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Geospatial Analysis of Rural Motor Vehicle Traffic Crashes in Oregon

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Geospatial Analysis of Rural Motor Vehicle Traffic Crashes in Oregon

by

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Abstract

This research examines the spatial extent of crashes in and around city boundaries in the state of Oregon in the U.S.A. For this study, summary of fatalities data for the year 2006 obtained from NHTSA's report (2009), crash data for the year 2012, and city boundaries were obtained from ODOT "Oregon Department of Transportation" FTP: www.odot.state.or.us. In order to differentiate between the urban and rural crashes, city boundaries were used to find the numbers of urban and rural crashes. Outside areas of this urban-rural boundary were divided into further boundaries of 2.5 miles. An intersection tool in ArcMap was used to locate crashes within these areas. Road crashes in Oregon were classified into fatality crashes, serious injury crashes (Injury Type A), non-fatal crashes (KABC), and PDO (Property damaged only) crashes. By using the miles of road method, this research found that the total number of crashes that were recorded were 49,790. The number of fatal crashes was 305 while non-fatal (KABC) crashes were 24,455 and while 25,030 crashes resulted in PDO, and 1432 crashes resulted in serious injuries. A difference in the percentage of fatal crashes has been observed in crashes involving the use of alcohol, unbelted occupants, during weekends, during nighttime and on US / State highways. Another difference in the percentage of fatal crashes was on interstate highways crashes. Fatal crashes have shown a difference on the results of this research and the one done by NHTSA in 2009, the difference was 1% on the urban zone, for the 10 mile buffer zone the difference was 21% from the year 2006 to 2012. Thus, it is essential to establish safety-associated outlays and shoulder widening, making suitable alterations to the existing vertical and horizontal curves, introduction of median treatments and to introduce the resurfacing will go long way in reducing the number of road accidents in the Oregon rural roads.

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1. Introduction

Road traffic crashes involve vehicles and result in harm to people and property in form of casualties, injuries, and damage to vehicle and damage to nearby properties. Broadly speaking, the damages of road crashes are divided into two categories 1) human and 2) financial damages. The first ever fatal traffic crash recorded in the history of the world took place in UK in year 1896, after the accident, the then British Secretary of Transport stated that, ‘never should we allow this to happen again’ (Balogun, 2007). However, unfortunately, the number of traffic crashes keeps on increasing with the ever- increasing number of motor vehicles and with the development of more transport infrastructure. In the United States in the year 2012, more than thirty three thousand people died in motor vehicle traffic crashes. There was a reported increase of 3.3% motor vehicle road crashes from year 2011 to year 2012 (Traffic Safety Facts: 2012 Motor Vehicle Crashes: Overview, 2013). It is reported that in 2012, approximately 2.36 million people were injured in road crashes as compared to 2.22 million in the year 2011 (NHTSA’s National Automotive Sampling System (NASS).

Earlier studies have shown that the road crashes are the most common source of fatalities and severe injuries leading to disabilities in western countries (Gkegkes, 2014). Vehicle crashes are critical from the operational point of view, and rural area crashes are most challenging in terms of mitigation measures. In USA, crashes in rural areas are slightly higher than urban area crashes. Studies prior to 2000 focused on establishing a strong relationship between traffic crashes and traffic flows (Aljanahi, Rhodes, & Metcalfe, 1999; Ceder & Livneh, 1982; Dickerson, Peirson, & Vickerman, 2000; Zhou & Sisiopiku, 1997). In recent years, research focus has been now diverted to geospatial.

Reliable data is vital for identifying the safety problems, the risks, areas of priority which in turn plays an instrumental role in policy formation, formulation of strategies, arriving at safety targets and monitoring the results. Policy makers require this data for arriving at the numbers and costs for the formulation of policy. Similar data when considered on the basis of geographical area, age and crash type will help to identify the black spots; the areas that require attention on a priority basis. This leads to the allocation of resources in the most effective manner. It is equally important that safety data is to be efficiently coded, processed and analyzed.

In every part of the world, road crashes take place on both urban as well as rural roads. However, the percentage of crashes may vary between these two broad categories of roads. Crashes on rural roads need as much attention as crashes on urban roads. In U.S. 54% of fatal crashes took place on rural roads compared to 46% fatal crashes on urban roads in the year 2012. There is a reported negligible decline in road crashes (Urban/Rural Comparison, 2012). However, for ensuring that the decline is continuing, it is important that improvements should be made with respect to safety on rural roads.

1.1 Introduction

The motivation of this project is a study done by NHTSA in 2009 "*Geospatial Analysis of Rural Motor Vehicle Traffic Fatalities*". The study was focused on determining the extent of fatalities that occur in or near urban areas. The definition of urban / rural areas used in the NHTSA study was based on United States census bureau. The current report examines the spatial extent of crashes in and around city boundaries in the state of Oregon. The difference on the definition of urban / rural areas between this study and the NHTSA study might result in inaccurate comparison, this could be avoided in future studies by using same definition of urban / rural areas. Furthermore, this research was extended to include all types of crash severity, and more categories related to the character of the road (curve / grade) and road surface condition (dry / wet). (Figure 1) reproduced below represents distribution of crashes throughout the state for the year 2012.

