975)**

- Rogers (2004) conducted a before-after study based on the seasonal (October–December) deployment of standard and nonstandard deer crossing signs in Algoma Township of Kent County in southwest Michigan, a rural area north of Grand Rapids. A total of 70 signs were installed. Although the study does not clearly describe the sign placement strategy, it seems to have consisted of a pair of signs about every mile along 35 miles of rural county highways. The deployment included 52 standard signs and 18 of a novel design with two graphics (car and deer) augmented with a HIGH CRASH AREA plaque.

Crashes reported to law enforcement were compared before and after the deployments, with data from three adjoining townships (where no additional signs were deployed) as controls. In Algoma Township, an average of 69 crashes per year occurred before deployment (1992–1997), while 55 crashes per year were reported after deployment (1998 and 2000). The change was not statistically significant. Crash counts in the three adjoining townships were unchanged (before: 36–62/year/township; after: 41–62/year/township). Data from 1999 were excluded from the study because the number of reported crashes in all four townships abruptly dropped by about 50% for that year only. There was no significant difference in average collision rates within 200 ft of the signs on seven road stretches that had only the novel sign design (before installation: 11/year/stretch; after: 9/year/stretch). Average vehicle speeds were not affected by the signs.

- Meyer (2006) attempted to evaluate the effectiveness of DEER CROSSING signs added at 22 geographically dispersed sites in Kansas. When the data set was limited to the 3 years before and after installation, a statistically significant 39% reduction in crashes was found for the sites where signs were added. Conversely, when the data series was extended to include the full range of available data (5 to 10 years before installation and up to 5 years after installation, depending on the site), the reduction was only 7% and was not statistically significant. Attempts to include additional variables in the analysis showed that the crashes tend to occur near wooded areas, a finding consistent with the known habitat preferences of deer. Meyer (2006) stated that the small size of the data set, lack of control segments, and sensitivity to analytical methods made it difficult to draw any firm conclusions about the signs' effectiveness.

- Found and Boyce (2011) used geolocated carcass data to identify 26 deer crash hotspots within the city limits of Edmonton, Alberta, Canada (which had a population of about 800,000 at the time of the study). Using a case-control study design, the authors randomly selected 13 locations for installation of standard diamond-shaped DEER CROSSING graphic signs augmented with a 1.6 km plaque intended to focus motorists' attention on the one-mile (1.6 km) area downstream of the sign. The other 13 locations remained unsigned. Based on follow-up carcass counts over a seven-month period (June to December 2008), the authors found that fewer crashes occurred at the signed locations compared to the unsigned controls. Specifically, the average annual number of crashes at the treatment sites dropped from 1.69 to 0.42, while the average at the control sites dropped from 1.69 to 1.00, reflecting a citywide decrease in deer crashes. Since a total of only 19 carcasses were observed in the study areas, the statistical power of the study is limited.

Stronger effects have been reported for highly targeted deer warning messages. Two relevant studies were found:

- Sullivan et al. (2004) conducted before-after studies of special deer warning signage deployed along five corridors in Utah, Nevada, and Idaho, all of which were subject to mule deer migration in the spring and autumn. All of the signs were of the folding (hinged) type, allowing them to be opened to display warning messages when deer migration was expected and closed to hide the messages for the remainder of the year (Figure 14).



After Sullivan et al. 2004

**Figure 14. Hinged signs for seasonal mule deer migration corridors**

At the upstream end of each corridor, a rectangular sign with the legend DEER MIGRATION AREA NEXT X MILES was installed. This message was reinforced every mile by standard diamond-shaped DEER CROSSING graphic signs, each augmented with a NEXT X MILES plaque identifying the distance to the end of the migration corridor. During migration periods, each sign was augmented with a flashing amber beacon and two to four orange flags. Specific migration dates were determined for each corridor in consultation with wildlife biologists. In the two-year periods following installation, use of the signage reduced deer crashes by 50% compared to pre-installation levels. The benefit appears to have resulted mainly from a reduction in the number of vehicles that were speeding.

- During the month of October 2015, the Virginia Department of Transportation began posting deer advisory messages on changeable message signs along a 16.7-mile segment of Interstate 64 (Donaldson and Kweon 2019). This was found to reduce vehicle speeds by about 2.8 mph and was accompanied by a statistically significant reduction in the number of carcass removals when the deer advisories were posted.

The international literature on the effectiveness of animal warning signs does not appear to be relevant to Iowa, as the studies relate to species and driving environments that are not found in the state.

Taken as a whole, the results of the six deer warning signage studies suggest that the effects of conventional deer warning signs displayed year-round are too subtle to capture in small-scale studies. This problem frequently occurs in health and safety research and can only be addressed by conducting larger studies with more statistical power. While Rogers (2004) and Found and Boyce (2011) controlled for potential regression-to-mean effects, most other studies did not. As a result, it is possible that some of the effects attributed to signs were actually due to changes in the size or location of the deer herd.

### *Feasible Options*

Taken as a whole, the prior research suggests the most technically feasible approaches for deer crash reduction include the following:

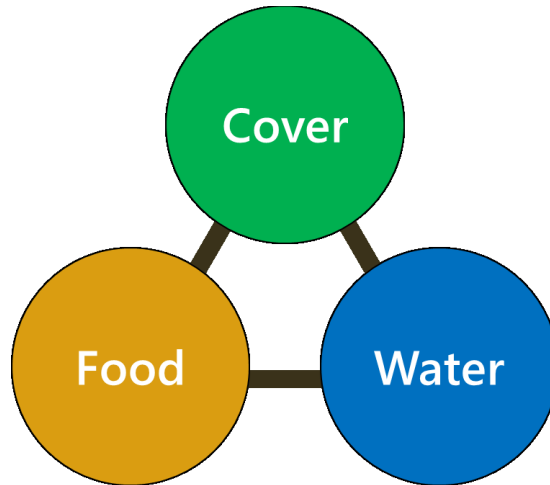
- Combinations of fencing and wildlife underpasses/overpasses, particularly for high-speed limited-access facilities (Figure 12)
- Advisory speed limits or other warnings displayed at the specific times when deer are most likely to be present, such as the dusk and dawn periods in October, November, and early December
- Traffic speed management to reduce the probability and severity of vehicle-animal crashes

In all cases, treatment benefits are likely to be underestimated if vehicle-deer crashes are underreported.



## GEOSPATIAL ANALYSIS OF DEER CRASH PATTERNS

White-tailed deer, also called Virginia deer, are abundant in Iowa and all across North America east of the Rocky Mountains (west of the Rockies mule deer are prevalent). The basic needs of white-tailed deer include (1) food, (2) water, and (3) cover from predators such as coyote and bobcats (Figure 15).



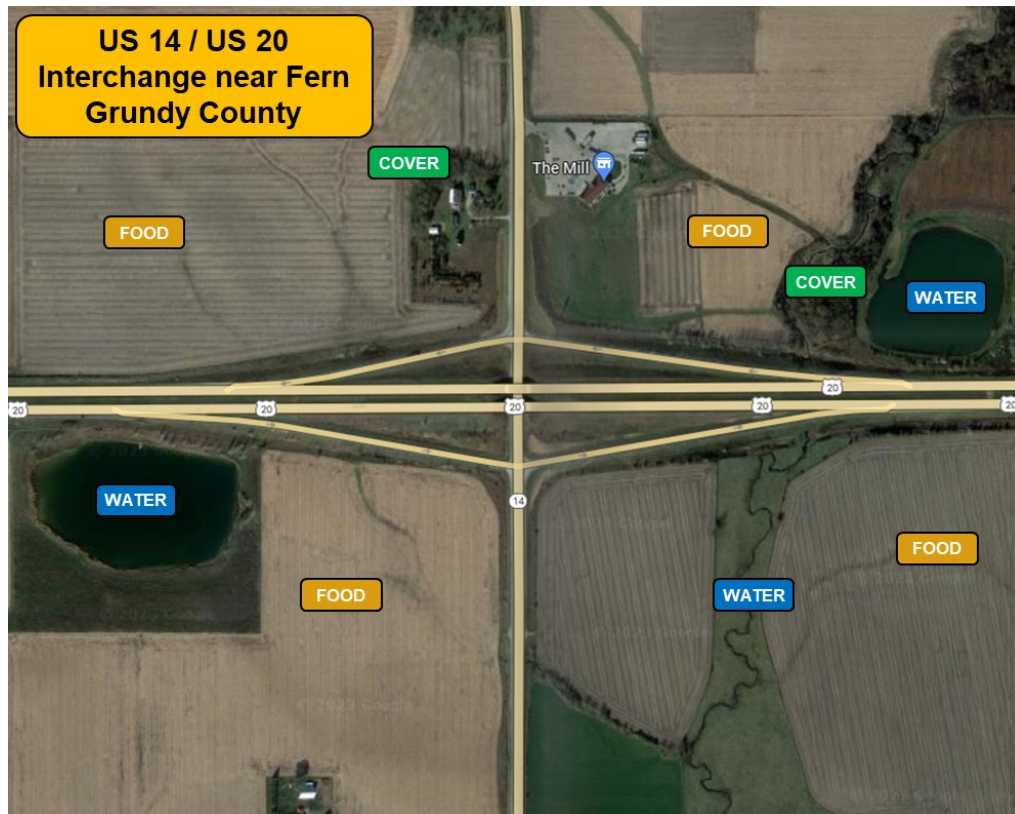
**Figure 15. Essential components of deer habitat: food sources, water sources, and cover from predators**

Deer are herbivores that eat the leafy parts of woody plants, along with herbaceous broad-leaved plants (forbs), grasses, seeds, nuts, mushrooms, and lichens. The major Iowa agricultural crops are all attractive food sources for deer: soybeans are forbs, while corn and wheat are grasses. Thus, although white-tailed deer are primarily native to forests and savannas, large deer populations are supported by the croplands that displaced Iowa's native prairie ecosystems.

With crops serving as a major food source, deer in Iowa are subject to seasonal displacements. Crop harvesting interrupts the availability of soy, corn, and wheat, and the cutting of corn stalks reduces cover from predators. This forces the animals to find cover in forested or brushy areas for the fall, winter, and early spring.

As a result of these habitat requirements, deer populations are highest in areas that are near the edge of a wooded area or forest, have access to open water such as a creek or river, and are close to a food source. Very often, highways separate one element of this trio from the others (Figure 16), putting the animals into conflict with motorized traffic. Roadside vegetation, salt residue from winter maintenance operations, and stormwater structures such as ditches and retention ponds can all attract deer to the highway right-of-way.





Base Image: © 2023 Google

**Figure 16. Roadways separating food, water, and cover**

## Geospatial Analysis

To understand the relationships between deer habitat and traffic crashes, the project team prepared geospatial analyses comparing the locations of reported deer crashes with habitat quality data provided by the Iowa DNR. Three sets of maps are presented in Appendix B:

- The first map series compares the number of observed animal crashes at each mile point on the Iowa primary highway system (Interstates, US highways, and state highways) with the deer habitat quality.
- The second series, also focusing on the primary system, identifies mile points with the top percentiles in terms of animal crash counts.
- The third series compares county-level animal crash involvement rates for the primary and secondary (county and municipal) road systems.

Areas with notable concentrations of animal crashes include the following:

- The counties in southeast and northeast Iowa
- Routes running parallel to rivers and other waterways
- River crossings

- The southwestern suburbs of the Des Moines metropolitan area

Animal crashes were less numerous in northwest and north-central Iowa, except near river crossings.

The mapping process confirms that crashes tend to occur where a high-volume roadway crosses a high-quality habitat. The effect is particularly notable at locations where major highways cross rivers and creeks. In Iowa, these riparian areas tend to be forested and to have smaller plants and grasses growing near the waterway, often putting all three elements of deer habitat into close proximity to roads.

This relationship appears to be consistent with the standard actuarial model, which posits that risk (the likelihood of an undesirable outcome) is the product of hazard (the extent and degree of harmful situations) multiplied by exposure (the number of times people are exposed to the hazard):

$$\text{Risk} = \text{Hazard} \times \text{Exposure}$$

In this sense, the habitat quality can be considered a measure of hazard, while the traffic volume can be taken as a measure of exposure. As discussed later in this report, this actuarial method could potentially be used to identify locations with elevated deer crash risk as part of a systemic safety management program, reducing the need for reliance on law enforcement data sets known to undercount deer crashes.

## MOTORIST SURVEY

Not all motor vehicle crashes are reported to law enforcement. For example, most states exempt the reporting of low-dollar-value, non-injury crashes. In 2015, the National Highway Traffic Safety Administration (NHTSA) published the results of a telephone survey that explored the overall rate of unreported crashes of all types (not limited to animal crashes) in the United States (NHTSA 2015). The weighted percentage of crashes that were not reported to law enforcement was **29.3%** (95% confidence interval 26.7% to 31.9%), while the weighted percentage of crashes that were not reported to an insurance company was 18.5% (95% confidence interval 16.2% to 20.9%). The severity of the unreported crashes tended to be low, with a substantial minority occurring in parking lots and driveways. The median vehicle repair cost was \$2,000 in reported crashes versus \$762 in unreported crashes.

To gain a more specific understanding of how this relates to non-reporting of Iowa deer crashes, we conducted a public survey. The survey instrument is presented in Appendix A. It was distributed through two channels: a panel survey through market research firm Dynata and invitations to participate distributed through the Iowa Department of Transportation's (DOT's) social media presence on Facebook. Although the questions presented to both groups were identical, separate databases were used to collect responses originating from the two sources.

Dynata convenes "panels" of individuals who agree to participate in online market research surveys. In exchange for survey completions, participants accumulate points that can be redeemed for store/restaurant gift cards or exchanged for a cash donation to a charity of their choice. The company actively recruits participants to attempt to obtain demographically balanced panels.

Since the objective of the survey was to identify characteristics of deer crashes occurring in Iowa, after discussions with Dynata it was agreed to focus on panel members who live in Iowa or a metropolitan area near the state line (e.g., Omaha-Council Bluffs, Quad Cities, Sioux City-South Sioux City). Screener questions were included to affirm that the individual drives in Iowa, and participants were asked to focus specifically on crashes that occurred within the state.

Iowa DOT uses Facebook to distribute information about road construction, roadway safety, and legislative changes that affect driver and vehicle licensing. Posts on the Facebook page were used to recruit participants for the deer crash survey.

### Survey Logic

The survey questions and survey flow logic were developed in consultation with the project's TAC. To meet the project objectives, the survey logic was organized into four blocks (Figure 17):

- An eligibility screening block to affirm that the respondent resides in Iowa or one of the six neighboring states (Illinois, Nebraska, Minnesota, Missouri, South Dakota, or Wisconsin)

and had driven in Iowa in the previous two years. Participants who answered no to either question were thanked for their interest, and the survey was terminated.

- A block of questions for motorists who reported involvement in a vehicle-deer collision in Iowa in the previous two years (2019 or 2020)
- A block of questions for motorists who reported involvement in a vehicle-deer collision in Iowa between 2010 and 2018
- A block of demographic questions such as the respondent's state of residence, age range, and gender

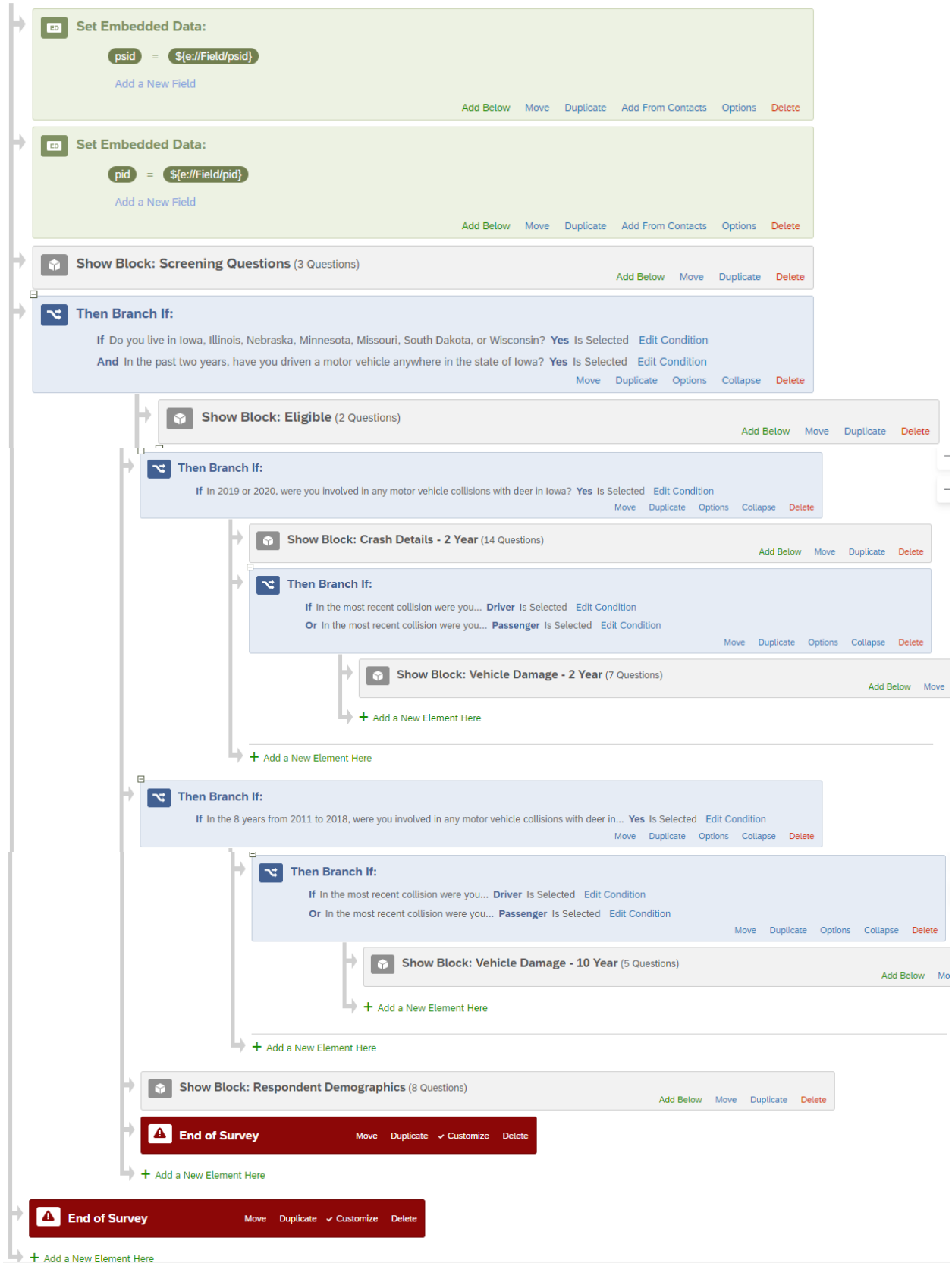


Figure 17. Deer crash survey logic

Questions were more detailed for participants who reported involvement in a deer crash in the current or previous year (2019 or 2020) compared to those whose crashes were farther back in the past (2011 to 2018). For example, participants who experienced a crash prior to 2019 were not asked about the cost of vehicle repairs.

## **Survey Completions**

A total of 2,185 responses met the survey inclusion criteria, 1,020 from the Dynata panel and 1,165 responses from the social media invitations. To be included, the respondent needed to report living in Iowa or one of the six neighboring states and driving in Iowa in the previous two years and needed to have answered at least one of the subsequent questions. Responses obtained through the Dynata channel were received from December 4 through 17, 2020, and those obtained through the social media channel were collected from January 20 through February 9, 2021.

## **Deer Crash Involvement**

A total of 481 respondents (22%) reported having been involved in a deer crash in 2019 or 2020, and an additional 486 respondents (22%) reported a crash involvement between 2011 and 2018. The comparatively lower rate of reported crash involvement over the eight-year period suggests the older results are likely to be less reliable than those based on more recent recall.

The rates of deer crash involvement were very different in the two data sources, with 13% of Dynata respondents reporting crash involvement in 2019–2020 compared to 30% of social media respondents. For older crashes, the rates were 17% and 27%, respectively. Respondents were not asked about older crashes if they had experienced a recent crash. Thus, overall 30% of Dynata respondents and 57% of social media respondents reported deer crash involvement. This suggests a high degree of self-selection bias among the respondents recruited through the social media channel: individuals were evidently more likely to participate in the survey if they had experienced a deer crash. Additionally, it is possible that the Dynata panel included a higher proportion of urban residents than the respondents recruited through social media.

### *Respondents Involved in Deer Crashes in 2019–2020*

Responses for participants who reported deer crash involvement in 2019–2020 are enumerated in Table 1.

The self-selection bias noted above is quite evident in the reported extent of deer crash involvement. Among respondents who were crash-involved in 2019–2020, 14% of Dynata respondents reported involvement in two or more deer crashes, while for social media respondents the figure was 35%. Overall, about a third of respondents experienced two or more deer crashes in the 2019–2020 timeframe.

Overall, about 78% of respondents who were crash-involved in 2019–2020 were drivers, while 18% were passengers and 2% were in other roles (pedestrian, bicyclist, bystander, etc.). Non-driver roles were more common among Dynata respondents, with just 68% reporting having been the driver compared to 81% of social media respondents.

Among the responses from respondents who were crash-involved in 2019–2020, about 5% reported that a human was injured or killed in their most recent crash. In 96% of cases, only the respondent's vehicle was involved in the crash, while about 4% of cases involved one or more other vehicles. In both cases, the differences between the two respondent groups are too small to make meaningful comparisons.