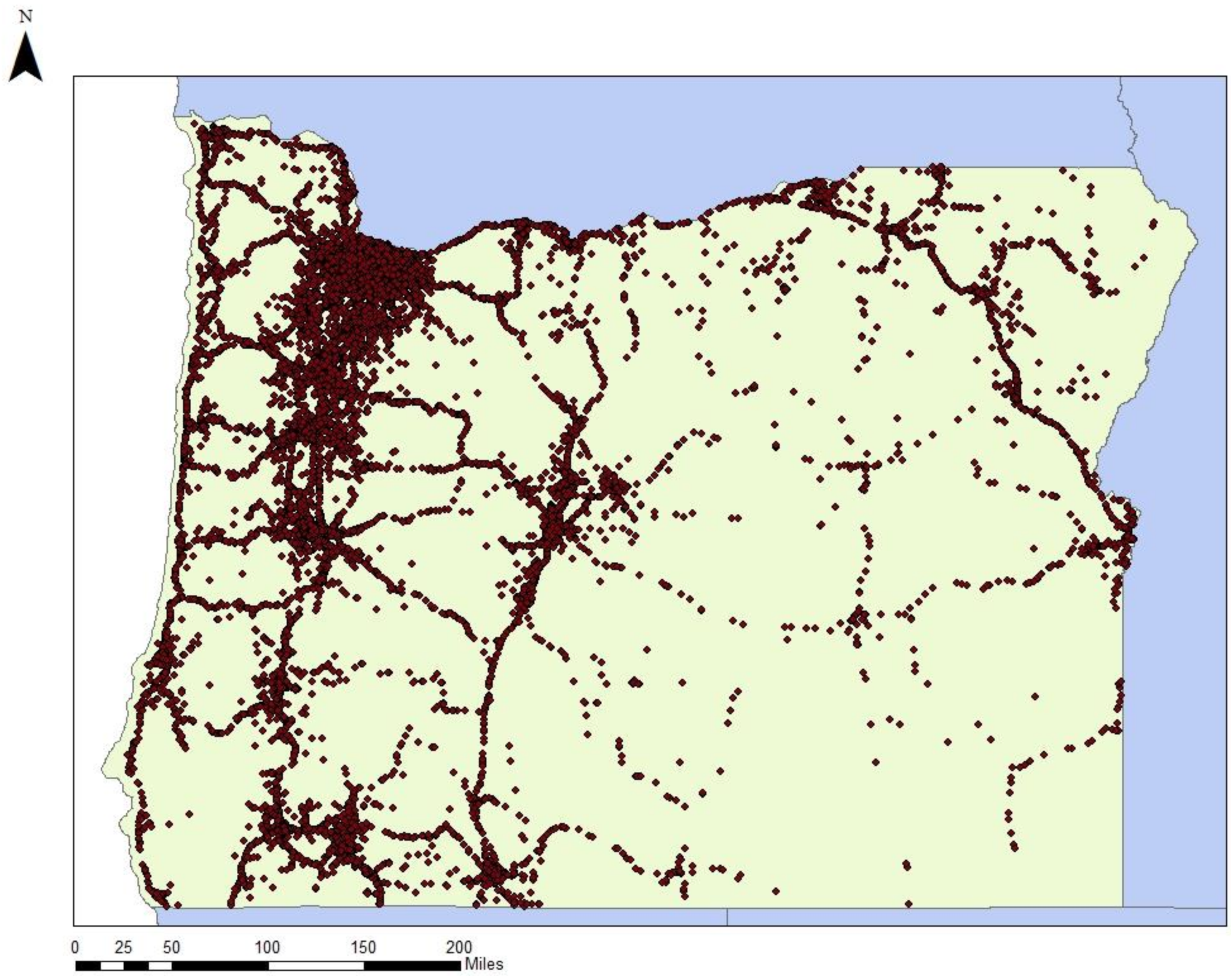

Figure 1: Statewide Crashes 2012 (Oregon)

There are many factors, which contribute to the road crashes but the human factors dominate crash causality. However, it is equally important to understand the secondary effects as well. R-Statistics application has been used for the purposes of this report. The report primarily focuses on quantifying spatial data of crashes in urban areas and rural areas that are in the form of buffers. The aim here is to use the information deciphered for the better organization of safety strategies and deployment of resources for dealing with crashes and resulting situations. The report takes into consideration speed related crashes, crashes involving bi-cyclists, pedestrians, and crashes involving alcohol and drug abuse to specify a few.

1.2 Organization

The report is divided in four main sections. Section 1 starts by defining Road Traffic Crashes and moves on to discuss the importance and need for conducting studies and accurate recording of data. In Section 2, data and methodology the scope of the report in terms of areas and types of crashes is discussed along with the sources from where data has been sourced. The results are discussed in Section 3 under 12 subheadings with the objective of understanding the extent and nature of crashes taking place on the roads. Section 4, discusses road density as a measure for urbanization around each crash by counting the sum of road lengths in a 1-mile buffer around each crash using ArcGIS followed by a discussion on the results obtained using this method. In Section 5 a conclusion has been drawn and the report summarized.

2. Data and methodology

For this study, all crash data for the year 2006 was obtained from NHTSA's report (2009), crash data for the year 2012, and city boundaries were obtained from ODOT "Oregon Department of Transportation" and FTP: www.odot.state.or.us. The files obtained from these sites were in the GIS format, and hence they were opened using ESRI ArcMap and then exported in the csv format for use in softwares such as Excel and R.

Buffer around these city boundaries were created for 2.5 miles, 5 miles, 7.5 miles and 10 miles were done. After the urban areas were buffered, the crashes were displayed on the maps. An intersection tool in ArcMap was used to locate crashes within these areas. For the purpose of analysis, following five zones were defined:

1. Crashes within the urban zone boundary;
2 Crashes within 2.5 miles from the urban zone boundary;
3. Crashes within 5 miles from the urban zone boundary;
4. Crashes within 7.5 miles from the urban zone boundary; and,
5. Crashes within 10 miles from the urban zone boundary.

Data on these five (5) categories were sorted in the form of 5 different tables. Then using R scripts software, filtration of the data was carried out for each category to produce a table containing specific crashes depending on crash severity. Data of these 5 tables in addition to the main file that contains all crashes was divided into subcategories, and for each main category, we have segregated them into the following groups:

1. Fatality crashes
2. Serious injury crashes (Injury Type A)
3. Non-fatal (KABC) crashes
4. PDO (Property damaged only) crashes

3. Results

As per the traffic records provided by NHTSA (2013), the number of motor vehicle fatalities have increased in the year 2012 after a continuous decline for previous six years. In the year 2012, 33561 lives were lost in roadway crashes as compared to 32479 lives lost in the year 2011. An increased number of crashes can be attributed to a variety of factors, including type of vehicle, location of crash, and driving under the influence of alcohol. A general rise in crashes involving pedestrians and motorcyclists has been observed. The trend continued well into 2012 for the entire country (NHTSA, 2013).

3.1 Overview of Crashes

The scope of this report is limited to crashes, injuries, and fatalities reported in the state of Oregon only. Crash data for state of Oregon containing figures on crashes, injuries and fatalities occurring over the period of five years from year 2008 to 2012, which has been presented and discussed below. This provides an overview of the magnitude of crashes, injuries and fatalities occurring in the region and helps understand the extent of the problem. After having this overview, a detailed results for each crash category will be discussed to have a better knowledge about the spatial extent of crashes in Oregon.

Table 1: Comparative Summary of Oregon Traffic Crashes, Personal Injuries and Deaths (2008 – 2012) (Traffic Safety Facts, 2012)

	CRASHES*					INJURIES*					DEATHS*				
MONTH	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
JANUARY	3,879	3,605	3,361	3,869	4,099	2,193	2,463	2,335	2,583	2,732	34	33	15	32	24
FEBRUARY	2,927	2,790	3,213	3,893	3,751	1,739	1,868	2,226	2,579	2,654	23	16	20	17	25
MARCH	3,307	2,967	3,477	3,675	3,931	2,046	2,006	2,442	2,540	2,772	29	22	21	23	17
APRIL	3,354	3,184	3,479	3,827	3,669	2,019	2,198	2,419	2,841	2,589	28	32	30	18	18
MAY	3,290	3,610	3,701	3,835	3,885	2,152	2,612	2,572	2,774	2,837	34	35	27	29	29
JUNE	3,336	3,288	3,263	3,868	3,919	2,228	2,261	2,191	2,894	2,942	33	25	24	35	32
JULY	3,428	3,500	3,752	4,077	4,143	2,434	2,601	2,803	3,220	3,236	34	39	39	25	22
AUGUST	3,534	3,450	3,629	4,315	4,318	2,563	2,469	2,590	3,250	3,258	59	43	29	40	31
SEPTEMBER	3,359	3,481	3,585	4,233	4,060	2,348	2,382	2,540	3,184	3,100	31	38	36	24	43
OCTOBER	3,667	3,585	3,921	4,387	4,776	2,434	2,335	2,741	3,044	3,587	48	28	27	26	31
NOVEMBER	3,514	3,561	4,355	4,583	4,546	2,350	2,323	2,777	3,197	3,154	30	27	30	37	35
DECEMBER	4,221	4,250	4,357	4,490	4,701	2,300	2,635	2,857	2,925	3,224	33	39	19	25	29
TOTALS	41,816	41,271	44,093	49,052	49,798	26,806	28,153	30,493	35,031	36,085	416	377	317	331	336

Table 1 meticulously presents the data for crashes, personal injuries and deaths in the state of Oregon for the years 2008 – 2012. It is obvious that the highest number of crashes and injuries have been reported in the year 2012 while the least number of crashes and resulting injuries have been reported in the year

2008. It is pertinent to mention here that, despite the lowest number of crashes in 2008-2009, the number of deaths in road crashes was the highest in the same year, and this rate of deaths has reduced gradually in the next years. Figure2, 3 and 4 provided below represents data for crash, injuries and deaths for the above-mentioned years, i.e. 2008 - 2012.