*Overall, 60% of respondents who were crash-involved in 2019–2020 indicated that their most recent crash was not reported to law enforcement, and another 4% were not sure whether the crash was reported. The responses varied dramatically between the two groups, with 36% of Dynata respondents and 69% of social media respondents indicating that the crash was not reported to law enforcement.*

*Overall, 35% of respondents who were crash-involved in 2019–2020 indicated that their most recent crash was not reported to the insurance company, while 2% were not sure whether the crash was reported. Again, there were considerable differences between the two groups, with 20% of Dynata respondents and 40% of social media respondents indicating that the crash was not reported to an insurance company.*

Overall, 92% of respondents who were crash-involved in 2019–2020 indicated that only one deer was struck, while 6% of cases involved striking two or more deer and 3% of cases involved striking three or more deer. These values were consistent between the two data sources.

Overall, about 46% of respondents who were crash-involved in 2019–2020 indicated that the deer died at the roadway, with 37% indicating that the carcass was left at the roadside or in the ditch and 9% indicating that it was harvested or removed for disposal. In 41% of cases, the deer ran away after the crash. About 10% of respondents indicated that the fate of the deer was unknown. The remaining 4% of respondents selected “other” for this item, but nearly all of the situations described in their open-ended responses were similar to one of the predefined categories. The responses were fairly consistent across the two data sources.

Overall, 61% of respondents who were crash-involved in 2019–2020 indicated the crash occurred on a paved two-lane rural highway, and a further 14% said the crash occurred on an unpaved road. Rural freeways reportedly accounted for 13% of the crashes, while only 3% occurred on urban freeways. About 8% of the crashes occurred on streets in cities, suburbs, or small towns. There were notable differences between the Dynata and social media respondents, with 15% of Dynata respondent crashes occurring on streets compared to just 5% for the social media respondents. This suggests that rural residents may have been overrepresented among the social media respondents. The distribution of crashes across facility types appeared to be similar for reported crashes and those not reported to law enforcement.

Both data sources were consistent in terms of the vehicle types involved in the crashes, with about 96% of the 2019–2020 crashes involving a car, pickup, van, or SUV; 4% involving a motorcycle; and an insignificant share involving some other type of vehicle. Both data sources were also consistent in indicating that 86% of 2019–2020 deer crashes resulted in vehicle damage.

Respondents' self-assessment of their vehicles' pre-damage value followed a bi-modal distribution, with 19% of vehicles reportedly valued at \$25,000 or more, 19% valued at \$5,000 to \$9,999, 15% valued at \$2,500 to \$4,999, and 13% valued at \$10,000 to \$14,999. This was consistent across the two data sources.

***For respondents who were crash-involved in 2019–2020, the \$1,500 legal threshold for reporting property-damage-only crashes did not appear to play a strong role in whether or not the crash was reported to law enforcement. Among all respondents who said their vehicle was damaged in 2019–2020 deer crashes, 46% said the damage cost less than \$2,500 to repair and 46% said the repairs cost \$2,500 to \$14,999. In comparison, among respondents who did not report the crash, 54% said the damage cost less than \$2,500 to repair and 41% said the repairs cost \$2,500 to \$14,999. Even among drivers with very severe damage, the rates of reporting the crash to law enforcement were similar. Damage severity among the social media respondents was somewhat higher than among the Dynata respondents, which is consistent with a greater proportion of crashes occurring on rural highways in the social media sample.***

Respondents who were crash-involved in 2019–2020 and did not report their crash to law enforcement appeared to be slightly more likely to continue driving their vehicle as-is compared to all participants (13% versus 9%). Similarly, drivers who did not report the crash were more likely to tolerate only a partial repair (17% versus 13%) and were less likely to replace the vehicle (11% versus 17%). In both cases, 52% of the vehicles were reportedly repaired completely.

#### *Respondents Involved in Deer Crashes in 2011–2018*

Responses for participants who reported deer crash involvement in 2011–2018 are tabulated in Table 2. In general, the response profiles are quite similar to those of the 2019–2020 crash-involved participants. Overall, 52% of the respondents indicated involvement in a deer crash that was not reported to law enforcement, 44% said their crash was reported, and 5% were unsure. The uncertainty rate was higher among Dynata participants than for those recruited through social media.

### **Survey Participant Demographics**

Participant demographics were computed using all survey responses, including those who did not report deer crash involvement. The results are presented in Table 3.



Overall, 92% of the respondents were licensed in Iowa, and 94% were Iowa residents. Although there were a handful of respondents who indicated they were not licensed drivers, a person could also respond to the survey as a passenger, pedestrian, bicyclist, or bystander. Out-of-state participants were more common in the Dynata panel, which included 10% Nebraska residents and 2% Illinois residents; this is consistent with the Dynata recruitment strategy, which included the entirety of the Omaha-Council Bluffs and Quad Cities metropolitan areas.

Older people were overrepresented in both samples, with 27% of all respondents age 65 or older.

Approximately 90% of all respondents identified their ethnicity as white, with 2% each for Black or African American and Hispanic or Latino. About 4% of participants declined to identify their race, while about 2% of participants identified as multiracial or a race not listed in the survey form. Respondents identifying as American Indian or Alaska Native comprised 0.6% of the overall sample, with 0.7% identifying as Asian.

Women were overrepresented in the Dynata panel, making up 60% of the respondents. Conversely, at 49%, women were slightly underrepresented among the respondents recruited through social media. Approximately 2% of respondents declined to identify their gender, while 0.1% identified as a gender not listed in the selection boxes.

**Table 1. Survey responses for respondents indicating crash involvement in 2019 or 2020**

	<b>Dynata</b>		<b>Social Media</b>		<b>Total</b>	
<b>Responses</b>	<b>1,020</b>	<b>100.0%</b>	<b>1,165</b>	<b>100.0%</b>	<b>2,185</b>	<b>100.0%</b>
<b>Involved in a deer crash in 2019 or 2020</b>	130	12.7%	351	30.1%	481	22.0%
<b>Number of deer crashes experienced in 2019–2020</b>						
1	111	86.0%	215	63.8%	326	70.0%
2	16	12.4%	73	21.7%	89	19.1%
3 or more	2	1.6%	49	14.5%	51	10.9%
<i>Total</i>	<i>129</i>	<i>100.0%</i>	<i>337</i>	<i>100.0%</i>	<i>466</i>	<i>100.0%</i>
<b>Respondent's role in crash</b>						
Driver	88	67.7%	285	84.6%	373	79.9%
Passenger	37	28.5%	49	14.5%	86	18.4%
Other (pedestrian, cyclist, bystander, etc.)	5	3.8%	3	0.9%	8	1.7%
<i>Total</i>	<i>130</i>	<i>100.0%</i>	<i>337</i>	<i>100.0%</i>	<i>467</i>	<i>100.0%</i>
<b>Number of vehicles involved in the crash</b>						
Only mine	112	89.6%	323	97.9%	435	95.6%
Mine and one other	10	8.0%	7	2.1%	17	3.7%
Mine and two or more others	3	2.4%	0	0.0%	3	0.7%
<i>Total</i>	<i>125</i>	<i>100.0%</i>	<i>330</i>	<i>100.0%</i>	<i>455</i>	<i>100.0%</i>
<b>Were any humans injured or killed in the crash?</b>						
Yes	18	14.0%	5	1.5%	23	4.9%
No	108	83.7%	333	98.5%	441	94.4%
Don't Know / Not Sure	3	2.3%	0	0.0%	3	0.6%
<i>Total</i>	<i>129</i>	<i>100.0%</i>	<i>338</i>	<i>100.0%</i>	<i>467</i>	<i>100.0%</i>
<b>Was the crash reported to the police or sheriff (or a DNR game warden)?</b>						
Yes	73	56.6%	95	28.4%	168	36.3%
No	46	35.7%	230	68.9%	276	59.6%
Don't Know / Not Sure	10	7.8%	9	2.7%	19	4.1%
<i>Total</i>	<i>129</i>	<i>100.0%</i>	<i>334</i>	<i>100.0%</i>	<i>463</i>	<i>100.0%</i>
<b>Was the crash reported to the insurance company?</b>						
Yes	87	76.3%	198	59.3%	285	63.6%
No	23	20.2%	133	39.8%	156	34.8%
Don't Know / Not Sure	4	3.5%	3	0.9%	7	1.6%
<i>Total</i>	<i>114</i>	<i>100.0%</i>	<i>334</i>	<i>100.0%</i>	<i>448</i>	<i>100.0%</i>
<b>Number of deer struck</b>						
1	115	89.8%	307	92.2%	422	91.5%
2	10	7.8%	16	4.8%	26	5.6%
3 or more	3	2.3%	10	3.0%	13	2.8%
<i>Total</i>	<i>128</i>	<i>100.0%</i>	<i>333</i>	<i>100.0%</i>	<i>461</i>	<i>100.0%</i>

	Dynata		Social Media		Total	
<b>Fate of Deer #1</b>						
I harvested it for the meat or gave it to someone to harvest	6	4.7%	7	2.1%	13	2.8%
I removed it for disposal	0	0.0%	2	0.6%	2	0.4%
Left dead in the ditch, weeds, woods, etc.	11	8.7%	67	20.1%	78	17.0%
Left dead on the road shoulder	26	20.5%	56	16.8%	82	17.8%
Removed from the site by police, sheriff, game warden, etc.	12	9.4%	18	5.4%	30	6.5%
Still alive - ran away	57	44.9%	131	39.3%	188	40.9%
Unknown	13	10.2%	35	10.5%	48	10.4%
Other	2	1.6%	17	5.1%	19	4.1%
<i>Total</i>	<i>127</i>	<i>100.0%</i>	<i>333</i>	<i>100.0%</i>	<i>460</i>	<i>100.0%</i>
<b>Fate of Deer #2</b>						
I harvested it for the meat or gave it to someone to harvest	0	0.0%	0	0.0%	0	0.0%
I removed it for disposal	0	0.0%	0	0.0%	0	0.0%
Left dead in the ditch, weeds, woods, etc.	2	16.7%	6	23.1%	8	21.1%
Left dead on the road shoulder	2	16.7%	13	50.0%	15	39.5%
Removed from the site by police, sheriff, game warden, etc.	2	16.7%	1	3.8%	3	7.9%
Still alive - ran away	4	33.3%	3	11.5%	7	18.4%
Unknown	0	0.0%	3	11.5%	3	7.9%
Other	2	16.7%	0	0.0%	2	5.3%
<i>Total</i>	<i>12</i>	<i>100.0%</i>	<i>26</i>	<i>100.0%</i>	<i>38</i>	<i>100.0%</i>
<b>Fate of Deer #3</b>						
I harvested it for the meat or gave it to someone to harvest	0	0.0%	0	0.0%	0	0.0%
I removed it for disposal	0	0.0%	0	0.0%	0	0.0%
Left dead in the ditch, weeds, woods, etc.	0	0.0%	0	0.0%	0	0.0%
Left dead on the road shoulder	0	0.0%	6	60.0%	6	42.9%
Removed from the site by police, sheriff, game warden, etc.	0	0.0%	0	0.0%	0	0.0%
Still alive - ran away	3	75.0%	3	30.0%	6	42.9%
Unknown	0	0.0%	1	10.0%	1	7.1%
Other	1	25.0%	0	0.0%	1	7.1%
<i>Total</i>	<i>4</i>	<i>100.0%</i>	<i>10</i>	<i>100.0%</i>	<i>14</i>	<i>100.0%</i>
<b>Fate of Deer #1 to #3</b>						
I harvested it for the meat or gave it to someone to harvest	6	4.2%	7	1.9%	13	2.5%
I removed it for disposal	0	0.0%	2	0.5%	2	0.4%
Left dead in the ditch, weeds, woods, etc.	13	9.1%	73	19.8%	86	16.8%
Left dead on the road shoulder	28	19.6%	75	20.3%	103	20.1%
Removed from the site by police, sheriff, game warden, etc.	14	9.8%	19	5.1%	33	6.4%
Still alive - ran away	64	44.8%	137	37.1%	201	39.3%
Unknown	13	9.1%	39	10.6%	52	10.2%
Other	5	3.5%	17	4.6%	22	4.3%
<i>Total</i>	<i>143</i>	<i>100.0%</i>	<i>369</i>	<i>100.0%</i>	<i>512</i>	<i>100.0%</i>

	Dynata		Social Media		Total	
<b>All Respondents: Which best describes the location where the crash occurred?</b>						
Freeway or expressway in a city or suburb	5	3.9%	10	3.0%	15	3.3%
Freeway or expressway in a rural area	19	15.0%	47	14.2%	66	14.4%
Paved two-lane rural highway	55	43.3%	224	67.5%	279	60.8%
Street in a city, suburb, or small town	19	15.0%	16	4.8%	35	7.6%
Unpaved (gravel) road	29	22.8%	35	10.5%	64	13.9%
<i>Total</i>	<i>127</i>	<i>100.0%</i>	<i>332</i>	<i>100.0%</i>	<i>459</i>	<i>100.0%</i>
<b>Not Reported: Which best describes the location where the crash occurred?</b>						
Freeway or expressway in a city or suburb	4	8.9%	7	3.1%	11	4.0%
Freeway or expressway in a rural area	6	13.3%	27	11.8%	33	12.1%
Paved two-lane rural highway	16	35.6%	154	67.5%	170	62.3%
Street in a city, suburb, or small town	9	20.0%	12	5.3%	21	7.7%
Unpaved (gravel) road	10	22.2%	28	12.3%	38	13.9%
<i>Total</i>	<i>45</i>	<i>100.0%</i>	<i>228</i>	<i>100.0%</i>	<i>273</i>	<i>100.0%</i>
<b>Vehicle Type</b>						
Car, pickup, van, or SUV	115	94.3%	312	96.0%	427	95.5%
Motorcycle	5	4.1%	13	4.0%	18	4.0%
Motorhome, RV, or car/pickup/van/SUV pulling a trailer	2	1.6%	0	0.0%	2	0.4%
Other	0	0.0%	2	0.6%	2	0.4%
<i>Total</i>	<i>122</i>	<i>100.0%</i>	<i>325</i>	<i>100.0%</i>	<i>447</i>	<i>100.0%</i>
<b>Was the vehicle damaged?</b>						
Yes	103	85.1%	283	86.5%	386	86.2%
No	18	14.9%	44	13.5%	62	13.8%
<i>Total</i>	<i>121</i>	<i>100.0%</i>	<i>327</i>	<i>100.0%</i>	<i>448</i>	<i>100.0%</i>
<b>If Damaged: What was the value of the vehicle before the crash?</b>						
Less than \$500	4	3.9%	10	3.6%	14	3.7%
500 to \$999	2	1.9%	4	1.4%	6	1.6%
\$1,000 to \$2,499	19	18.4%	20	7.2%	39	10.2%
\$2,500 to \$4,999	14	13.6%	44	15.8%	58	15.2%
\$5,000 to \$9,999	19	18.4%	52	18.6%	71	18.6%
\$10,000 to \$14,999	12	11.7%	37	13.3%	49	12.8%
\$15,000 to \$19,999	13	12.6%	32	11.5%	45	11.8%
\$20,000 to \$24,999	7	6.8%	22	7.9%	29	7.6%
\$25,000 or more	13	12.6%	58	20.8%	71	18.6%
<i>Total</i>	<i>103</i>	<i>100.0%</i>	<i>279</i>	<i>100.0%</i>	<i>382</i>	<i>100.0%</i>

	Dynata		Social Media		Total	
<b>Cost of Repairs: All Damaged Vehicles</b>						
\$0 (no damage)	2	1.9%	1	0.4%	3	0.8%
\$1 to \$249	8	7.7%	9	3.3%	17	4.7%
\$250 to \$499	10	9.6%	18	6.7%	28	7.8%
\$500 to \$999	20	19.2%	18	6.7%	38	10.6%
\$1,000 to \$2,499	23	22.1%	57	21.1%	80	22.2%
\$2,500 to \$4,999	13	12.5%	66	24.4%	79	21.9%
\$5,000 to \$9,999	12	11.5%	58	21.5%	70	19.4%
\$10,000 to \$14,999	0	0.0%	18	6.7%	18	5.0%
\$15,000 to \$19,999	6	5.8%	9	3.3%	15	4.2%
\$20,000 to \$24,999	3	2.9%	4	1.5%	7	1.9%
\$25,000 or more	3	2.9%	2	0.7%	5	1.4%
Not sure / waiting for estimates / unknown	4	3.8%	10	3.7%	14	3.9%
<i>Total</i>	<i>104</i>	<i>100.0%</i>	<i>270</i>	<i>100.0%</i>	<i>360</i>	<i>100.0%</i>
<b>Cost of Repairs: Vehicles Damaged in Unreported Crashes</b>						
\$0 (no damage)	2	2.0%	1	0.5%	3	1.1%
\$1 to \$249	8	7.8%	10	5.4%	18	6.5%
\$250 to \$499	10	9.8%	17	9.2%	27	9.8%
\$500 to \$999	20	19.6%	18	9.7%	38	13.8%
\$1,000 to \$2,499	23	22.5%	41	22.2%	64	23.2%
\$2,500 to \$4,999	13	12.7%	42	22.7%	55	19.9%
\$5,000 to \$9,999	12	11.8%	37	20.0%	49	17.8%
\$10,000 to \$14,999	0	0.0%	9	4.9%	9	3.3%
\$15,000 to \$19,999	4	3.9%	1	0.5%	5	1.8%
\$20,000 to \$24,999	3	2.9%	1	0.5%	4	1.4%
\$25,000 or more	3	2.9%	1	0.5%	4	1.4%
Not sure / waiting for estimates / unknown	4	3.9%	7	3.8%	11	4.0%
<i>Total</i>	<i>102</i>	<i>100.0%</i>	<i>185</i>	<i>100.0%</i>	<i>276</i>	<i>100.0%</i>
<b>All Respondents: What did you end up doing about the vehicle?</b>						
Continued driving it as-is	9	8.6%	27	9.7%	36	9.4%
Partially repaired it	15	14.3%	36	12.9%	51	13.4%
Received insurance payout but didn't buy a replacement vehicle	6	5.7%	7	2.5%	13	3.4%
Repaired it completely	45	42.9%	154	55.4%	199	52.2%
Replaced it	21	20.0%	42	15.1%	63	16.5%
Sold or scrapped the vehicle but didn't replace it	2	1.9%	6	2.2%	8	2.1%
Still deciding what to do	6	5.7%	5	1.8%	11	2.9%
Unknown	1	1.0%	1	0.4%	2	0.5%
<i>Total</i>	<i>105</i>	<i>100.0%</i>	<i>278</i>	<i>100.0%</i>	<i>381</i>	<i>100.0%</i>

	<b>Dynata</b>		<b>Social Media</b>		<b>Total</b>	
<b>Unreported Crashes: What did you end up doing about the vehicle?</b>						
Continued driving it as-is	5	15.2%	23	12.2%	28	12.7%
Partially repaired it	7	21.2%	31	16.5%	38	17.3%
Received insurance payout but didn't buy a replacement vehicle	2	6.1%	3	1.6%	5	2.3%
Repaired it completely	12	36.4%	102	54.3%	114	51.8%
Replaced it	2	6.1%	22	11.7%	24	10.9%
Sold or scrapped the vehicle but didn't replace it	1	3.0%	2	1.1%	3	1.4%
Still deciding what to do	4	12.1%	4	2.1%	8	3.6%
Unknown	0	0.0%	1	0.5%	1	0.5%
<i>Total</i>	<i>33</i>	<i>100.0%</i>	<i>188</i>	<i>100.0%</i>	<i>220</i>	<i>100.0%</i>

**Table 2. Survey responses for participants indicating deer crash involvement between 2011 and 2018**

	<b>Dynata</b>		<b>Social Media</b>		<b>Total</b>	
<b>Responses</b>	<b>1,020</b>	<b>100.0%</b>	<b>1,165</b>	<b>100.0%</b>	<b>2,185</b>	<b>100.0%</b>
<b>Involved in a deer crash 2011–2018</b>	<b>173</b>	<b>17.0%</b>	<b>313</b>	<b>26.9%</b>	<b>486</b>	<b>22.2%</b>
<b>Number of deer crashes experienced in 2011–2018</b>						
1	138	80.2%	194	62.4%	332	68.7%
2	25	14.5%	87	28.0%	112	23.2%
3 or more	9	5.2%	30	9.6%	39	8.1%
<i>Total</i>	<i>172</i>	<i>100.0%</i>	<i>311</i>	<i>100.0%</i>	<i>483</i>	<i>100.0%</i>
<b>Respondent's role in crash</b>						
Driver	108	62.8%	269	86.5%	377	78.1%
Passenger	60	34.9%	42	13.5%	102	21.1%
Other (pedestrian, cyclist, bystander, etc.)	4	2.3%	0	0.0%	4	0.8%
<i>Total</i>	<i>172</i>	<i>100.0%</i>	<i>311</i>	<i>100.0%</i>	<i>483</i>	<i>100.0%</i>
<b>Number of vehicles involved in the crash</b>						
Only mine	158	94.6%	293	96.4%	451	95.8%
Mine and one other	8	4.8%	7	2.3%	15	3.2%
Mine and two or more others	1	0.6%	4	1.3%	5	1.1%
<i>Total</i>	<i>167</i>	<i>100.0%</i>	<i>304</i>	<i>100.0%</i>	<i>471</i>	<i>100.0%</i>
<b>Were any humans injured or killed in the crash?</b>						
Yes	6	3.5%	6	1.9%	12	2.5%
No	164	95.3%	302	97.1%	466	96.5%
Don't Know / Not Sure	2	1.2%	3	1.0%	5	1.0%
<i>Total</i>	<i>172</i>	<i>100.0%</i>	<i>311</i>	<i>100.0%</i>	<i>483</i>	<i>100.0%</i>
<b>Was the crash reported to the police or sheriff (or a DNR game warden)?</b>						
Yes	81	47.4%	126	41.4%	207	43.6%
No	76	44.4%	169	55.6%	245	51.6%
Don't Know / Not Sure	14	8.2%	9	3.0%	23	4.8%
<i>Total</i>	<i>171</i>	<i>100.0%</i>	<i>304</i>	<i>100.0%</i>	<i>475</i>	<i>100.0%</i>
<b>Was the crash reported to the insurance company?</b>						
Yes	108	62.8%	209	68.8%	317	66.6%
No	49	28.5%	88	28.9%	137	28.8%
Don't Know / Not Sure	15	8.7%	7	2.3%	22	4.6%
<i>Total</i>	<i>172</i>	<i>100.0%</i>	<i>304</i>	<i>100.0%</i>	<i>476</i>	<i>100.0%</i>
<b>Number of deer struck</b>						
1	164	96.5%	264	86.6%	428	90.1%
2	2	1.2%	28	9.2%	30	6.3%
3 or more	4	2.4%	13	4.3%	17	3.6%
<i>Total</i>	<i>170</i>	<i>100.0%</i>	<i>305</i>	<i>100.0%</i>	<i>475</i>	<i>100.0%</i>