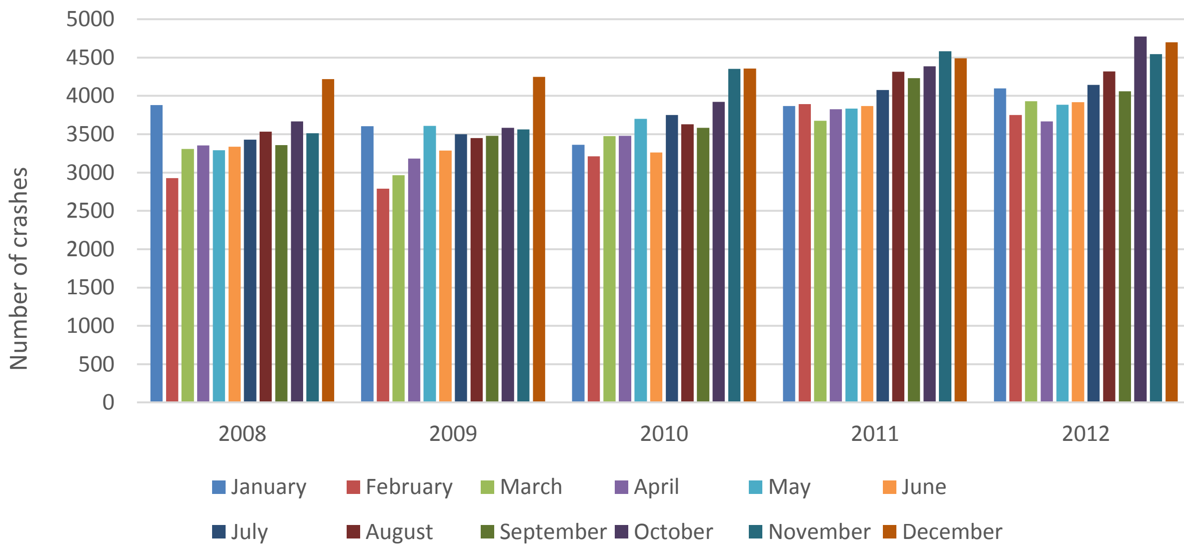

Figure 2: Number of Crashes by month (Oregon) 2008-2012

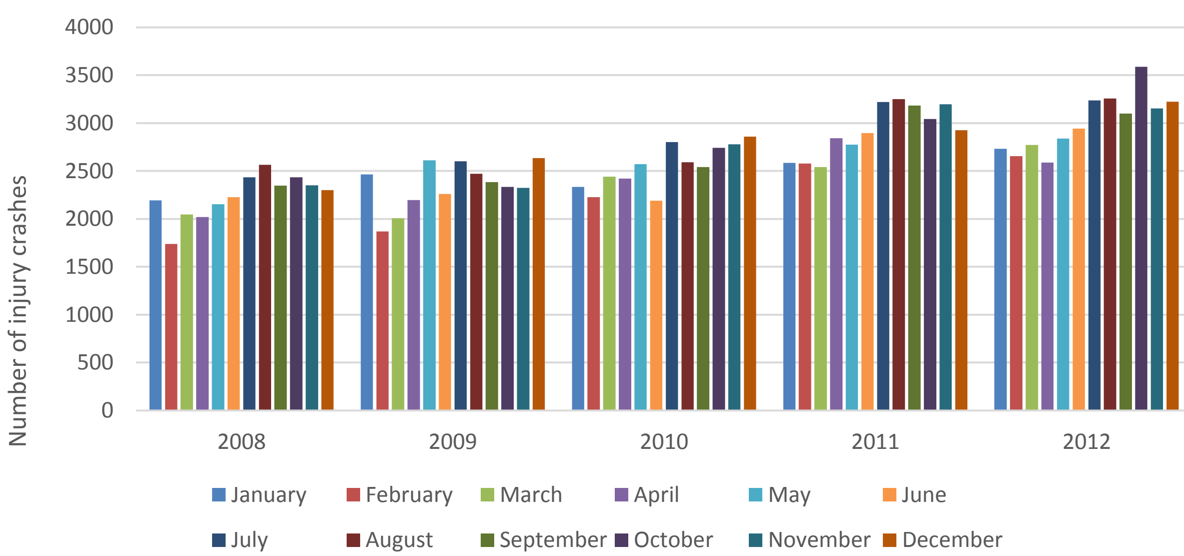

Figure 3: Number of Injury Crashes by month (Oregon) 2008 -2012

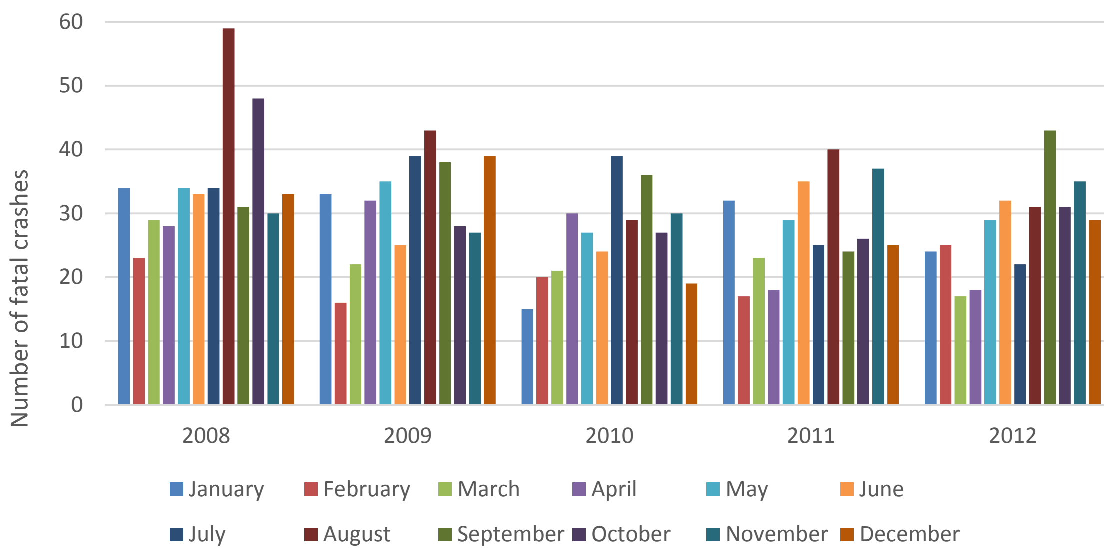

Figure 4: Number of Fatal Crashes by month (Oregon) 2008-2012

Table 2 provides a brief summary of the months during which highest and lowest number of crashes had been observed from year 2008 to year 2012. This data is represented under respective categories of crashes, injuries, deaths.