	Dynata		Social Media		Total	
<b>Fate of Deer #1</b>						
I harvested it for the meat or gave it to someone to harvest	5	2.9%	10	3.3%	15	3.2%
I removed it for disposal	0	0.0%	1	0.3%	1	0.2%
Left dead in the ditch, weeds, woods, etc.	22	12.9%	50	16.4%	72	15.1%
Left dead on the road shoulder	26	15.2%	45	14.8%	71	14.9%
Removed from the site by police, sheriff, game warden, etc.	26	15.2%	19	6.2%	45	9.5%
Still alive - ran away	71	41.5%	122	40.0%	193	40.5%
Unknown	19	11.1%	40	13.1%	59	12.4%
Other	2	1.2%	18	5.9%	20	4.2%
<i>Total</i>	<i>171</i>	<i>100.0%</i>	<i>305</i>	<i>100.0%</i>	<i>476</i>	<i>100.0%</i>
<b>Fate of Deer #2</b>						
I harvested it for the meat or gave it to someone to harvest	0	0.0%	3	7.3%	3	6.3%
I removed it for disposal	1	14.3%	9	22.0%	10	20.8%
Left dead in the ditch, weeds, woods, etc.	1	14.3%	5	12.2%	6	12.5%
Left dead on the road shoulder	0	0.0%	3	7.3%	3	6.3%
Removed from the site by police, sheriff, game warden, etc.	3	42.9%	0	0.0%	3	6.3%
Still alive - ran away	1	14.3%	15	36.6%	16	33.3%
Unknown	1	14.3%	6	14.6%	7	14.6%
Other	0	0.0%	0	0.0%	0	0.0%
<i>Total</i>	<i>7</i>	<i>100.0%</i>	<i>41</i>	<i>100.0%</i>	<i>48</i>	<i>100.0%</i>
<b>Fate of Deer #3</b>						
I harvested it for the meat or gave it to someone to harvest	1	25.0%	1	7.7%	2	11.8%
I removed it for disposal	0	0.0%	0	0.0%	0	0.0%
Left dead in the ditch, weeds, woods, etc.	0	0.0%	4	30.8%	4	23.5%
Left dead on the road shoulder	0	0.0%	0	0.0%	0	0.0%
Removed from the site by police, sheriff, game warden, etc.	2	50.0%	0	0.0%	2	11.8%
Still alive - ran away	1	25.0%	5	38.5%	6	35.3%
Unknown	0	0.0%	3	23.1%	3	17.6%
Other	0	0.0%	0	0.0%	0	0.0%
<i>Total</i>	<i>4</i>	<i>100.0%</i>	<i>13</i>	<i>100.0%</i>	<i>17</i>	<i>100.0%</i>
<b>Fate of Deer #1 to #3</b>						
I harvested it for the meat or gave it to someone to harvest	6	3.3%	14	3.9%	20	3.7%
I removed it for disposal	1	0.5%	10	2.8%	11	2.0%
Left dead in the ditch, weeds, woods, etc.	23	12.6%	59	16.4%	82	15.2%
Left dead on the road shoulder	26	14.3%	48	13.4%	74	13.7%
Removed from the site by police, sheriff, game warden, etc.	31	17.0%	19	5.3%	50	9.2%
Still alive - ran away	73	40.1%	142	39.6%	215	39.7%
Unknown	20	11.0%	49	13.6%	69	12.8%
Other	2	1.1%	18	5.0%	20	3.7%
<i>Total</i>	<i>182</i>	<i>100.0%</i>	<i>359</i>	<i>100.0%</i>	<i>541</i>	<i>100.0%</i>



	<b>Dynata</b>		<b>Social Media</b>		<b>Total</b>	
<b>All Respondents: Which best describes the location where the crash occurred?</b>						
Freeway or expressway in a city or suburb	17	9.9%	11	3.6%	28	5.9%
Freeway or expressway in a rural area	30	17.5%	54	17.8%	84	17.7%
Paved two-lane rural highway	89	52.0%	204	67.3%	293	61.8%
Street in a city, suburb, or small town	12	7.0%	14	4.6%	26	5.5%
Unpaved (gravel) road	23	13.5%	20	6.6%	43	9.1%
<i>Total</i>	<i>171</i>	<i>100.0%</i>	<i>303</i>	<i>100.0%</i>	<i>474</i>	<i>100.0%</i>
<b>Vehicle Type</b>						
Car, pickup, van, or SUV	164	98.2%	292	99.7%	456	99.6%
Motorcycle	0	0.0%	0	0.0%	0	0.0%
Motorhome, RV, or car/pickup/van/SUV pulling a trailer	1	0.6%	1	0.3%	2	0.4%
Other	2	1.2%	10	3.4%	12	2.6%
<i>Total</i>	<i>167</i>	<i>98.8%</i>	<i>293</i>	<i>100.0%</i>	<i>458</i>	<i>100.0%</i>
<b>Was the vehicle damaged?</b>						
Yes	145	86.8%	274	90.4%	419	89.1%
No	22	13.2%	29	9.6%	51	10.9%
<i>Total</i>	<i>167</i>	<i>100.0%</i>	<i>303</i>	<i>100.0%</i>	<i>470</i>	<i>100.0%</i>
<b>Respondents with vehicle damage: What did you end up doing about the vehicle?</b>						
Continued driving it as-is	24	16.6%	24	8.8%	48	11.7%
Partially repaired it	20	13.8%	26	9.6%	46	11.2%
Received insurance payout but didn't buy a replacement vehicle	3	2.1%	3	1.1%	6	1.5%
Repaired it completely	73	50.3%	180	66.2%	253	61.7%
Replaced it	16	11.0%	30	11.0%	46	11.2%
Sold or scrapped the vehicle but didn't replace it	4	2.8%	7	2.6%	11	2.7%
Unknown	5	3.4%	2	0.7%	7	1.7%
<i>Total</i>	<i>145</i>	<i>100.0%</i>	<i>272</i>	<i>100.0%</i>	<i>410</i>	<i>100.0%</i>

**Table 3. Survey participant demographics**

<b>Participant Demographics</b>	<b>Dynata</b>		<b>Social Media</b>		<b>Total</b>	
<b>Driving License State</b>						
Illinois	22	2.2%	7	0.6%	29	1.4%
Iowa	868	85.6%	1,095	98.4%	1,963	92.3%
Minnesota	1	0.1%	3	0.3%	4	0.2%
Missouri	3	0.3%	4	0.4%	7	0.3%
Nebraska	99	9.8%	1	0.1%	100	4.7%
South Dakota	0	0.0%	1	0.1%	1	0.0%
Wisconsin	3	0.3%	0	0.0%	3	0.1%
Other	8	0.8%	2	0.2%	10	0.5%
Not Licensed	10	1.0%	0	0.0%	10	0.5%
<i>Total</i>	<i>1,014</i>	<i>100.0%</i>	<i>1,113</i>	<i>100.0%</i>	<i>2,127</i>	<i>100.0%</i>
<b>Iowa Resident</b>						
Yes	901	88.9%	1,099	98.7%	2,000	94.0%
No	113	11.1%	14	1.3%	127	6.0%
<i>Total</i>	<i>1,014</i>	<i>100.0%</i>	<i>1,113</i>	<i>100.0%</i>	<i>2,127</i>	<i>100.0%</i>
<b>Age Range</b>						
13 or Younger	1	0.1%	1	0.1%	2	0.1%
14-17	5	0.5%	10	0.9%	15	0.7%
18-24	119	11.7%	65	6.0%	184	8.7%
25-34	136	13.4%	162	14.9%	298	14.2%
34-44	164	16.2%	188	17.2%	352	16.7%
45-54	122	12.0%	174	16.0%	296	14.1%
55-64	151	14.9%	249	22.8%	400	19.0%
65-74	253	25.0%	200	18.3%	453	21.5%
75+	62	6.1%	41	3.8%	103	4.9%
<i>Total</i>	<i>1,013</i>	<i>100.0%</i>	<i>1,090</i>	<i>100.0%</i>	<i>2,103</i>	<i>100.0%</i>
<b>Ethnicity</b>						
American Indian or Alaska Native	6	0.6%	7	0.6%	13	0.6%
Asian	13	1.3%	1	0.1%	14	0.7%
Black or African American	43	4.3%	1	0.1%	44	2.1%
Hispanic or Latino	25	2.5%	9	0.8%	34	1.6%
White	879	87.3%	991	90.7%	1,870	89.0%
Multiracial	19	1.9%	8	0.7%	27	1.3%
Prefer not to answer	19	1.9%	64	5.9%	83	4.0%
Other	3	0.3%	12	1.1%	15	0.7%
<i>Total</i>	<i>1,007</i>	<i>100.0%</i>	<i>1,093</i>	<i>100.0%</i>	<i>2,100</i>	<i>100.0%</i>
<b>Gender</b>						
Woman	604	59.7%	521	49.1%	1,125	54.5%
Man	398	39.3%	539	50.8%	937	45.4%
Non-Binary	1	0.1%	2	0.2%	3	0.1%
Prefer not to answer	9	0.9%	28	2.6%	37	1.8%
<i>Total</i>	<i>1,012</i>	<i>99.1%</i>	<i>1,062</i>	<i>100.0%</i>	<i>2,065</i>	<i>100.0%</i>

## DEER CRASH DETECTION

Two sources of deer crash data have been used in Iowa in the past: law enforcement reports and carcass location records gathered by maintenance personnel. For closely monitored sections of the state highway network, traffic management center records are another potential data source of deer crash information. Although several methods for detecting animals near the highway right-of-way have been developed, no existing systems for automating animal *crash* detection were found.

### Deer Crash Data Applications

Current transportation practice recognizes two distinct approaches for identifying road safety problems: a **reactive** approach based on analysis of *past* crash locations (sometimes called hot spot or black spot analysis) and a **proactive** approach based on identifying conditions with a high probability of *future* crashes (International Transport Forum 2016). The reactive approach is predicated on the assumption that casualty locations and severity levels are stable over time, while the proactive approach potentially incorporates forecasting variables indicative of future changes in crash intensity.

A major limitation of reactive deer crash analyses is year-to-year variation in the locations of deer herd concentrations. Spatial variations in winter weather differentially affect survival rates. Over time, localized population surges that initially increase crashes are potentially diminished by predation, disease, starvation, or hunting. In the longer term, human activities can create or destroy deer habitat, also leading to shifts in deer population distribution; examples include changes in agricultural crop planting patterns, land development, and floodplain restoration.

The significant underreporting of deer crashes identified through the surveys presents difficulties for reactive safety analyses, mainly because the underreporting rates are unlikely to be uniform across Iowa. For example, deer crashes on heavily traveled routes are probably more likely to be reported than those in locales where a deer crash is less likely to be witnessed. Variations in law enforcement response time—potentially exacerbated by high deer crash caseloads in some areas—could also contribute to differences in reporting levels. In this context, it is important to note that while some crashes fall below legal reporting thresholds, underreporting could also result from a desire to conceal concurrent issues such as driving without insurance, intoxicated driving, or driving on a suspended license. These behaviors are also unlikely to be spatially uniform.

Carcass reporting rates are also subject to geographical variation. For example, a location immediately adjacent to a highway maintenance facility will be traversed by maintenance staff more often than one in a distant corner of a maintenance district. As a result, a carcass far from the maintenance facility has a lower probability of being detected before it is consumed by scavengers.

## **Deer Detection Systems**

Several animal detection systems have been developed for the purpose of activating dynamic warning messages (Huijser et al. 2006, Huijser et al. 2009, Zhou et al. 2009, Chen et al. 2019). Older systems that used emitter-detector pairs in a break-the-beam configuration had low reliability. They have generally been supplanted by systems built around optical-spectrum devices such as infrared (thermal) sensors, infrared cameras, or lidar. Radar has also been used (Huijser et al. 2017). Image processing algorithms are applied to identify animal presence and activate a warning message.

A crucial limitation has been the need to install relatively large numbers of sensors to cover the length of highway corridors. Energy sources and telecommunications are required, and the optical-spectrum systems require clear sight lines between the sensors and the road shoulder. Both false positives and false negatives have been reported in previous research. For example, false positives can be caused by windblown debris or humans walking along the roadside. Another known source of false positives is deer that briefly enter the detection zone and then retreat (Siddique and Ahmed 2023).

An alternative large animal detection technology, known as buried cable radio frequency intrusion detection, utilizes two long inductive loops buried approximately 1 to 6 feet apart (Southwest Microwave 2017, Senstar 2022). The operational principle is similar to that of the century-old Theremin musical instrument: a radio frequency (RF) signal is transmitted on one loop and detected on the other, the capacitance of a nearby animal attenuates the strength of the received signal, and this difference is processed to trigger a warning message. Buried cable systems have been commercialized to detect human intruders at sensitive facilities such as power stations and have been applied experimentally to trigger deer presence warnings along highway corridors (Druta and Alden 2019, Huijser et al. 2012). Compared to optical detection, the RF systems appear to be less sensitive to false positives caused by weather and debris.

## **Deer Crash Detection**

Wildlife ecologists have long used manual surveys to capture snapshots of animal populations and animal mortality, including mortality along roadways (Livingston 2019). In recent years, these methods have been augmented by aerial imaging from drones, and machine learning algorithms have been developed to assist with data reduction (Lenzi et al. 2023). Future research could explore the use of these methods for carcass counting based on imaging from drones flown along the right-of-way, maintenance vehicles equipped with rooftop cameras or lidar units, or images from roadside traffic surveillance cameras.

Extensive testing would likely be required to determine whether the deer carcasses can consistently be distinguished from the roadside landscape. Like most herbivores, deer have evolved to blend in with their habitat. In addition to this camouflaging, the task of automating carcass detection is made more challenging by carcass mutilation from the crash and post-crash decay. In the absence of continuous observation, carcasses removed by scavenger animals are unlikely to be detected (Lee et al. 2021).

In principle, artificial intelligence (AI) algorithms might be trained to identify vehicle-deer collisions in real-time for locations where overhead camera coverage is available. An important challenge could be identifying enough video footage of previous collisions to train the algorithms to identify these rare events accurately. Extensive testing would likely be required to determine whether the systems can accurately distinguish deer crashes from near-misses. Since most Iowa DOT cameras are already monitored by traffic management center operators, the benefits of the AI compared to manual incident logging might be marginal.

## **Self-Reporting**

A number of traffic safety studies have used surveys similar to the one developed for this report to obtain self-reported data on crash characteristics. Kamaluddin et al. (2018) reviewed 134 self-report crash studies from Europe, North America, Australia, New Zealand, and developing countries to identify common features of the studies and methodological challenges. Although some primary studies focused on specialized road user groups such as pedestrians, elderly people, or people with disabilities, Kamaluddin et al. (2018) found that most focused on adult road users and car users. Questionnaires (either paper based or online) were the most often used method. Participants were usually asked to recall crashes that occurred in the previous one-year period, mainly due to concerns about the reliability of longer recall periods. Although researchers using these methods appeared confident in their data, Kamaluddin et al. (2018) expressed concern about the potential for underreporting of misbehaviors that may have contributed the self-reported crashes; these concerns were heightened when the surveys were not fully anonymized.

Environmental scientists sometimes conduct “citizen science” initiatives intended to increase knowledge about animal populations and behaviors. These efforts are often enabled by web-based reporting tools or mobile phone apps. Because they rely on volunteers, these initiatives are often limited to a specific day or group of days. While this strategy could potentially be applied to deer crash or carcass reporting, the reliability of the resulting data would likely depend on the participant recruitment strategy, the ease of use of the reporting system, and other study design variables.

## **Predictive Analytics**

Much recent safety literature focuses on developing proactive approaches for safety analysis. Typically, this involves modeling the factors that contribute to a specific type of crash. For example, the standard actuarial model often takes the following form:

$$R = H \times E$$

where

R is the risk of an adverse outcome, often expressed as the expected number of casualties or the monetary value of expected losses

H is the degree of hazard present in the environment of interest

E is a measure of exposure to the hazard

In the case of deer crashes, one potential measure of hazard intensity is the Iowa DNR deer habitat quality index, a numerical score representing the extent to which a given locale provides the food, water, and cover desired by deer. This is a proxy variable, more readily observable and easier to localize than deer population itself. Motor vehicle traffic volume, available from the Iowa DOT's statewide traffic counting program, is a measure of exposure to the deer hazard.

Thus, the actuarial model can be rewritten as follows:

$$R = Q \times V$$

where

R is a measure of deer crash risk

Q is Iowa DNR habitat quality index

V is the bidirectional traffic volume at the site

The crash maps presented in Appendix B suggest a strong correlation between existing crash counts and the product of  $Q \times V$ . For example, notable deer crash concentrations are observed at many of the sites where high-volume highways cross waterways that are bordered by narrow strips of woodland that adjoin corn or soy fields. With further testing, this model-based approach could be an alternative to developing a program or technology for direct observations of deer crashes.

## DEER CRASH COSTS

In the United States, no single payer bears all of the costs of motor vehicle crashes. Instead, costs are shared by various public agencies, insurance companies, state and national healthcare programs, employers, families, and individuals. The National Safety Council (NSC), Centers for Disease Control and Prevention (CDC), and U.S. Department of Transportation (USDOT) all publish estimates of the comprehensive costs of crashes. All three organizations take a whole-of-society approach rather than looking at costs solely from the perspective of any single entity.

NSC's current valuation considers wage and productivity losses, medical expenses, administrative expenses (such as the administration of insurance claims), motor vehicle damage, and employers' uninsured costs (such as the cost of hiring and training a new employee to replace an injured worker) (NSC 2022). In addition, NSC's comprehensive cost valuations include a measure of the value of lost quality of life, obtained through empirical studies of what people actually pay to reduce their safety and health risks. The average comprehensive costs on a *per injured person* basis are shown in Table 4.

**Table 4. National Safety Council average comprehensive cost per person injured by injury severity, 2021**

<b>Injury Severity</b>	<b>Valuation</b>
Death	\$12,474,000
Disabling injury	\$1,016,000
Evident injury	\$221,000
Possible injury	\$120,000
No injury observed	\$17,000

Source: National Safety Council

CDC developed state-specific valuations for fatal injuries (CDC 2023). For Iowa, CDC estimated the combined costs (medical costs + value of a statistical life) for a motor vehicle occupant fatality to be \$10.65 million as of 2020, very slightly higher than the national average of \$10.64 million. The CDC provides costs for nonfatal injuries only on a national basis. For 2020, nonfatal motor vehicle occupant injuries requiring hospital admission cost an average of \$269,563, while cases that could be treated and released by a hospital emergency department (with no need for overnight admission) cost an average of \$86,485. Since the CDC's work is based on hospital data, the agency does not provide cost estimates for property-damage-only incidents.

In 2018, the Federal Highway Administration (FHWA) published a guidebook on crash costs for highway safety analysis (FHWA 2018). Comprehensive costs *per crash* are presented in Table 5. Various alternative methods for describing crash severity are also described in the document, along with valuations on a per injury (rather than per crash) basis. The document additionally includes comparisons to valuation methodologies utilized in previous federal and American Association of State Highway and Transportation Officials (AASHTO) publications.

**Table 5. USDOT comprehensive unit cost per crash in 2016 dollars**

<b>Crash Severity</b>	<b>Comprehensive Crash Unit Cost (2016 dollars)</b>
K (Death)	\$11,295,400
A (Serious Injury)	\$655,000
B (Minor injury)	\$198,500
C (Possible injury)	\$125,600
O (No injury)	\$11,900

Source: FHWA

The direct costs of deer crashes for Iowa public agencies are a small fraction of these comprehensive cost valuations. For example, Cerro Gordo Sheriff Kevin Pals estimated the costs for labor and mileage to respond to a typical deer crash to be around \$70 per incident; assuming facilities and administrative costs of 60%, this would bring the agency cost of each response to around \$115.

Most deer carcass cleanup appears to be completed as an incidental part of other highway maintenance operations. Although the Iowa DOT highway maintenance management system does not treat deer carcass cleanups as a specific cost center, the number of cleanup operations is tracked by maintenance shops. About 96% of these operations are classified as “tall grass burials” (moving the carcass into the grass adjacent to the roadway), while nearly all of the remainder are classified as relocations (removal from the roadway). As shown in Table 6, this information was used in combination with the 2023 Iowa DOT Local Systems Equipment Rates to estimate the costs of carcass cleanup constructively. Each removal was assumed to require 60 minutes including travel time. Including a facilities and administrative cost rate of 38.51%, this brings the cost of each cleanup to about \$181.

**Table 6. Estimated Iowa DOT deer carcass cleanup costs**

<b>Item</b>	<b>Quan.</b>	<b>Unit</b>	<b>Quan</b>	<b>Unit</b>	<b>Rate</b>	<b>Unit</b>	<b>Total</b>
Highway Technician Wages	2	persons	1.0	hours	\$30.00	/hour	\$60.00
Employee Benefits - Merit	48.9%						\$29.34
Single-Axle Dump Truck	1	vehicle	1.0	hours	\$41.48	/hour	\$41.48
<i>Subtotal</i>							<i>\$130.82</i>
Facilities and Administrative Costs	38.5%						\$50.38
<b>Total</b>							<b>\$181.20</b>

Given the scale of these agency costs in comparison to the loss-of-health, loss-of-work, and medical costs included in the NSC, CDC, and USDOT methodologies and the vehicle repair costs embedded in the NSC and USDOT valuations, it does not appear that appending the agency response and cleanup costs will have a major effect on project selection decisions. Additionally, there is a risk of double-counting, given that the NSC and USDOT valuations include these costs in principle (though the CDC probably does not).



Due to their slightly lower severity, the costs associated with unreported deer crashes are likely to be lower than those attributable to reported crashes. Based on the survey findings, in many cases vehicle owners fix the damage themselves, perhaps using low-cost materials. A substantial number of drivers simply drive the vehicle as-is for the remainder of its useful life.

Of greater financial concern is the possibility that unreported crashes lead to downstream medical costs for crash-involved drivers and their passengers. Treatment delays are likely, implying that these costs are potentially borne by health insurance companies and state/federal medical programs rather than by vehicle insurers. A follow-up survey would be necessary to develop estimates of these costs.

## CONCLUSIONS AND RECOMMENDATIONS

More than 7,300 crashes involving animals are reported in Iowa each year, accounting for 13.5% of all reported motor vehicle crashes (Iowa DOT 2023). These crashes occur on roadways of every classification and in all 99 counties of the state. Although it is likely that some of the reported animal crashes involve small mammals, large birds, or domesticated animals such as dogs or cattle, the majority result from collisions with white-tailed deer (*odocoileus virginianus*).

About 96% of Iowa deer crashes are property-damage-only. From 2013 through 2022, an average of 3.2 animal-involved fatal crashes occurred in Iowa each year. Most of the fatalities involved a motorcyclist or ATV rider striking the animal, or a motorist who lost control (possibly after swerving to avoid the animal).

### Unreported Deer Crashes

Previous research leaves little doubt that law enforcement reports undercount the actual number of deer crashes, both in Iowa and nationally. To assess the prevalence of unreported deer crashes, this project conducted public surveys of two samples, one recruited through Dynata (a major market research firm) and the other recruited through the Iowa DOT's social media presence.

Social media respondents were much more likely to indicate involvement in an unreported crash than those recruited from the Dynata panel. Although some of this appears to be related to more rural driving among the respondents recruited through social media (indicated by substantially greater involvement in crashes on two-lane rural highways), the social media channel appeared to produce a very high degree of self-selection bias: individuals recruited through social media were evidently more likely to participate in the survey if they had been involved in a deer crash than if they had not. In addition, drivers who had been involved in two or more deer crashes appeared to be particularly likely to respond to the social media survey. Therefore, the Dynata results indicating that about **40%** of deer crashes are not reported to law enforcement appear to provide the more reliable figure.

Surprisingly, the crash reporting rates do not appear to differ much based on the severity of the damage sustained by the crash-involved vehicles. Iowa's \$1,500 threshold for reporting property-damage-only crashes appears to have almost no influence on whether the driver reports the crash to law enforcement. Crashes are more likely to be reported to an insurance carrier than to law enforcement.

The results of both surveys suggest that carcass counts very substantially undercount deer crashes. According to the survey participants, about 40% of deer are still alive after the crash and run away. Presumably, the vast majority of these injured deer ultimately die away from the roadside or are taken down by predators. Around 20% of the deer end up on the road shoulder, while another 17% end up in the ditch, weeds, woods, etc.

According to the survey participants, around 60% of the crashes occur on paved two-lane rural highways or unpaved rural roads, about 20% occur on freeways, and around 20% occur on urban, suburban, or small-town streets.

## **Crash Locations and Countermeasures**

The Iowa DOT is fighting an uphill battle against vehicle-deer crashes, likely driven by growth in the deer population and changes in land use that increase vehicle-deer conflicts. The timing of the annual corn and soy harvests coincides with the start of deer mating season, resulting in abrupt migration of the deer population. Moreover, this disruption coincides with the annual switch to standard time, which shifts the evening commute to sunset—precisely the time of day when deer are most active.

Numerous deer crash countermeasures have been explored in the research literature, but only a few appear to be effective:

- Previous research indicates that the most comprehensive way to reduce vehicle-deer crashes would be to remain on daylight savings time for the entire year (Cunningham et al. 2022). This would separate the daily peak of deer activity from the daily peak of motorized traffic. For Iowa, it is mathematically equivalent to switching to Eastern Standard Time year-round.
- Another cost-effective method for preventing vehicle-deer crashes is to display deer warning messages very selectively on existing dynamic message signs (DMS) (Donaldson and Kweon 2019). These messages can be narrowly targeted to locations and times when deer are likely to be near the roadway, such as forested/riverside areas around dusk and dawn from late October through early December. This selective messaging can be far more salient to motorists than static signs, which are often seen at times when deer are unlikely to be present.
- Combinations of fencing and underpasses or overpasses appear to be the most effective physical deer crash prevention approach. Although costly to retrofit to existing sites, these countermeasures can potentially be implemented incidental to new roadway construction and when bridges over waterways are reconstructed.

Habitat fragmentation potentially contributes to the deer crash problem in Iowa. Numerous roadways include bridges over waterways that are buffered by narrow strips of woods, which in turn adjoin agricultural fields. This puts the three key elements of deer habitat (food, water, and cover) into close proximity. If one element is separated from the others by a roadway, frequent deer crossings can be expected. In very site-specific cases, defragmenting the habitat—for example, by adding a small culvert to bring water to the opposite side of a highway—might reduce the need for deer to cross the roadway, though in some cases it might also create more habitat that supports an even larger near-road deer population.

## **Deer Crossing Signs**

Only four studies, all small in scale, have explored the effectiveness of static DEER CROSSING signs displayed year-round or slightly modified versions of the standard signage. Most show

small reductions in crash counts following the installation of additional deer crash warning signs, but due to considerable fluctuation in baseline crash counts, only one study generated statistically significant results. Two additional studies show promising results for warning messages that are highly targeted to locations and time periods with high deer crash risk.

Taken as a whole, the results of the six deer warning signage studies suggest that the effects of conventional deer warning signs displayed year-round are too subtle to capture in small-scale studies. This problem frequently occurs in health and safety research and can only be addressed by conducting larger studies with more statistical power. Most studies did not attempt to control for regression-to-mean effects. As a result, it is possible that some of the effects attributed to signs were actually due to changes in the size or location of the deer herd.

The results tend to support the view that road users tend to habituate to deer warning signs, a concern expressed by practitioners since at least the mid-1960s (Pojar et al. 1975). Recent studies suggest that the signs' salience and value to road users can be enhanced by making the message highly specific in terms of the times and places where deer are likely to be present. This suggests a move away from generic messaging (e.g., DEER CROSSING NEXT 10 MILES) toward more narrowly targeted messages. For example, similar to the recommendations in Khalilikhah and Heaslip (2017), an agency might explore the use of hinged signs that are displayed near river crossings in the autumn months, possibly augmented by flashing amber lights that illuminate during the twilight hours (when deer activity is high).

## **Deer Crash Detection**

Video surveys from drones or maintenance vehicles appear to be the only feasible means of automating the collection of deer crash location information. Wildlife biologists are currently exploring the potential to automate the process of extracting carcass locations from video data using machine learning techniques. Since many carcasses are promptly scavenged by predators, the reliability of the resulting data will be highly dependent on the frequency of the video data collection. The reliability of the carcass counts is doubtful, given that the survey respondents indicate that about 40% of injured deer remain alive long enough to take cover away from the roadway right-of-way.

## **Deer Crash Costs**

The NSC, CDC, and USDOT all publish recommended values for motor vehicle crash valuation. These recommendations are stratified based on crash severity and endeavor to capture the costs incurred by all payers, including public agencies, health insurers and government healthcare programs, employers, families, and individuals. The direct costs of response and carcass removal are small in relation to those associated with morbidity and mortality, loss of wages and productivity, medical treatment, vehicle repairs, and claims administration.

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## APPENDIX A. DEER CRASH SURVEY INSTRUMENT

### Screening Questions

#### Iowa Vehicle-Deer Crash Survey

On behalf of the Iowa Department of Transportation, we are gathering information about vehicle-deer crashes in Iowa. We invite you to participate in this survey if you **drive** in Iowa, even if you live in one of the six neighboring states (IL, NE, MN, MO, SD, WI). Your response is anonymous and your participation in the survey is voluntary.

If you have questions about this project, please contact the Principal Investigator, John Shaw on (515) 294-4366 or [jwshaw@iastate.edu](mailto:jwshaw@iastate.edu).

Do you live in Iowa, Illinois, Nebraska, Minnesota, Missouri, South Dakota, or Wisconsin?

- ☐ Yes
- ☐ No

In the past two years, have you driven a motor vehicle anywhere in the state of Iowa?

- ☐ Yes
- ☐ No

#### Eligible

In 2019 or 2020, were you involved in any motor vehicle collisions with deer in Iowa?

- ☐ Yes
- ☐ No

In the 8 years from 2011 to 2018, were you involved in any motor vehicle collisions with deer in Iowa?

- ☐ Yes
- ☐ No

### Crash Details - 2 Year

How many deer-vehicle crashes were you involved in?

- ☐ 1
- ☐ 2
- ☐ 3 or more

When did the most recent deer-vehicle collision occur?

In the most recent collision were you...

- ☐ Driver
- ☐ Passenger
- ☐ Other (pedestrian, bicyclist, bystander, etc.)

Were any humans injured or killed in the crash?

- ☐ Yes
- ☐ No
- ☐ Not sure / don't know

How many vehicles were involved in the crash?

- ☐ Only mine
- ☐ Mine and one other
- ☐ Mine and two or more others

Was the crash reported to the police or sheriff (or a DNR game warden)?

- ☐ Yes
- ☐ No
- ☐ Not sure / don't know

Was the crash reported to the insurance company?

- ☐ Yes
- ☐ No
- ☐ Not sure / don't know

How many deer were struck?

- ☐ 1
- ☐ 2
- ☐ 3 or more

After the crash, what happened to deer #1?

- ☐ Still alive - ran away
- ☐ Left dead on the road shoulder
- ☐ Left dead in the ditch, weeds, woods, etc.
- ☐ Removed from the site by police, sheriff, game warden, etc.
- ☐ I removed it for disposal

- ☐ I harvested it for the meat (or gave it to someone else to harvest)
- ☐ Unknown
- ☐ Other (please explain)

After the crash, what happened to deer #2?

- ☐ Still alive - ran away
- ☐ Left dead on the road shoulder
- ☐ Left dead in the ditch, weeds, or woods
- ☐ Removed from the site by police, sheriff, game warden, etc.
- ☐ I removed it for disposal
- ☐ I harvested it for the meat (or gave it to someone else to harvest)
- ☐ Unknown
- ☐ Other (please explain)

After the crash, what happened to deer #3?

- ☐ Still alive - ran away
- ☐ Left dead on the road shoulder
- ☐ Left dead in the ditch, weeds, or woods
- ☐ Removed from the site by police, sheriff, game warden, etc.
- ☐ I removed it for disposal
- ☐ I harvested it for the meat (or gave it to someone else to harvest)
- ☐ Unknown

☐ Other (please explain)

Which best describes the location where the crash occurred?

- ☐ Unpaved (gravel) road
- ☐ Paved two-lane rural highway
- ☐ Freeway or expressway in a rural area
- ☐ Freeway or expressway in a city or suburb
- ☐ Street in a city, suburb, or small town

Do you know which county you were in at the time of the crash?

- ☐ Yes
- ☐ No or Not Sure

Please indicate the county where the crash occurred:

### Vehicle Damage - 2 Year

Which best describes the vehicle you were in?

- ☐ Car, pickup, van, or SUV
- ☐ Motorcycle
- ☐ Motorhome, RV, or car/pickup/van/SUV pulling a trailer
- ☐ Bus or schoolbus that seats 16 or more passengers
- ☐ CDL truck such as a semi or dumptruck weighing more than 26,000 pounds

☐ Other

Was the vehicle damaged?

☐ Yes

☐ No

What was the value of the vehicle before the crash?

☐ Less than \$500

☐ \$500 to \$999

☐ \$1,000 to \$2,499

☐ \$2,500 to \$4,999

☐ \$5,000 to \$9,999

☐ \$10,000 to \$14,999

☐ \$15,000 to \$19,999

☐ \$20,000 to \$24,999

☐ \$25,000 or more

What was the approximate cost of repairing the damage?

☐ \$0 (no damage)

☐ \$1 to \$249

☐ \$250 to \$499

☐ \$500 to \$999

☐ \$1,000 to \$2,499

☐ \$2,500 to \$4,999

☐ \$5,000 to \$9,999

☐ \$10,000 to \$14,999

☐ \$15,000 to \$19,999

☐ \$20,000 to \$24,999

☐ \$25,000 or more

☐ Not sure / waiting for estimates / unknown

What did you end up doing about the vehicle?

- ☐ Replaced it
- ☐ Repaired it completely
- ☐ Partially repaired it
- ☐ Continued driving it as-is
- ☐ Sold or scrapped the vehicle but didn't replace it
- ☐ Received insurance payout but didn't buy a replacement vehicle
- ☐ Still deciding what to do
- ☐ Unknown

Was the second-most recent crash reported to the police or sheriff (or a DNR game warden)?

- ☐ Yes
- ☐ No
- ☐ Not sure / don't know

Was the third-most recent crash reported to the police or sheriff (or a DNR game warden)?

- ☐ Yes
- ☐ No
- ☐ Not sure / don't know

### Crash Details - 10 Year

How many deer-vehicle crashes were you involved in?

- ☐ 1
- ☐ 2
- ☐ 3 or more

In the most recent collision were you...

- ☐ Driver
- ☐ Passenger
- ☐ Other (pedestrian, bicyclist, bystander, etc.)

Were any humans injured or killed in the crash?

- ☐ Yes
- ☐ No
- ☐ Not sure / don't know

How many vehicles were involved in the crash?

- ☐ Only mine
- ☐ Mine and one other
- ☐ Mine and two or more others

Was the crash reported to the police or sheriff (or a DNR game warden)?

- ☐ Yes
- ☐ No
- ☐ Not sure / don't know

Was the crash reported to the insurance company?

- ☐ Yes



- ☐ No
- ☐ Not sure / don't know

How many deer were struck?

- ☐ 1
- ☐ 2
- ☐ 3 or more

After the crash, what happened to deer #1?

- ☐ Still alive - ran away
- ☐ Left dead on the road shoulder
- ☐ Left dead in the ditch, weeds, woods, etc.
- ☐ Removed from the site by police, sheriff, game warden, etc.
- ☐ I removed it for disposal
- ☐ I harvested it for the meat (or gave it to someone else to harvest)
- ☐ Unknown
- ☐ Other (please explain)

After the crash, what happened to deer #2?

- ☐ Still alive - ran away
- ☐ Left dead on the road shoulder
- ☐ Left dead in the ditch, weeds, woods, etc.
- ☐ Removed from the site by police, sheriff, game warden, etc.
- ☐ I removed it for disposal
- ☐ I harvested it for the meat (or gave it to someone else to harvest)
- ☐ Unknown

☐ Other (please explain)

After the crash, what happened to deer #3?

- ☐ Still alive - ran away
- ☐ Left dead on the road shoulder
- ☐ Left dead in the ditch, weeds, woods, etc.
- ☐ Removed from the site by police, sheriff, game warden, etc.
- ☐ I removed it for disposal
- ☐ I harvested it for the meat (or gave it to someone else to harvest)
- ☐ Unknown
- ☐ Other (please explain)

Which best describes the location where the crash occurred?

- ☐ Unpaved (gravel) road
- ☐ Paved two-lane rural highway
- ☐ Freeway or expressway in a rural area
- ☐ Freeway or expressway in a city or suburb
- ☐ Street in a city, suburb, or small town

### Vehicle Damage - 10 Year

Which best describes the vehicle you were in?

- ☐ Car, pickup, van, or SUV
- ☐ Motorcycle
- ☐ Motorhome, RV, or car/pickup/van/SUV pulling a trailer
- ☐ Bus or schoolbus that seats 16 or more passengers
- ☐ CDL truck such as a semi or dumptruck weighing more than 26,000 pounds
- ☐ Other

Was the vehicle damaged?

- ☐ Yes
- ☐ No

What did you end up doing about the vehicle?

- ☐ Replaced it
- ☐ Repaired it completely
- ☐ Partially repaired it
- ☐ Continued driving it as-is
- ☐ Sold or scrapped the vehicle but didn't replace it
- ☐ Received insurance payout but didn't buy a replacement vehicle
- ☐ Unknown

Was the second-most recent crash reported to the police or sheriff (or a DNR game warden)?

- ☐ Yes
- ☐ No
- ☐ Not sure / don't know

Was the third-most recent crash reported to the police or sheriff (or a DNR game warden)?

- ☐ Yes
- ☐ No
- ☐ Not sure / don't know

## Respondent Demographics

To help us make sure our survey is reaching a representative cross-section of Iowa road users, please tell us a bit about yourself.

From which state or country is your driving license?

- ☐ Iowa
- ☐ Illinois
- ☐ Nebraska
- ☐ Minnesota
- ☐ Missouri
- ☐ South Dakota
- ☐ Wisconsin
- ☐ Other US state or territory
- ☐ Canada
- ☐ Mexico
- ☐ Other international licenses
- ☐ Not licensed

Do you live in Iowa?

- ☐ Yes
- ☐ No

Which county of Iowa do you live in?

In a typical week, how many hours do you spend driving in the state of Iowa?

- ☐ None
- ☐ 1 to 4
- ☐ 5 to 9
- ☐ 10 to 14
- ☐ 15 to 19
- ☐ 20 to 29
- ☐ 30 to 39
- ☐ 40 or more

What is your age range?