Table 2: Brief summary of months with highest and lowest numbers of crashes, injuries and deaths in Oregon (2008 – 2012)

Category	Year	Month (With Lowest No. of Cases Reported)	Month (With Highest No. of Cases Reported)
Crash	2008	February	December
	2009	February	December
	2010	February	December
	2011	March	November
	2012	April	November
Injury	2008	February	August
KABC	2009	February	December
	2010	June	December
	2011	March	August
	2012	April	October
Deaths	2008	February	August
K	2009	February	August
	2010	January	July
	2011	February	November
	2012	March	September

3.2 Spatial Extent

The primary focus of this research analysis is not only to determine the percentages of crashes in urban areas of Oregon but also to determine crashes occurring in rural areas, which are just buffered around the urban areas. The data throughout the report is expressed as a cumulative percentages within a specific category in urban areas and rural areas adjacent to urban areas. The report takes into consideration to rural areas, which are divided into four segments according to the distances which are 2.5 miles, 5.0 miles, 7.5 miles and 10 miles. The report takes into consideration the extent of crashes in urban and rural areas adjacent to it. Figure 5 reproduced below represents the city boundaries in the state of Oregon. Figure6 represents the buffered city boundaries in the state.

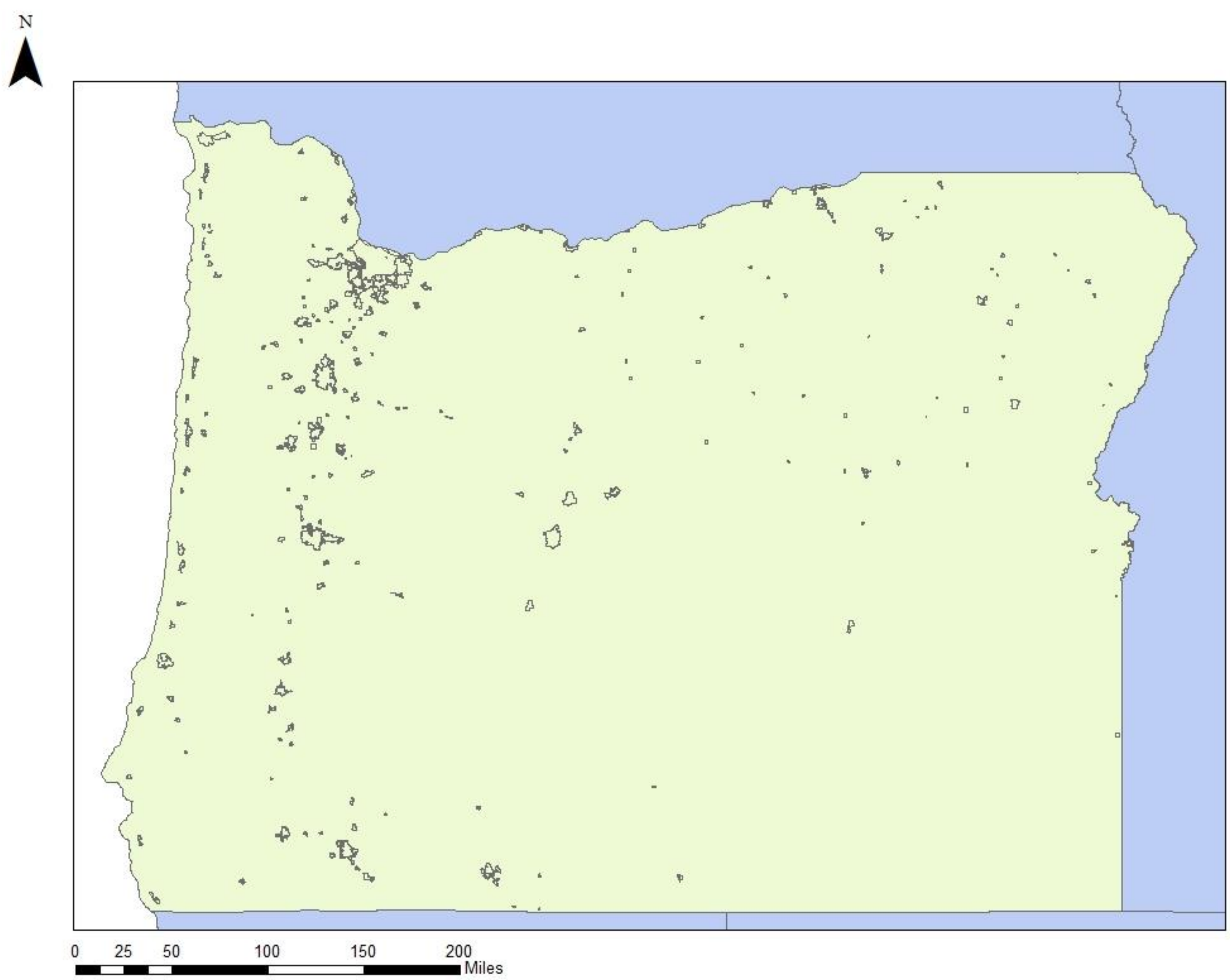

Figure 5: Cities Boundaries (Oregon)