- ☐ 13 or younger
- ☐ 14 - 17
- ☐ 18 - 24
- ☐ 25 - 34
- ☐ 35 - 44
- ☐ 45 - 54
- ☐ 55 - 64
- ☐ 65 - 74
- ☐ 75 - 84
- ☐ 85 or older

Which best describes your ethnicity? (select all that apply)

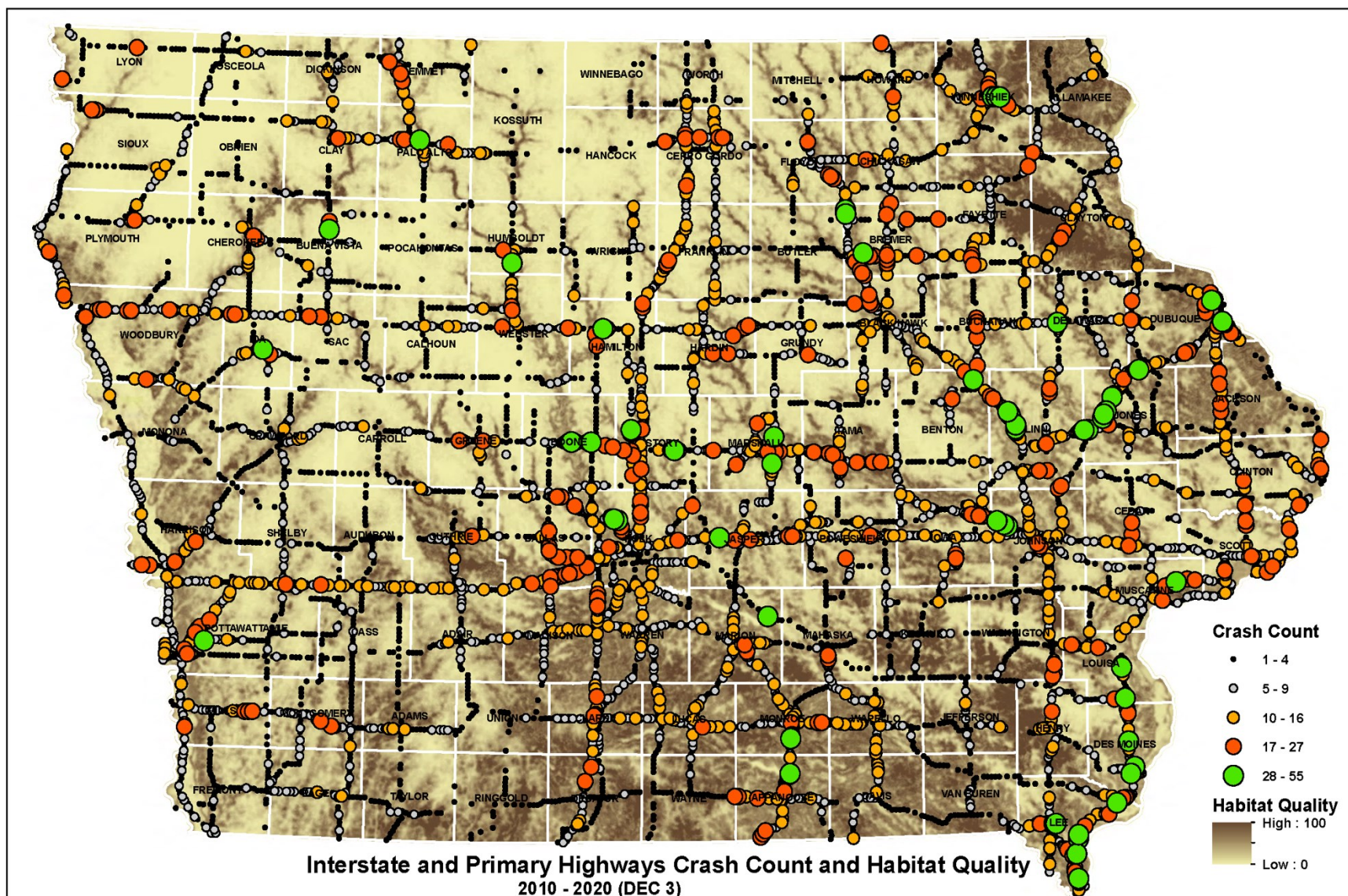
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Hispanic or Latino

- ☐ Native Hawaiian or Pacific Islander
- ☐ White
- ☐  Prefer to describe as indicated below
- ☐ Prefer not to answer

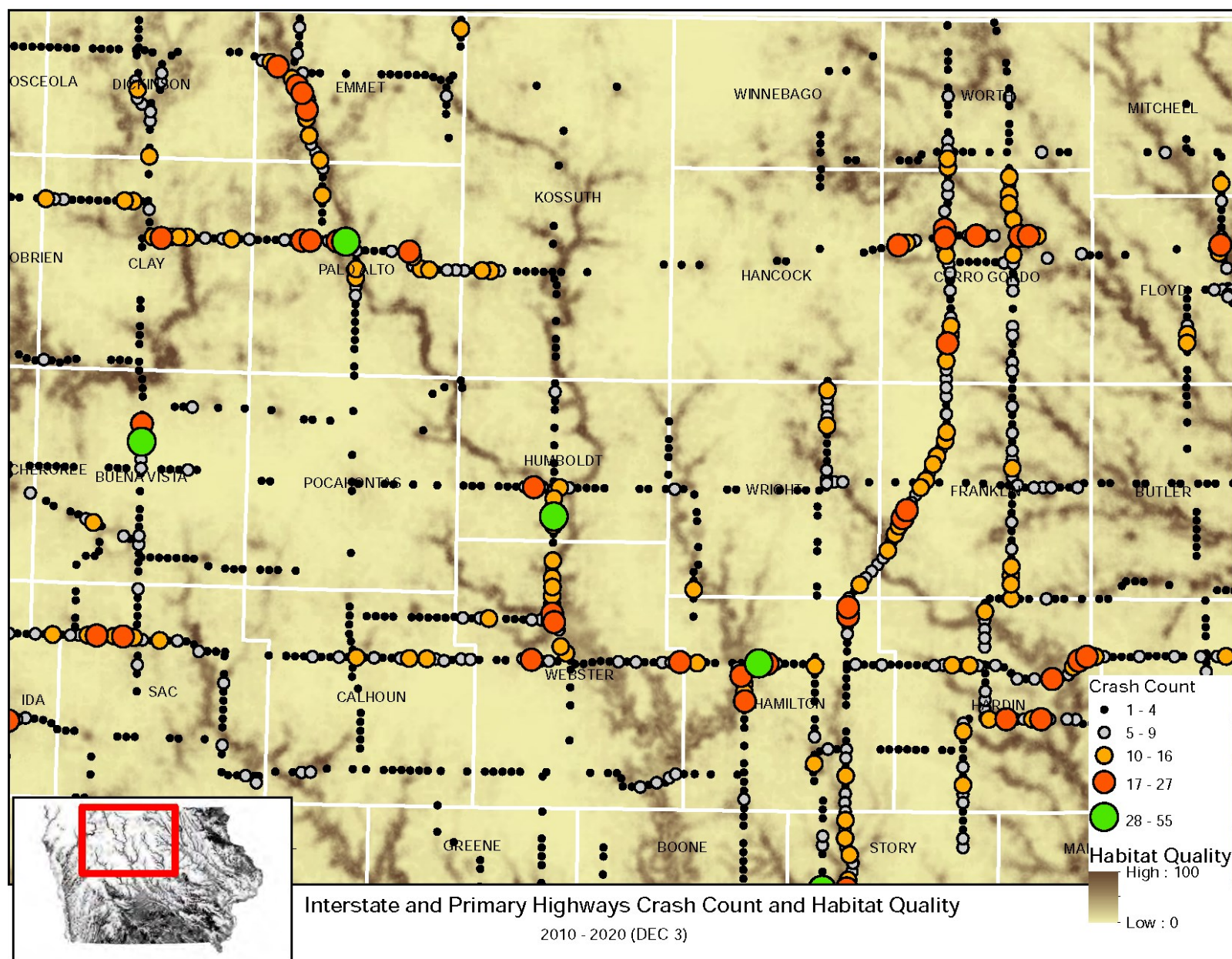
Which best describes your gender?

- ☐ Woman
- ☐ Man
- ☐  Prefer to describe as indicated below
- ☐ Prefer not to answer

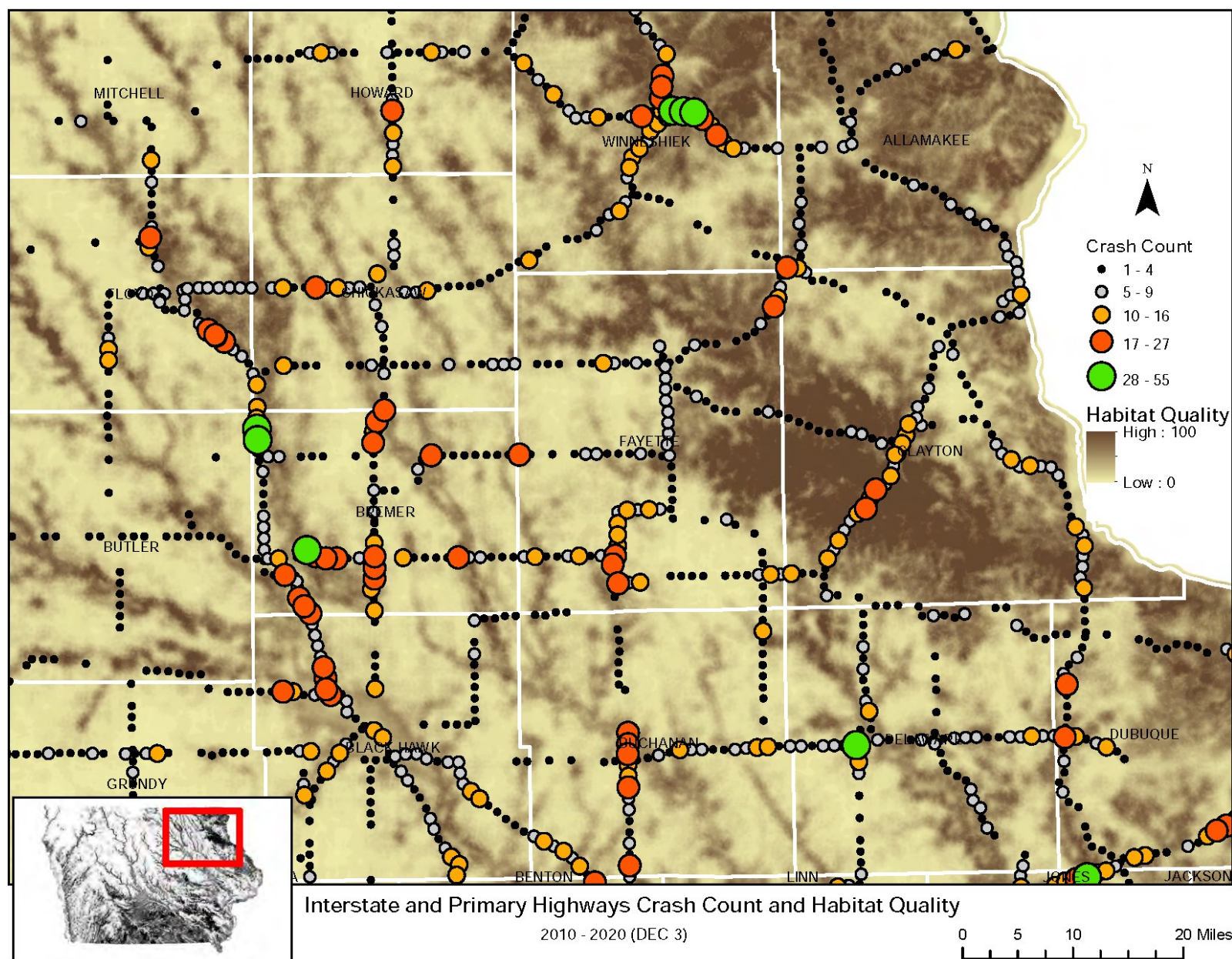
## **APPENDIX B. DEER CRASH LOCATION MAPS**



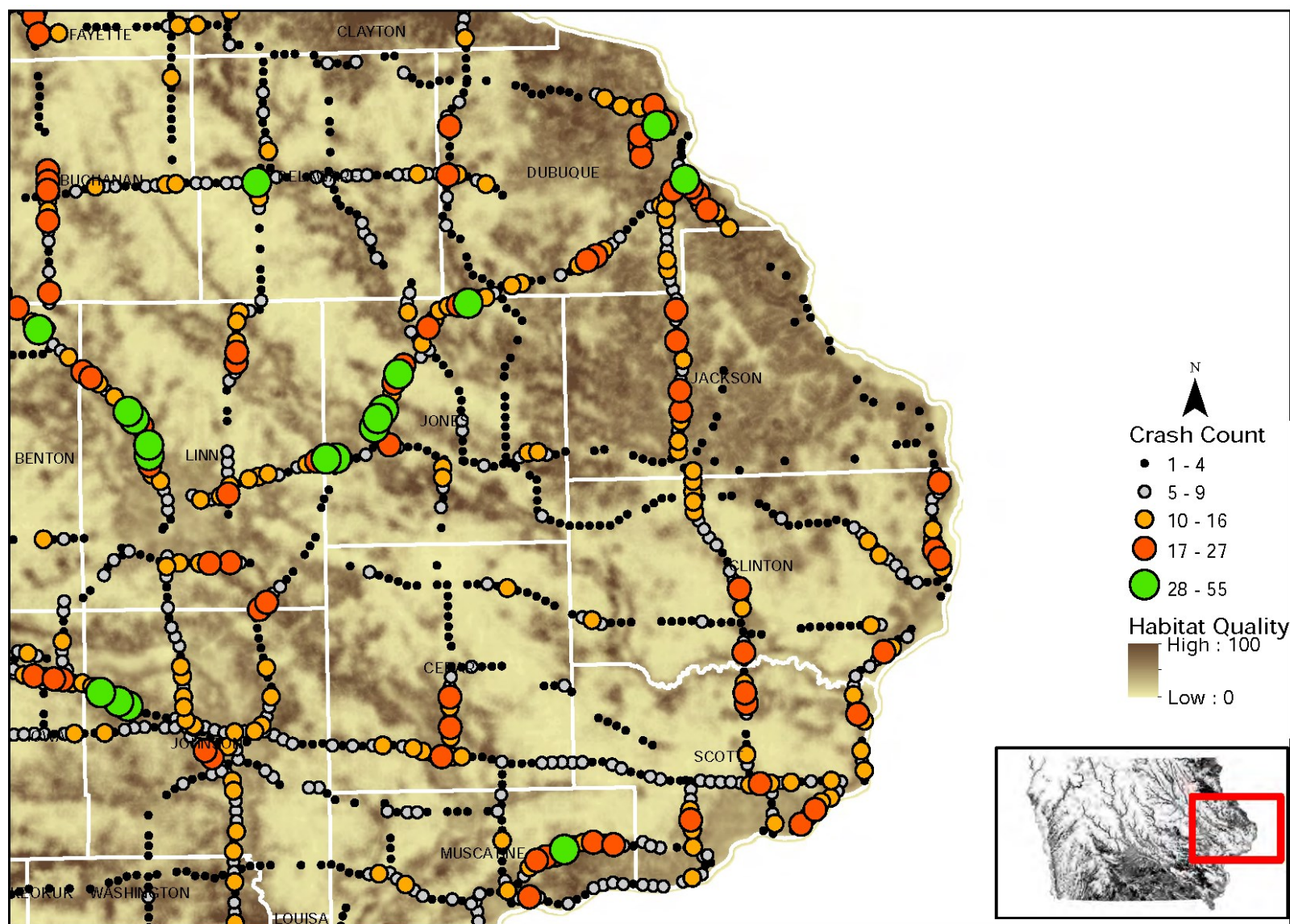










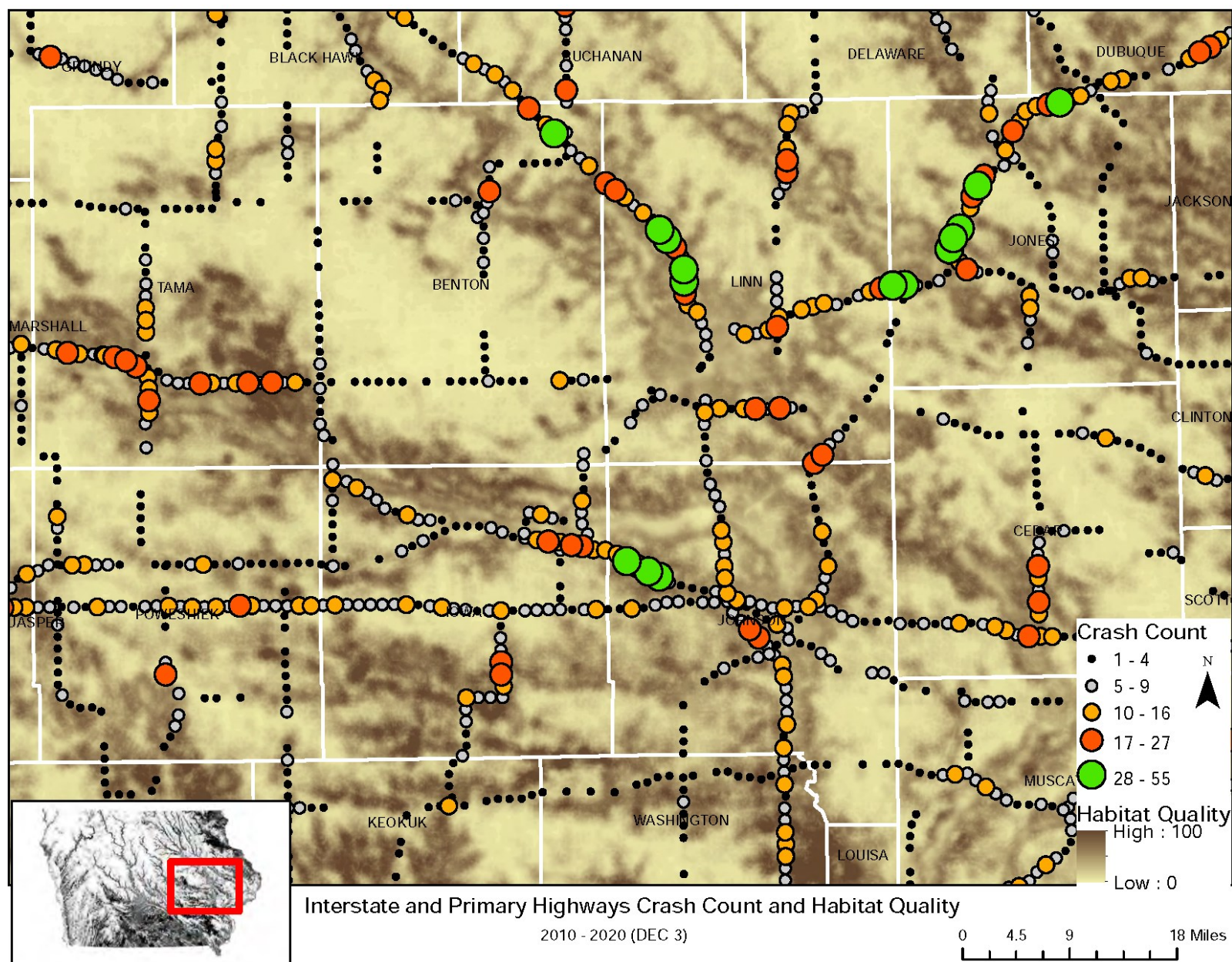


Interstate and Primary Highways Crash Count and Habitat Quality

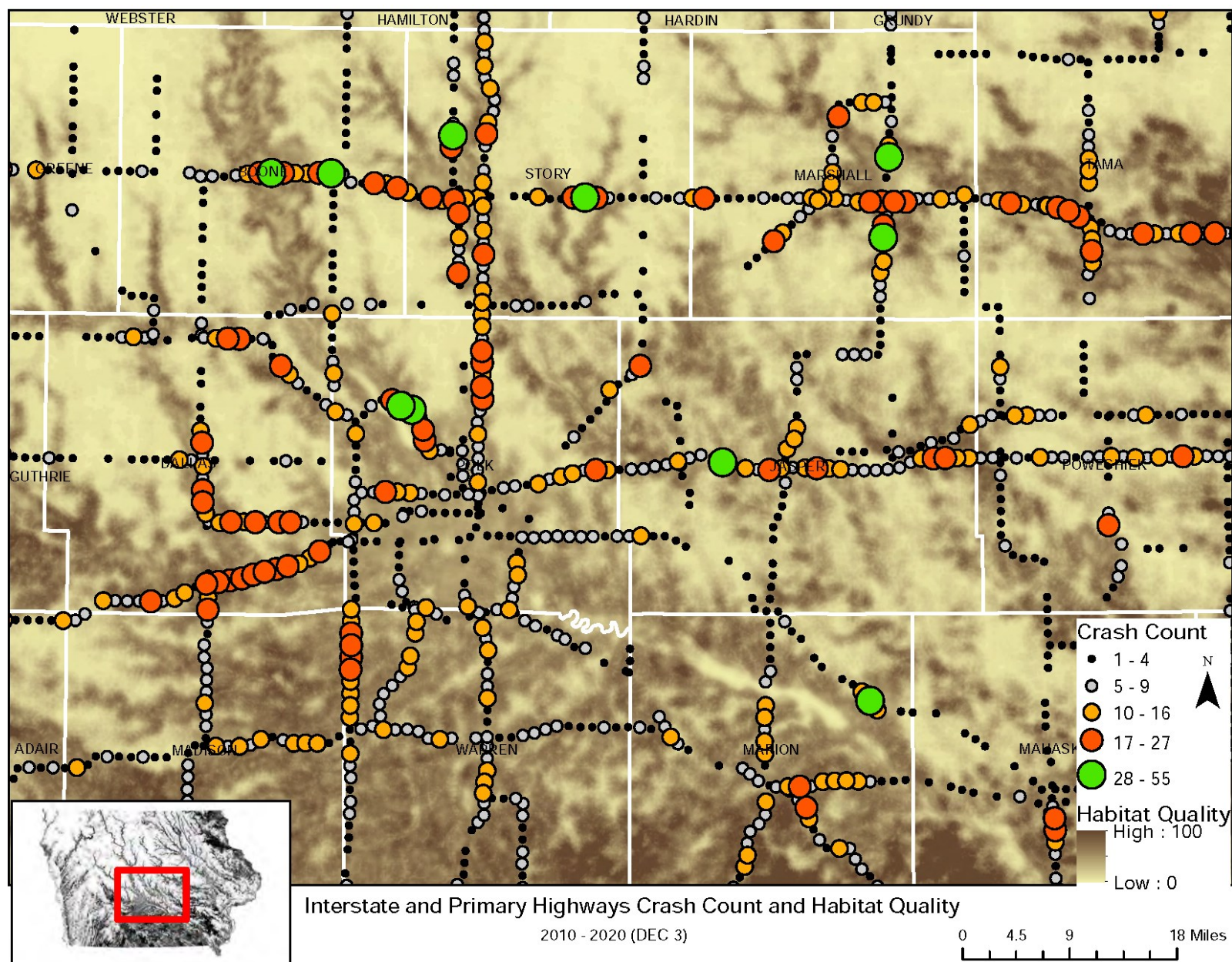
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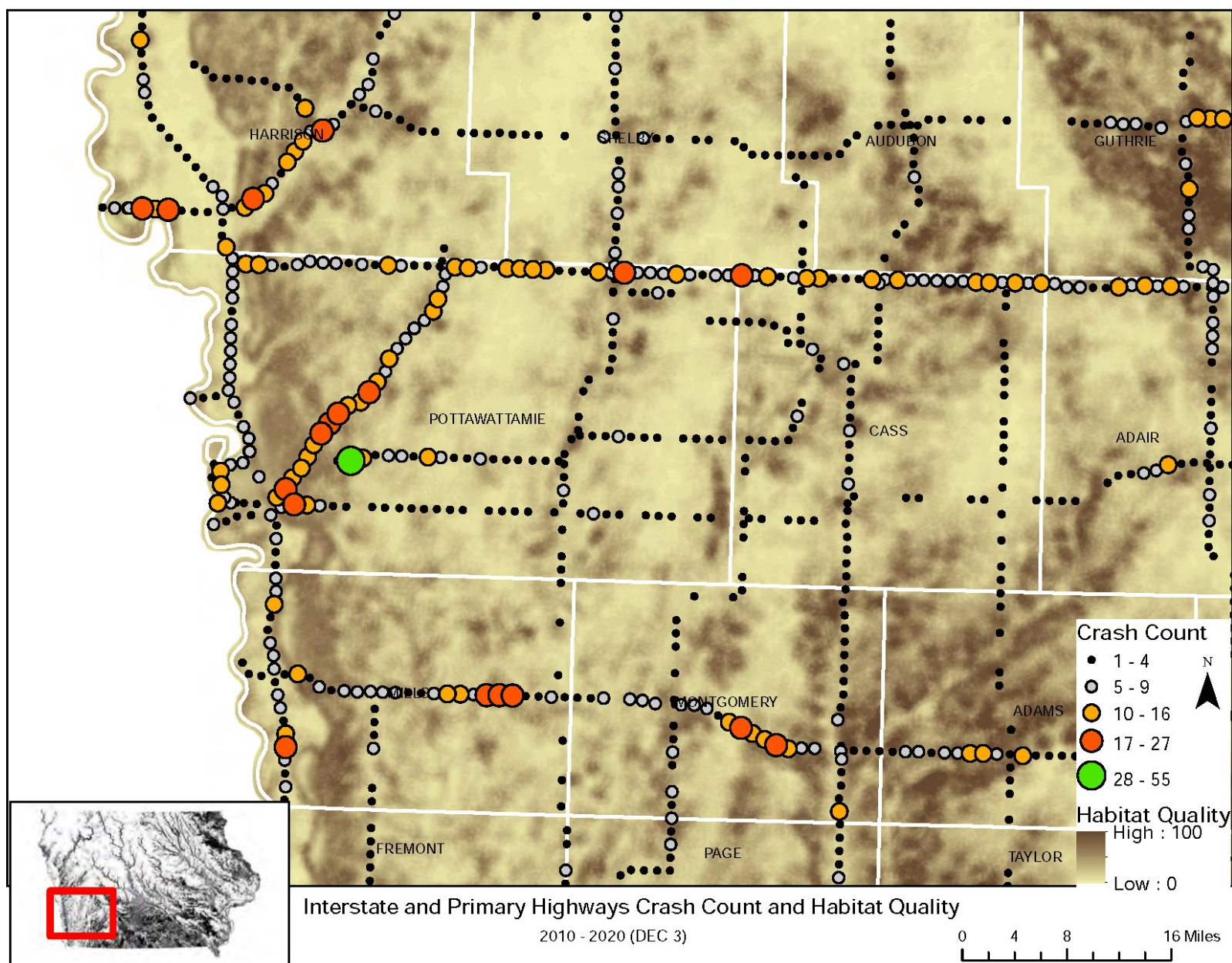