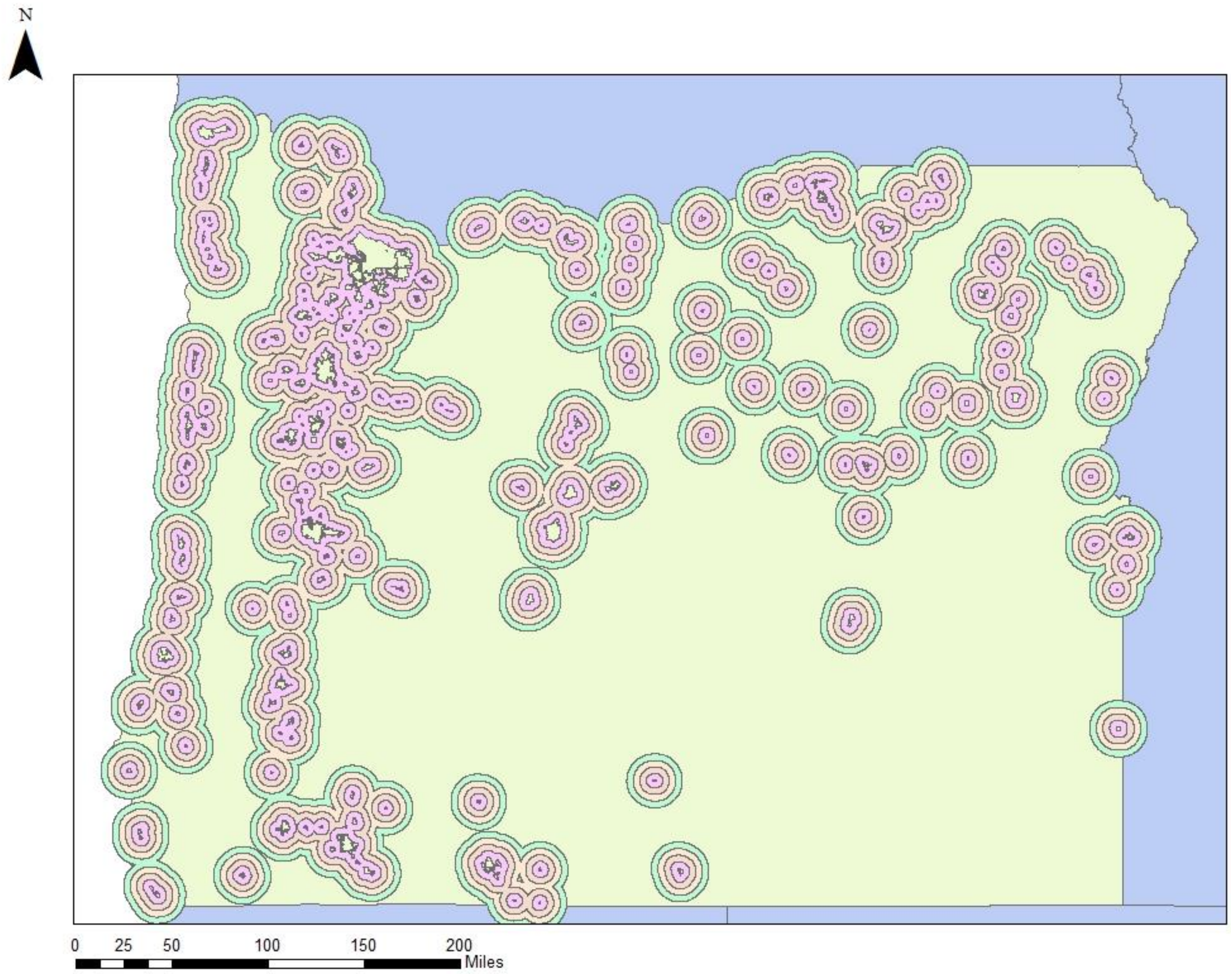

Figure 6: Buffered Cities Boundaries (Oregon)

Table 3 given below summarize the data for different categories of crashes by buffers around urban areas for the state of Oregon. The data is represented in a cumulative percentages and is illustrative of the year 2012 figures.

Table 3: Percentages of All Crashes by Buffers around Urban Areas in Oregon 2012

Category	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	69.9%	88.7%	93.6%	95.7%	96.9%
Speed Related	36.5%	67.5%	79.8%	87.5%	90.5%
Pedestrian Involved Crashes	88.3%	98.3%	99.5%	99.7%	99.8%
Drug or Alcohol impaired crashes	59.8%	85.5%	93.3%	95.5%	97.1%
Unbelted Passenger Vehicle Occupants	58.5%	79.3%	88.2%	91.5%	94.0%
Crashes during weekends	63.5%	83.8%	90.4%	93.3%	95.1%

Nighttime crashes & light condition	62.1%	84.7%	91.9%	94.6%	96.4%
Crashes on Interstate Highways	62.7%	85.6%	91.6%	95.0%	96.6%
Crashes on U.S/State Highways	58.3%	81.4%	88.2%	91.2%	93.3%
Crashes by Character of the Road (Curve / Grade)	26.6%	58.5%	73.6%	81.8%	87.1%
Crashes by surface of the Road (Dry)	73.0%	90.7%	95.1%	96.8%	97.8%
Crashes by surface of the Road (Wet)	71.3%	91.0%	95.5%	97.2%	98.3%
Bicycle Involved	89.4%	98.4%	99.4%	99.6%	99.8%