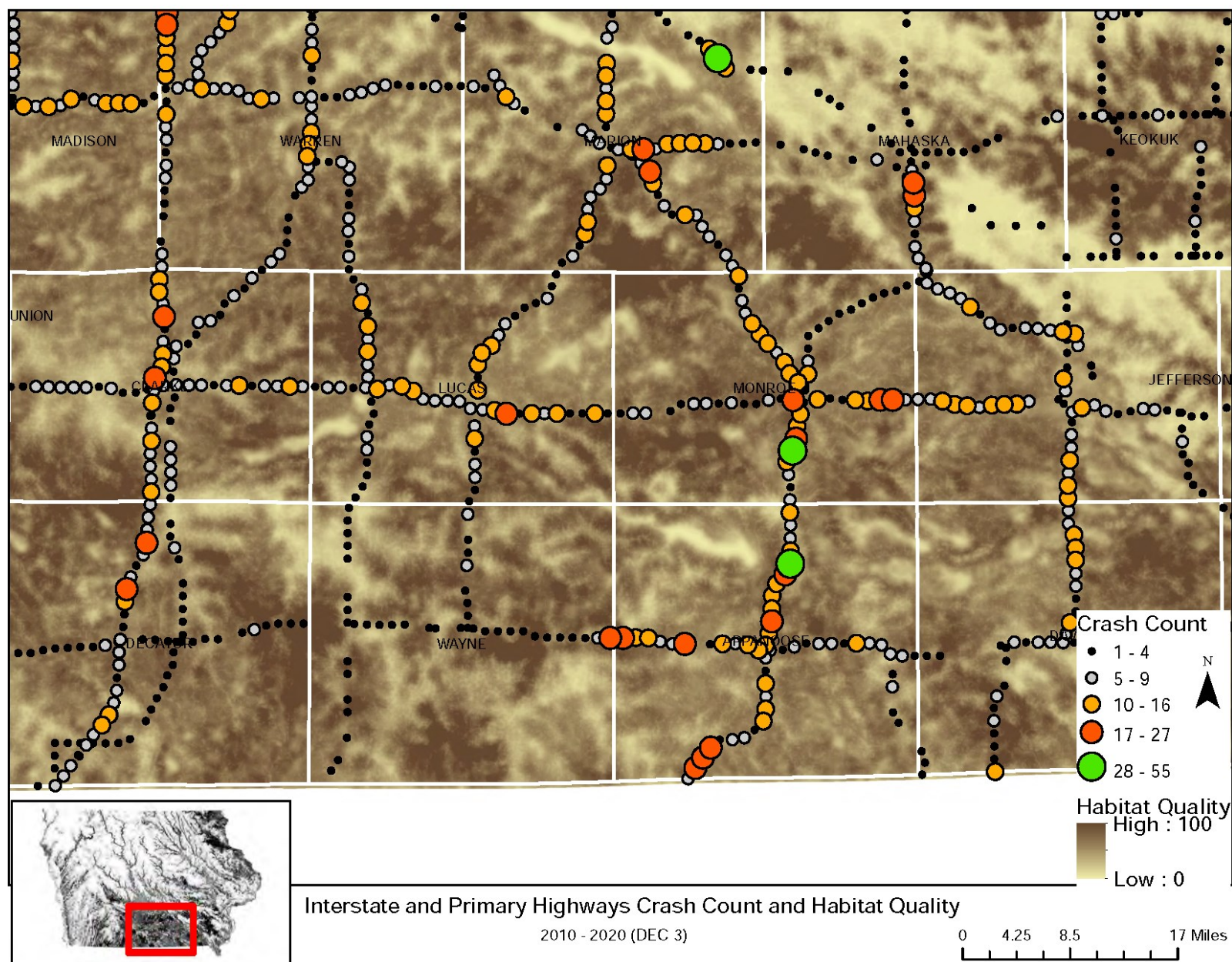


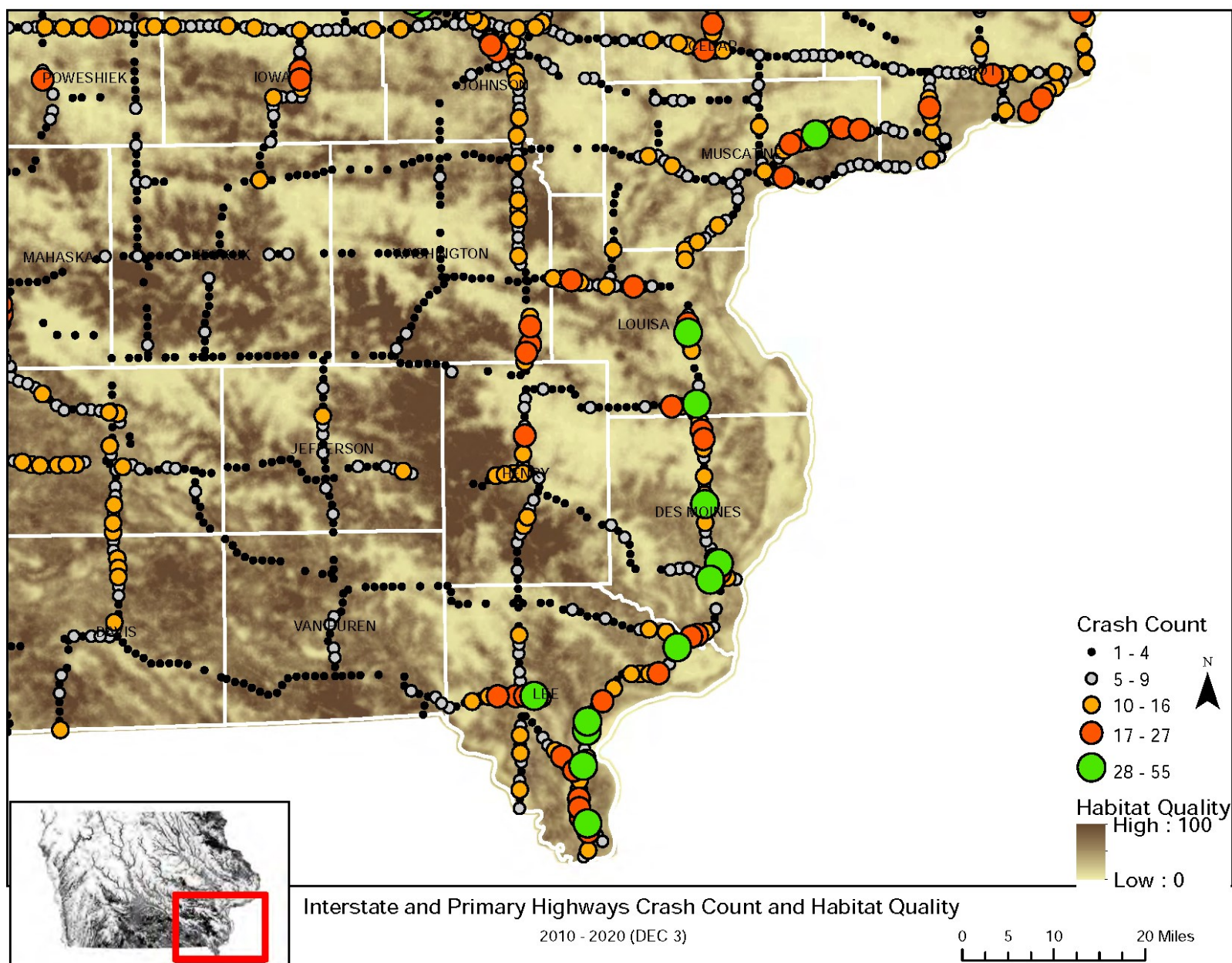




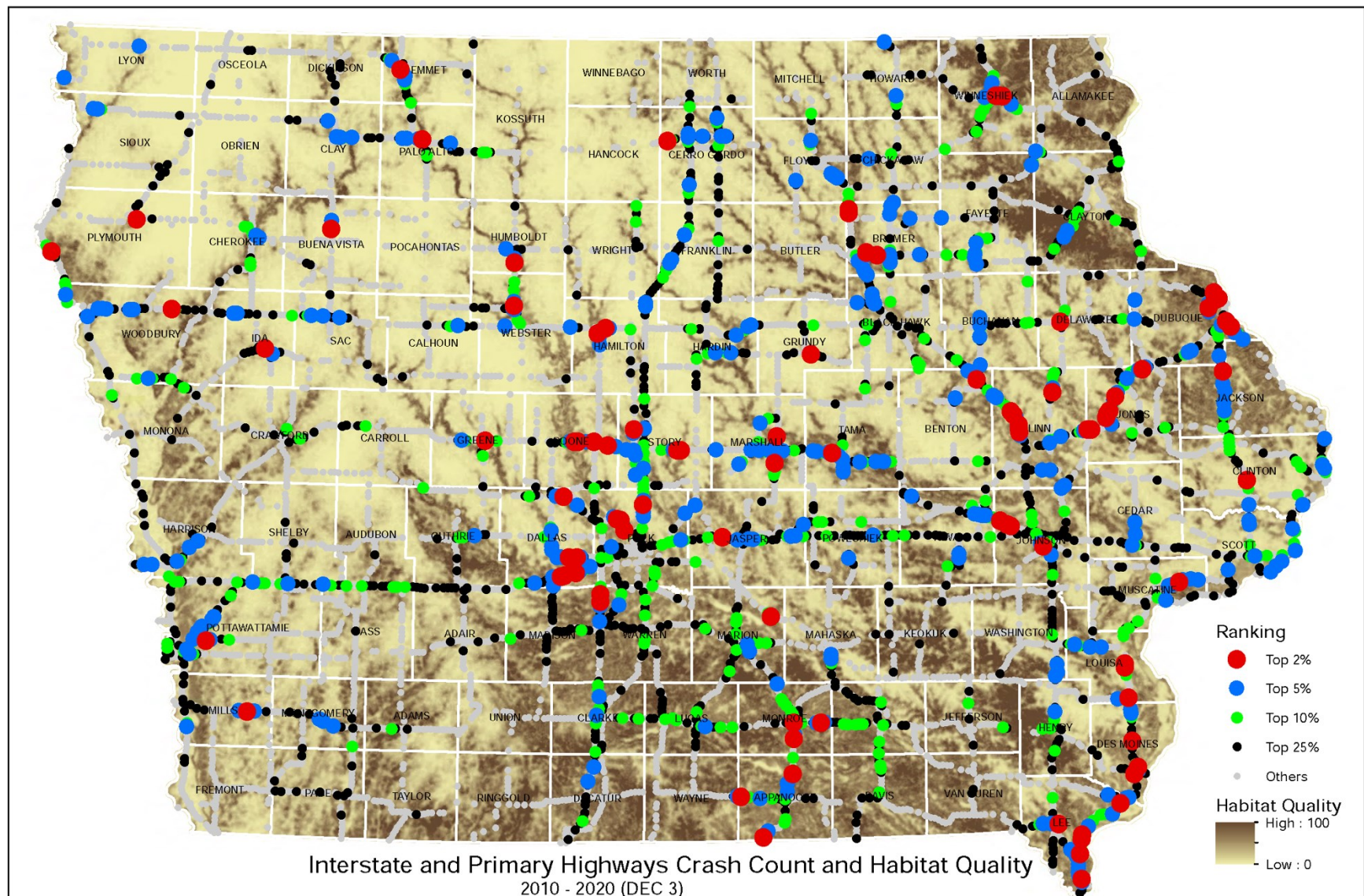




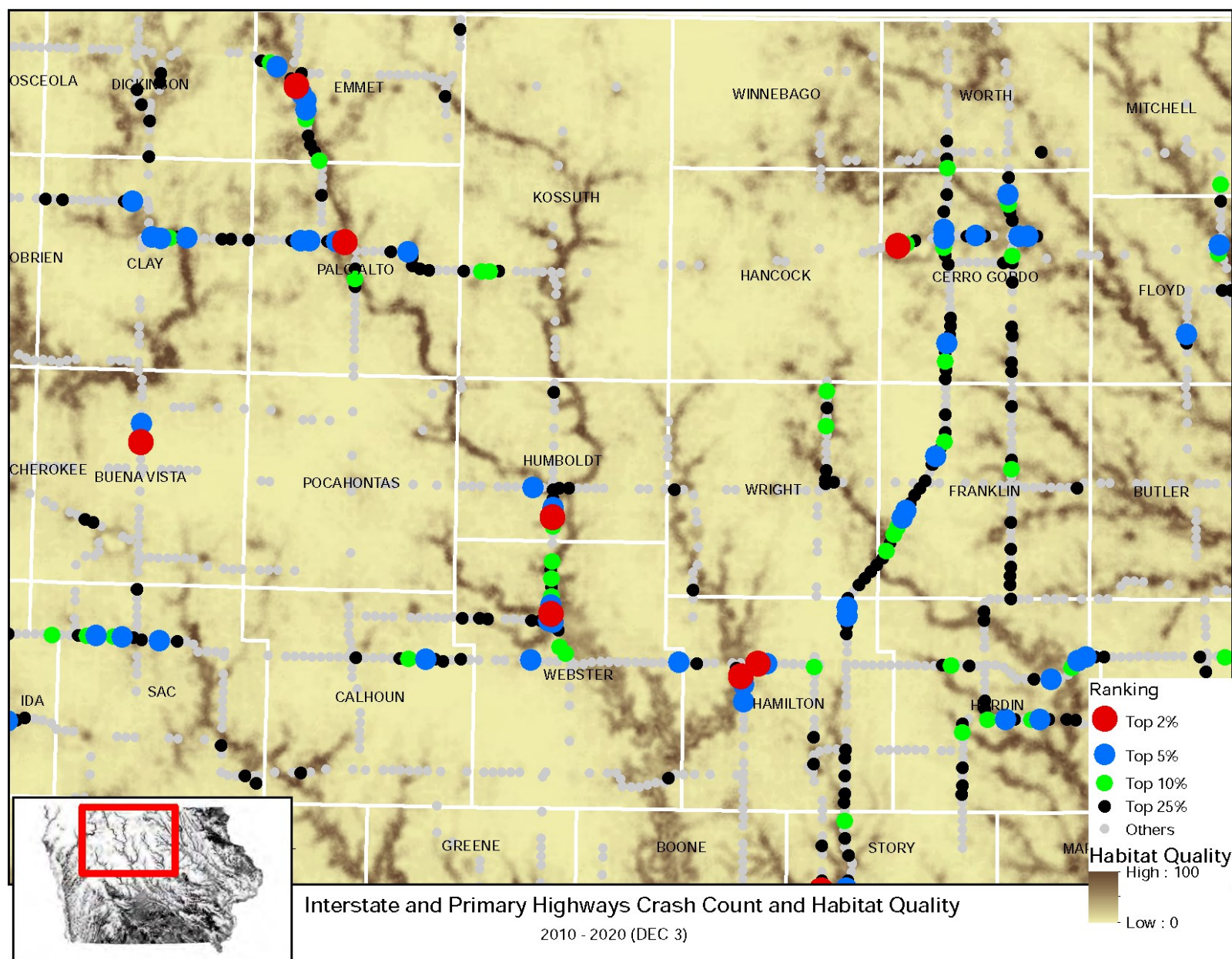




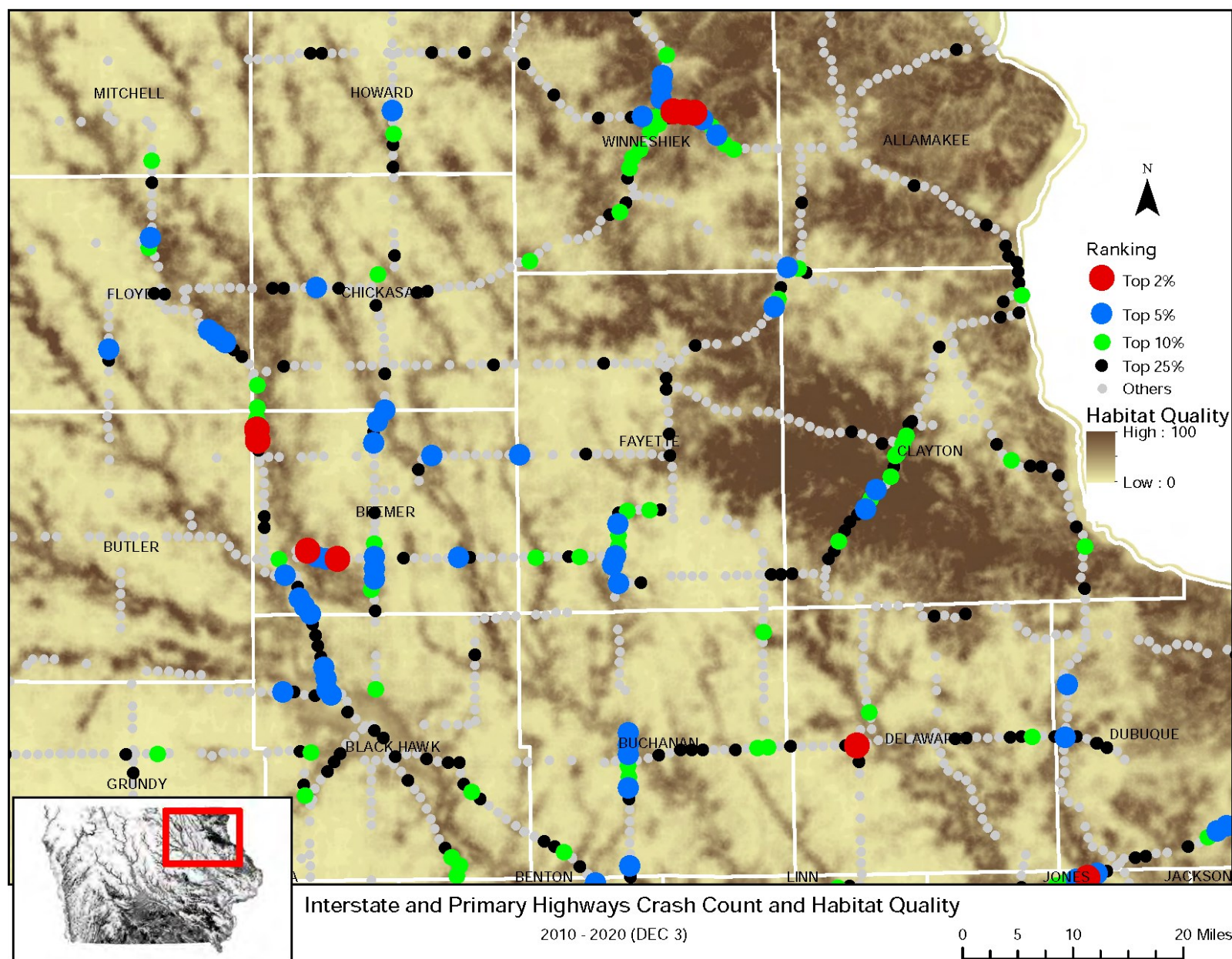


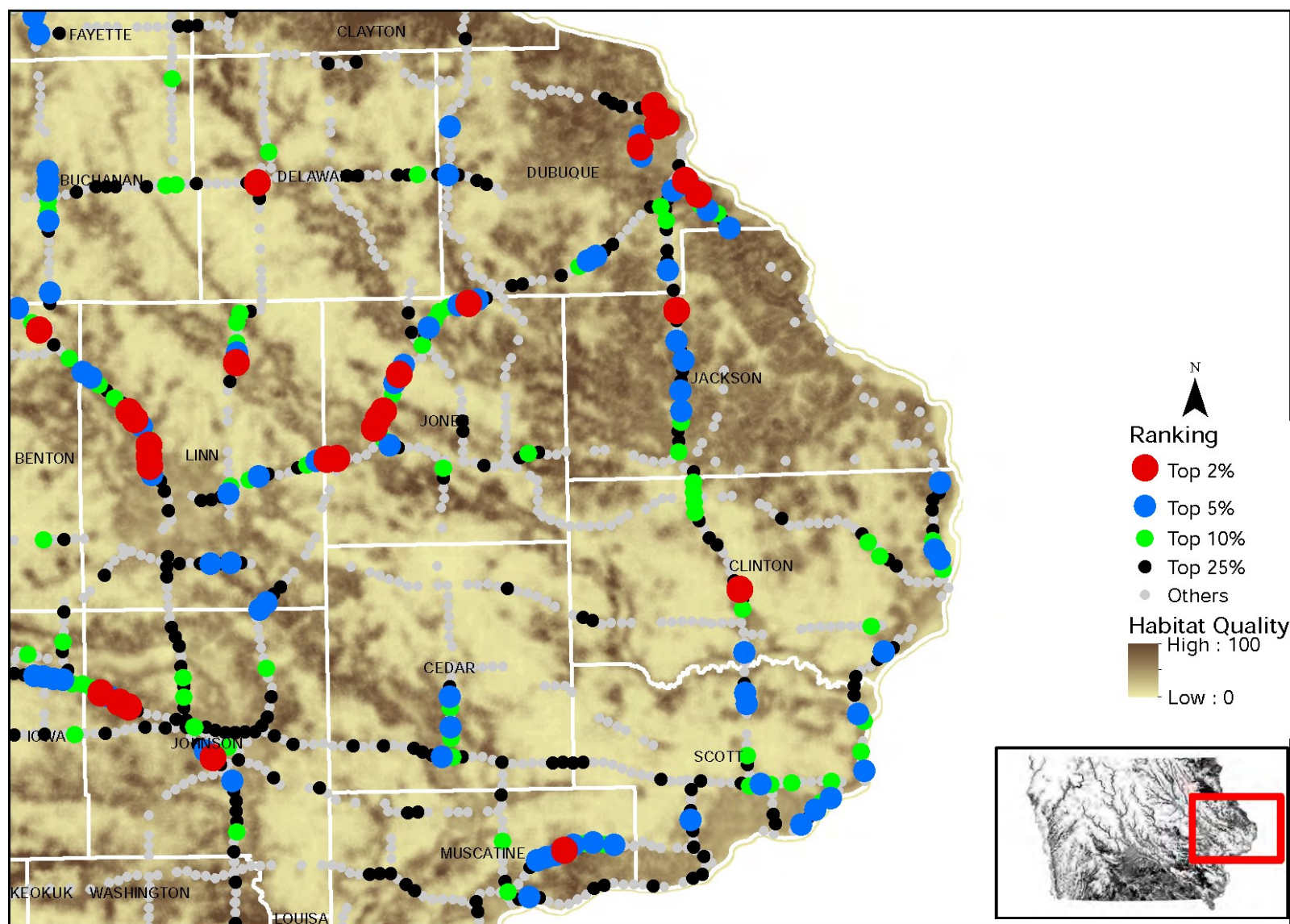








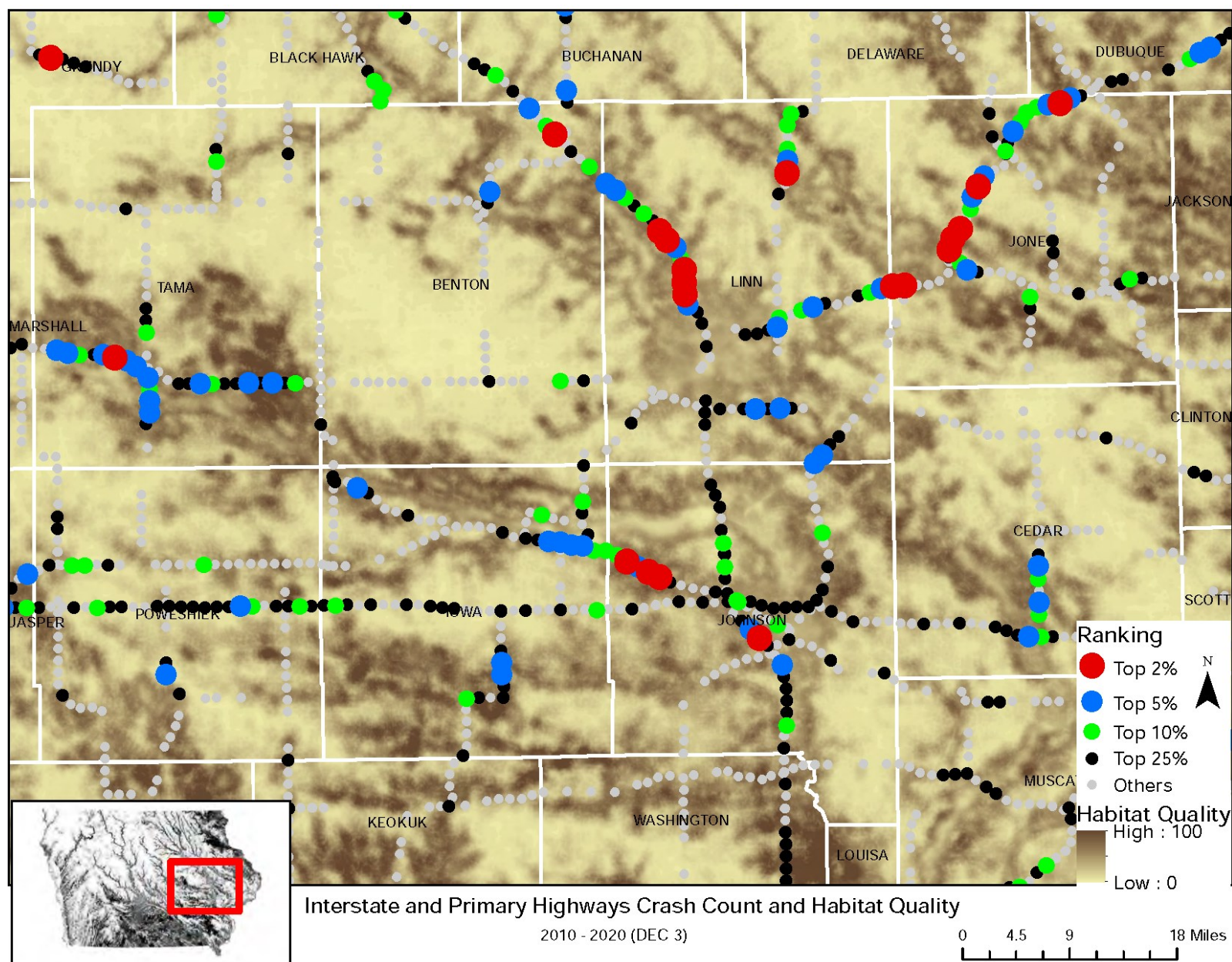




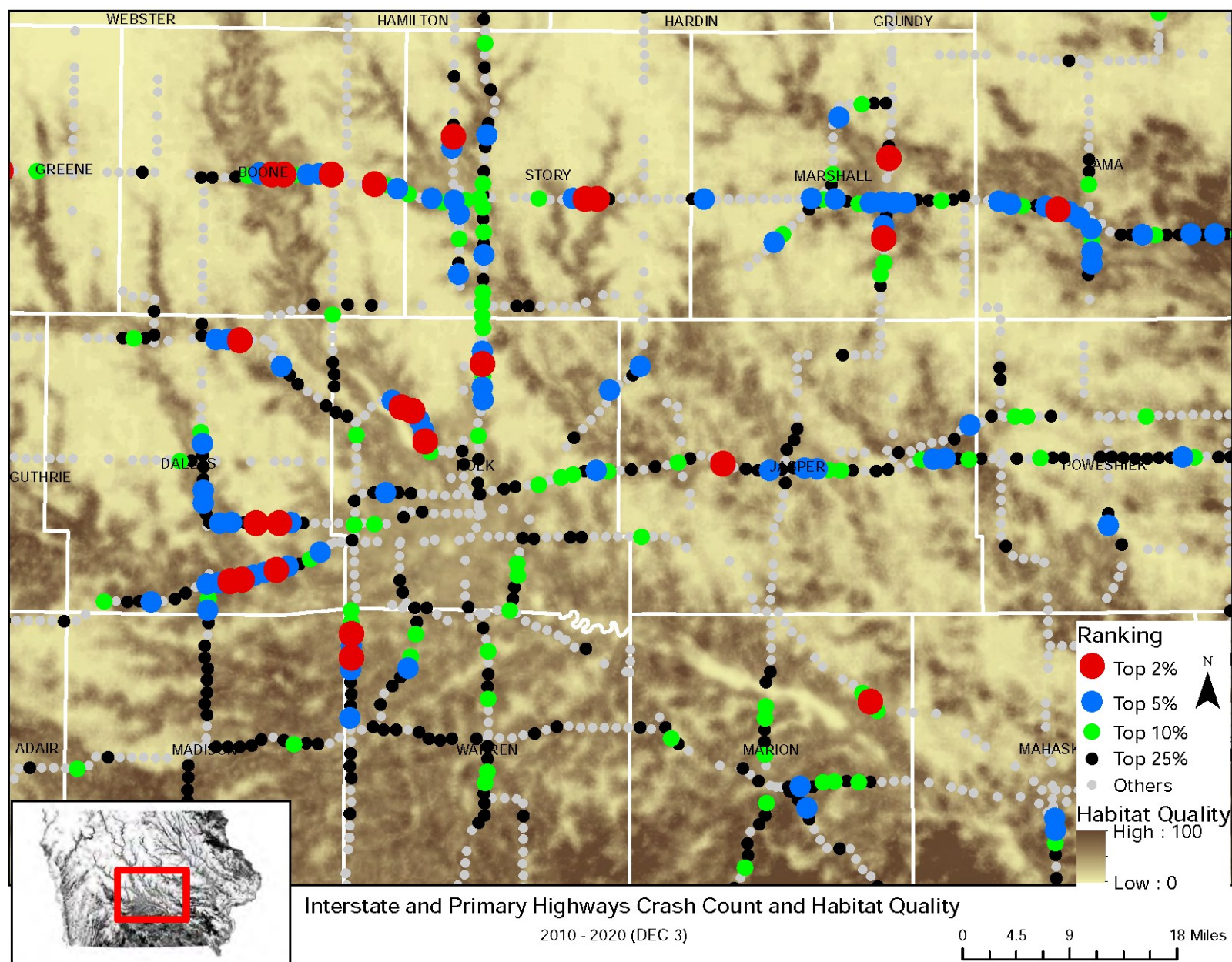
Interstate and Primary Highways Crash Count and Habitat Quality

2010 - 2020 (DEC 3)

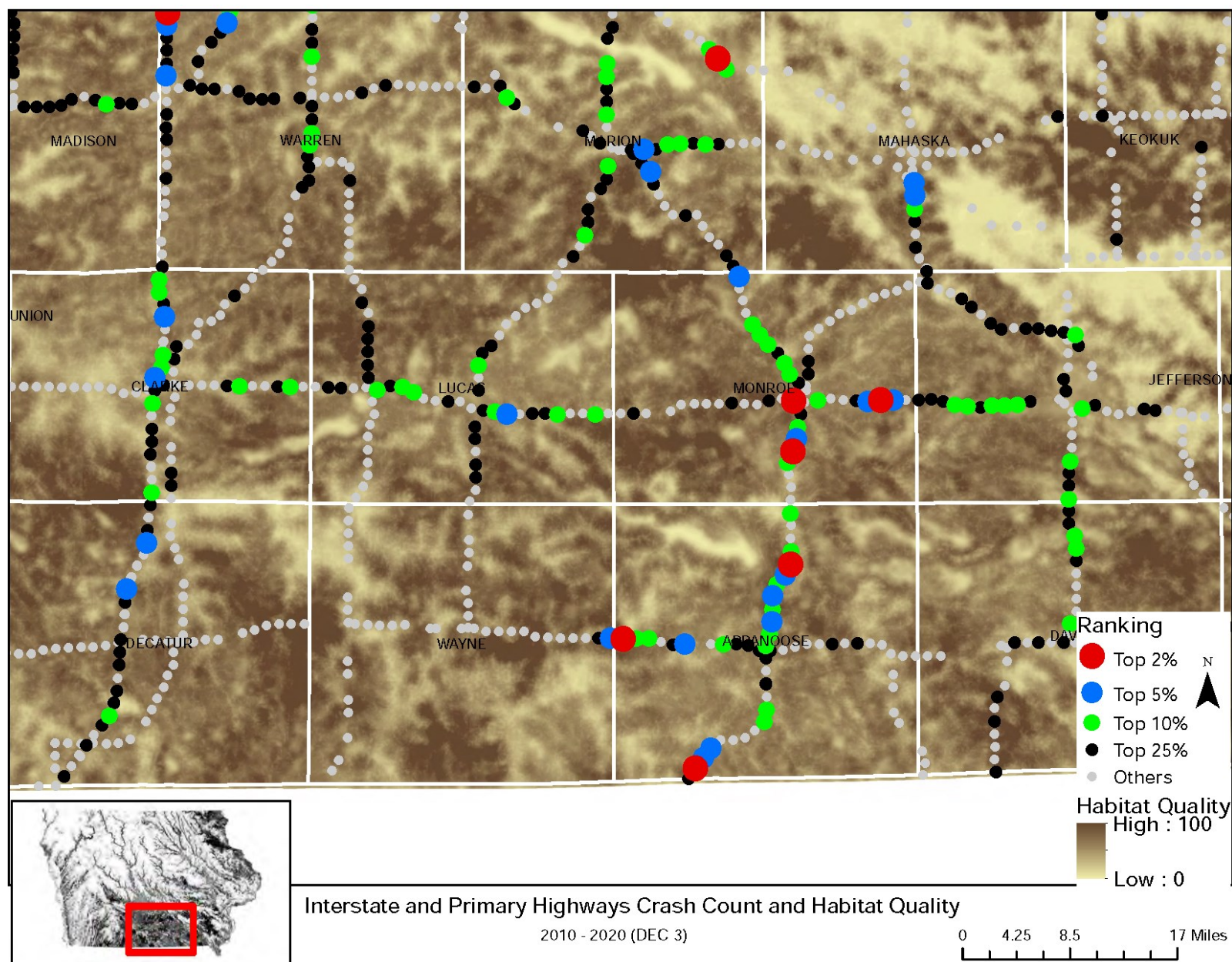


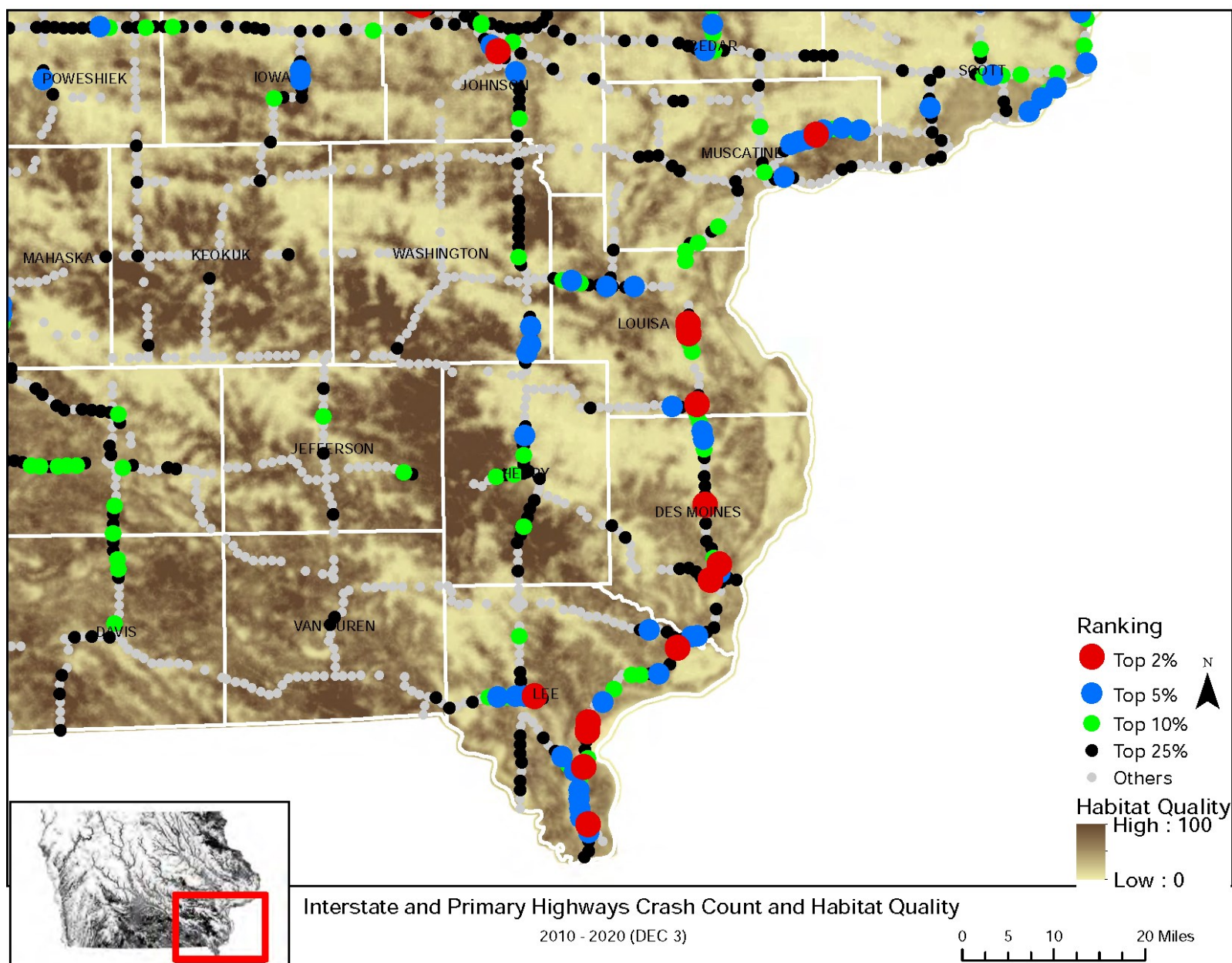




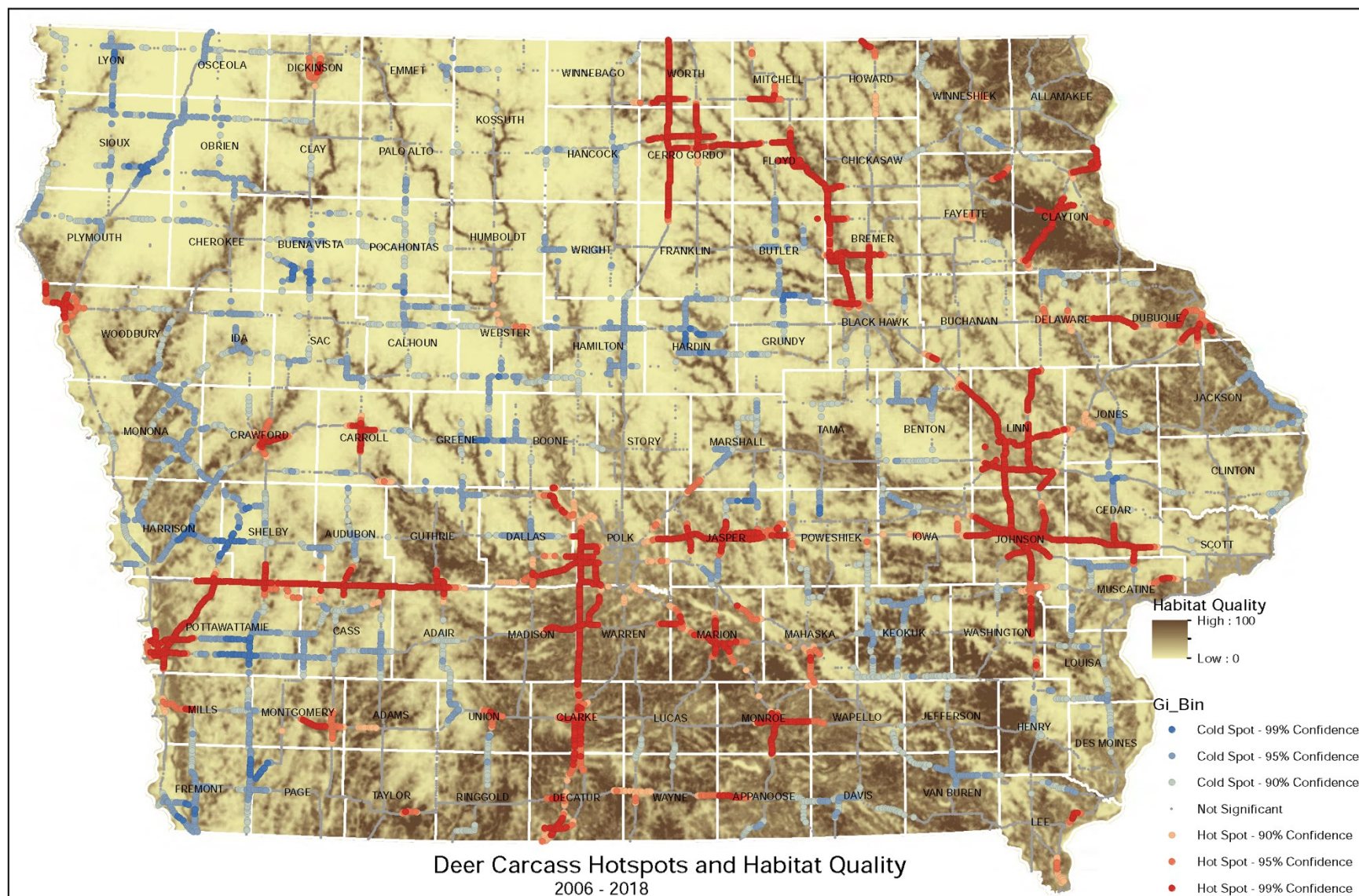




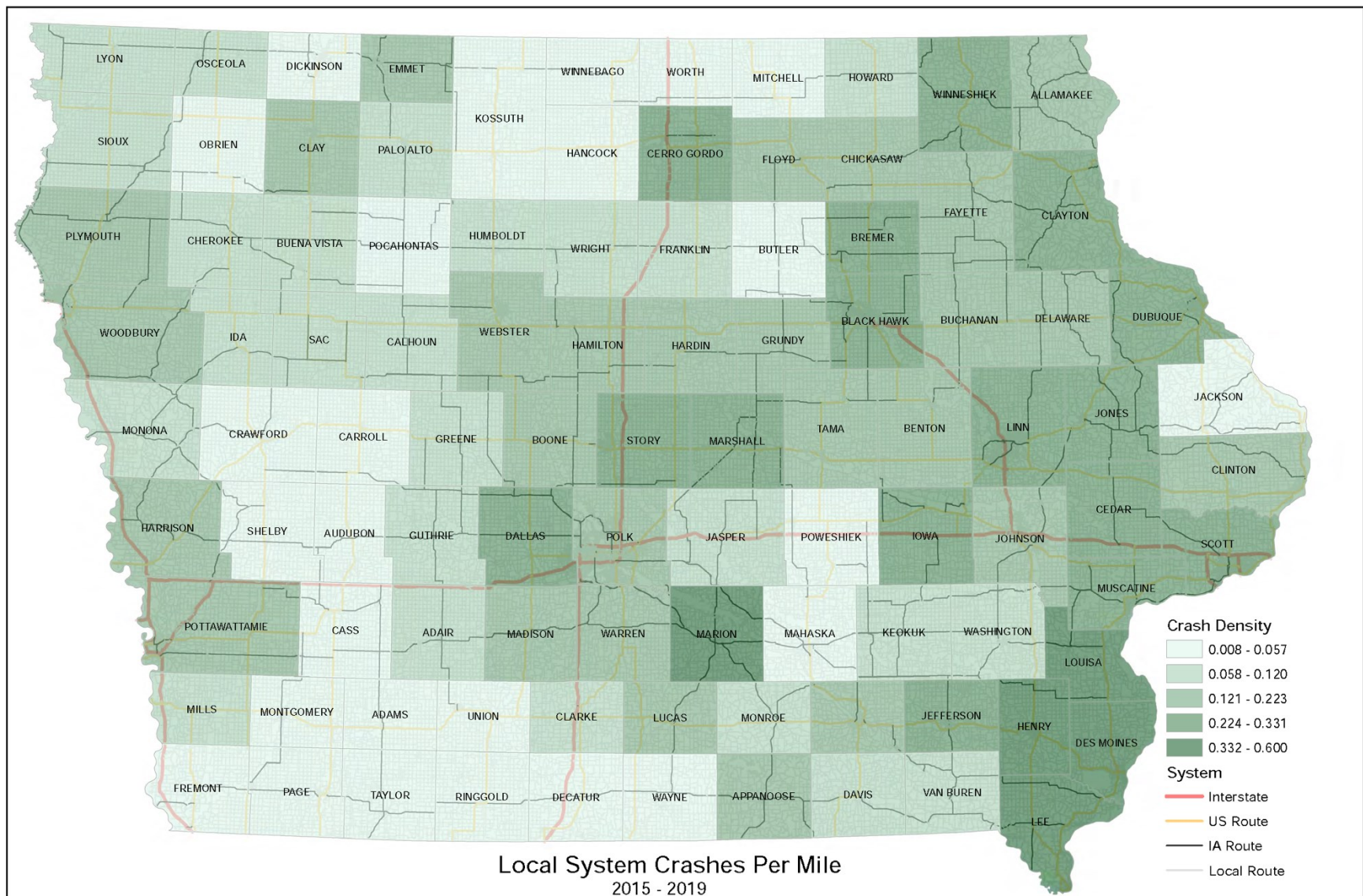


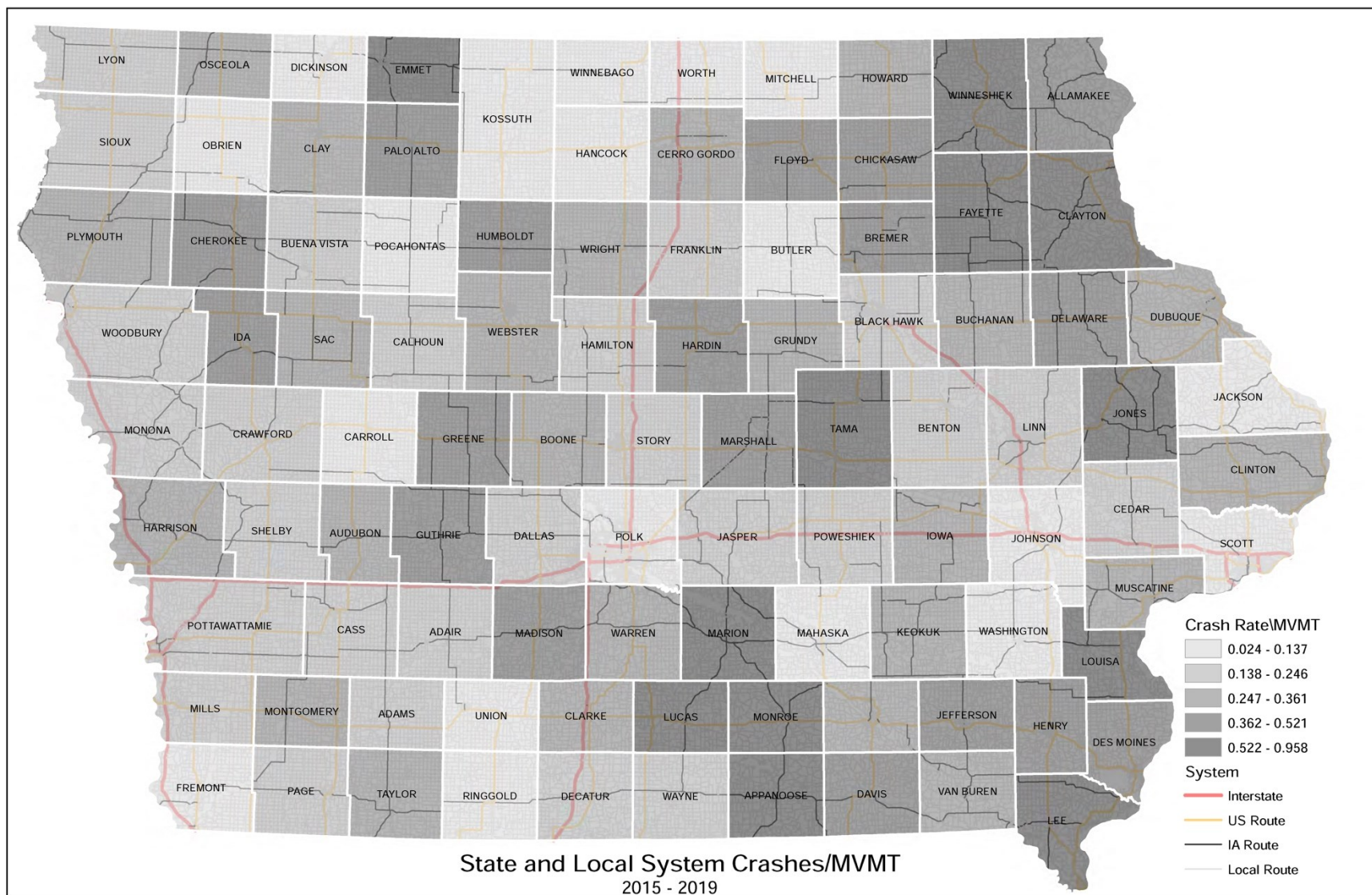