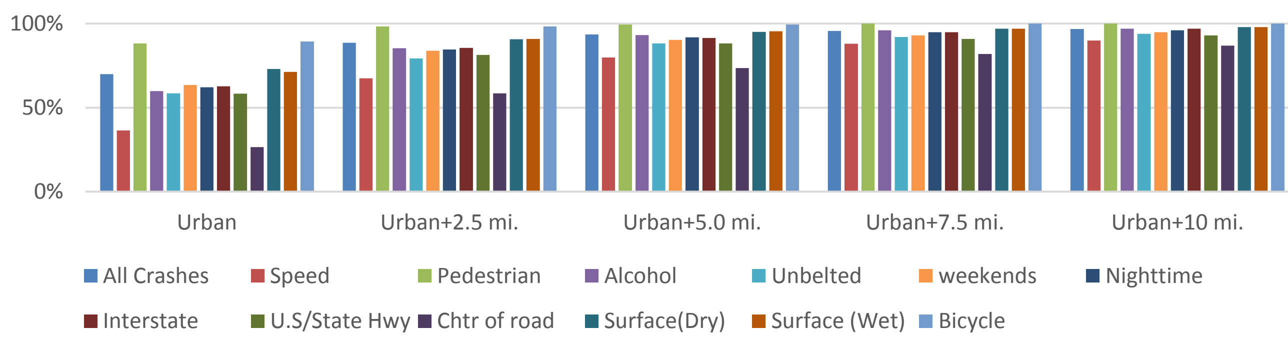

Figure 7: Percentages of Crashes by Buffers around Urban Areas in Oregon 2012

3.2.1 Total Crashes and Fatalities

Table 4: Percentages of Fatalities by Buffers around Urban Areas in Oregon – 2006, 2012

Year	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
NHTSA 2006	31%	52%	63%	70%	73%
Fatalities 2012	32%	67%	80%	89%	95%

Table 4 provides a comparison of data for total fatalities that happened in the year 2006 and 2012 in the state of Oregon. It is clear from the data that the percentages of fatalities within the urban and buffered rural areas for the year 2012 are different than the one obtained by NHTSA, keeping in mind this comparison is not necessary accurate due to the difference in the definitions of urban / rural areas between this research and the NHTSA 2009 study. The percentage of fatalities in urban areas is slightly more for the year 2012. In the buffer zones, the difference is substantial. In 2006, about 27% of all crashes were happening outside the +10 miles buffer zone. While in 2012, only just 5% of the fatalities were occurred outside the +10 miles buffer. This indicates that there was a big difference in all crashes happening inside or near urbanized areas.

Table 5 reproduced below shows the various percentages of crashes for the state of Oregon. Overall, 70% crashes occurred in the urban areas or more specifically within cities boundaries, when rural areas within

2.5 miles of urban boundary are included the percentage of crashes, which rises to 88.7%, 93.6%, 95.7% and 96.9% for 2.5 miles, 5 miles, 7.5 miles and 10 miles respectively. In short, around 96.9% of total crashes have occurred in areas encompassing urban areas and within the 10-mile buffer in the state of Oregon.

Table 5: Total Crashes (Oregon, 2012)

Category	**Total number**	**Urban**	**Urban+2.5 mi.**	**Urban+5.0 mi.**	**Urban+7.5 mi.**	**Urban+10 mi.**
All Crashes	49794	69.9%	88.7%	93.6%	95.7%	96.9%
Fatal Crashes	305	31.5%	63.9%	76.0%	83.6%	88.5%
Serious Injury (A)	1432	46.4%	76.3%	86.6%	90.3%	93.6%
Non-Fatal (KABC)	24454	68.7%	88.7%	93.9%	96%	97.2%
PDO Crashes	25035	71.7%	88.9%	93.50%	95.6%	96.9%

The total fatalities in the state are represented in the map given below.