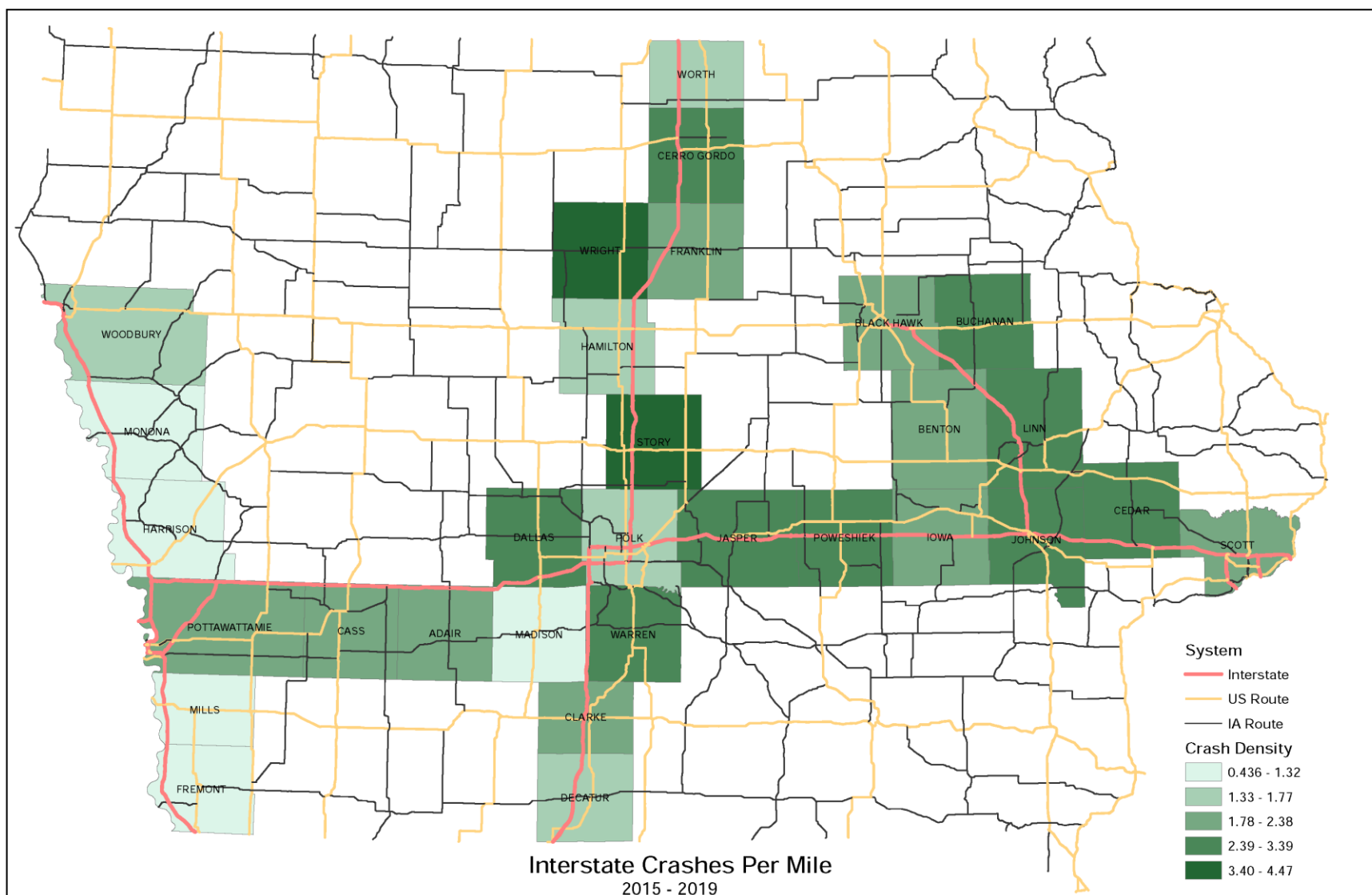




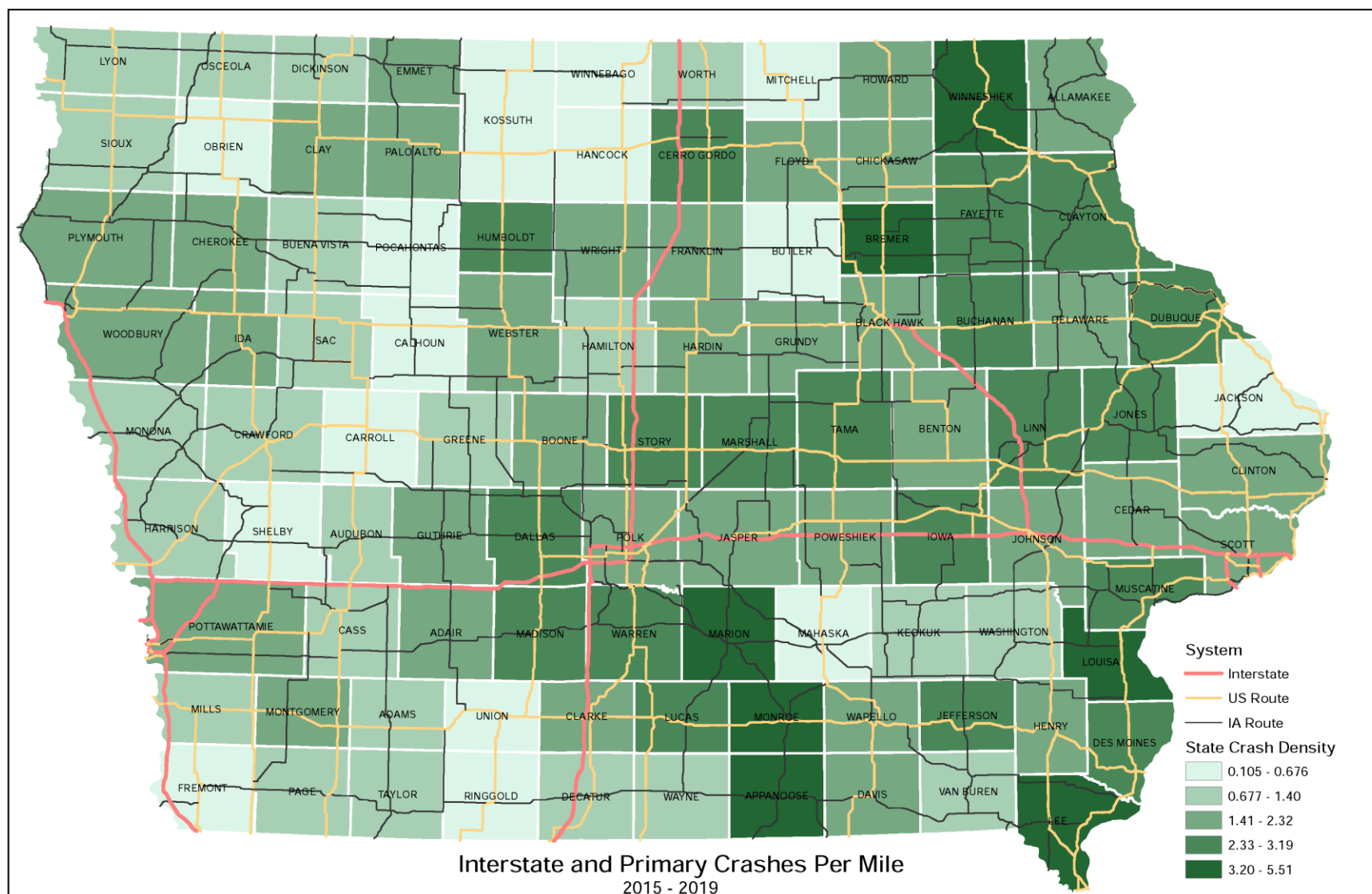


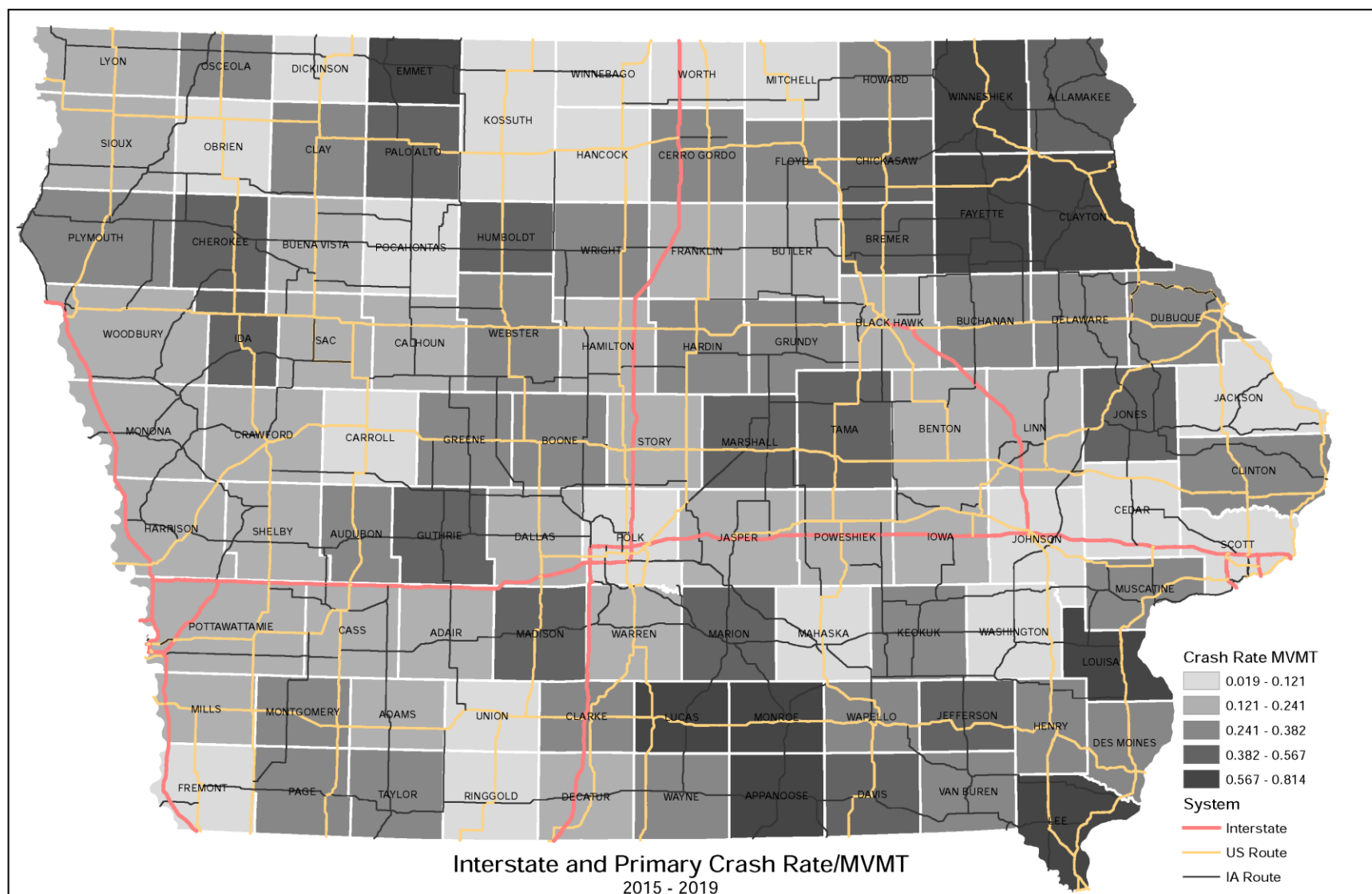














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