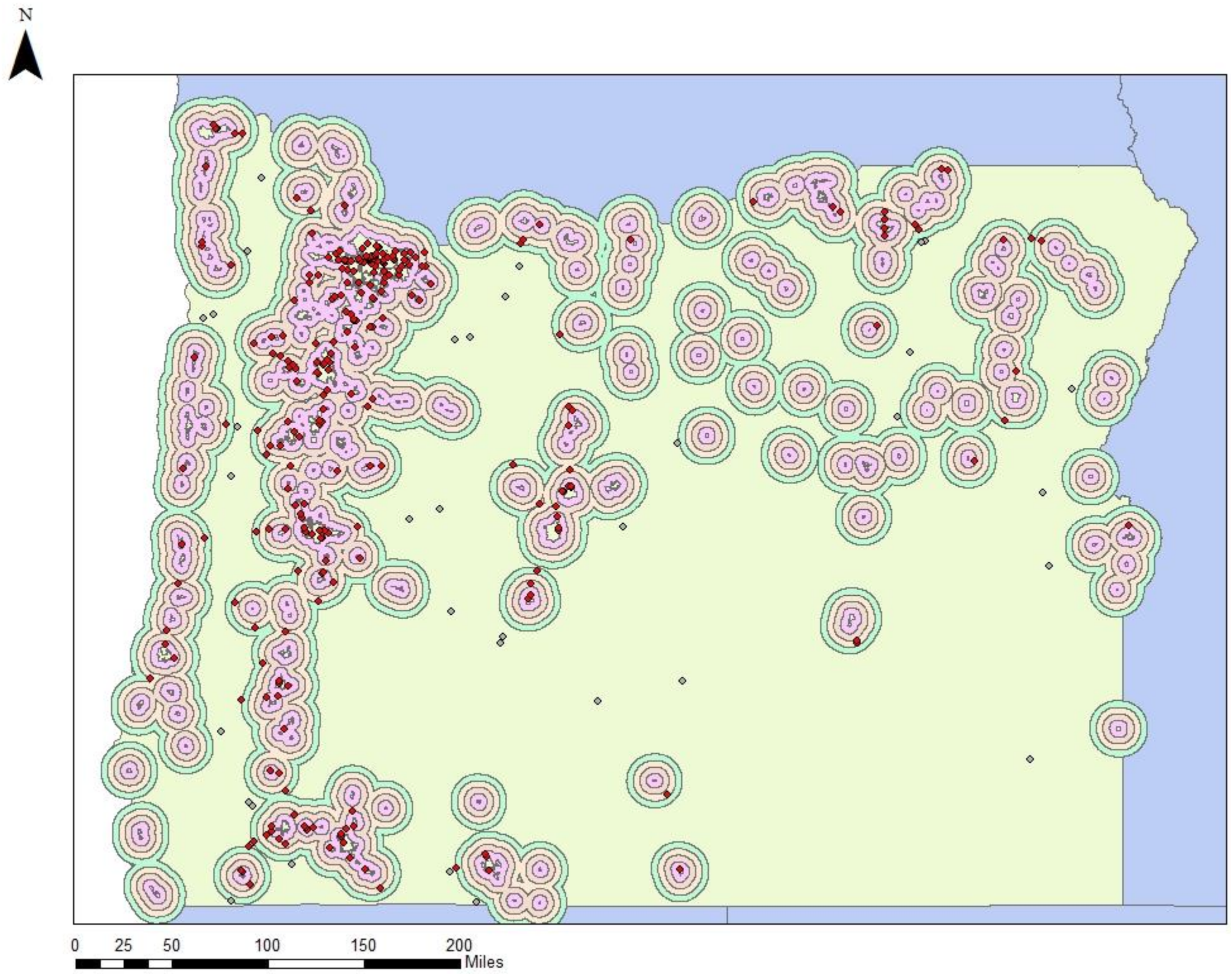

Figure 8: Fatal Crashes (Oregon, 2012)

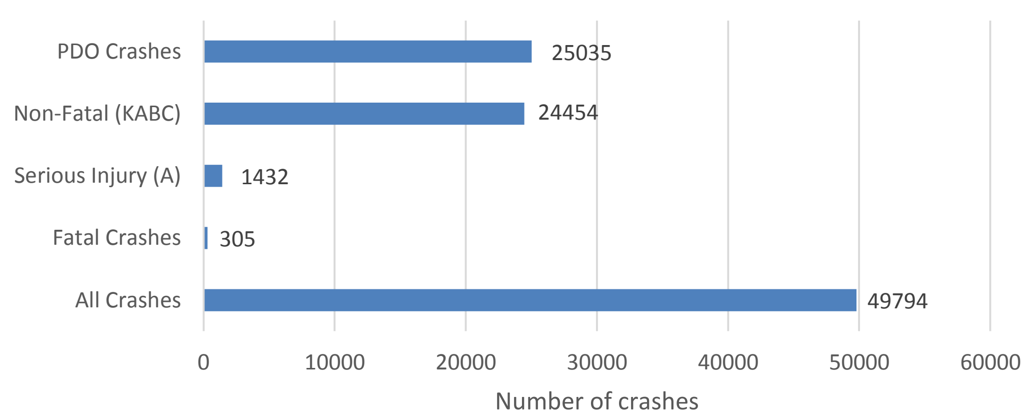

Figure 8: All Crashes (Oregon, 2012)

It is clear from figure 9 given above that the highest number of crashes occurred in the PDO category to be followed by non-fatal (KABC) crashes. The number of crashes leading to serious injuries has been reported at 1,432 and for fatal crashes at 305 for all zones.

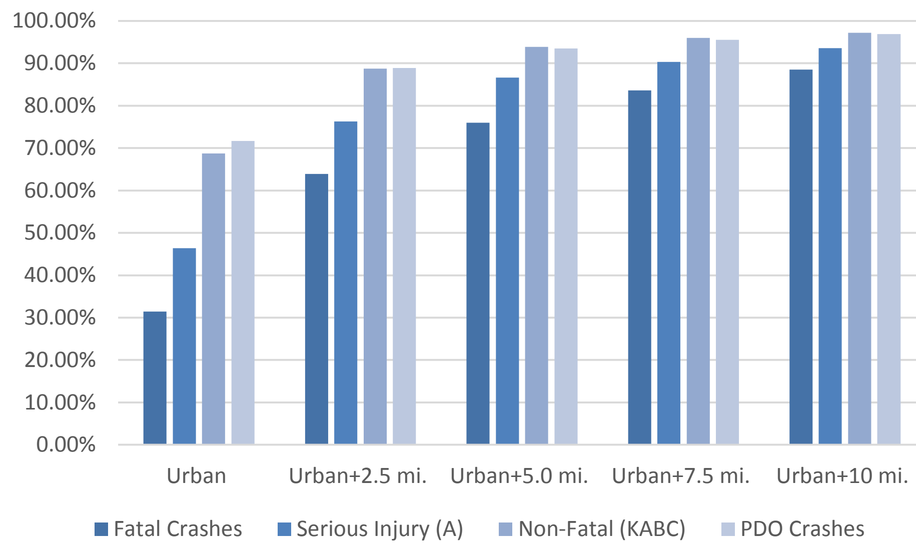

Figure 9: All Crashes (Oregon, 2012 - Based on Zone and Crash Severity)

It can be seen from figure 10 that all crashes while moving from the urban to the 2.5- mile buffer and 5-mile buffer increase considerably but beyond this distance (for 7.5-mile and 10- mile buffer) the increase in the number of crashes is not significant. When it comes to fatal crashes the number nearly doubles in the 2.5- mile buffer as compared to the number in the urban zone. The percentage continues to increase in a gradient for the other buffer zones. It is important to note that while fatal crashes and serious injuries are below 50% in the urban areas, non-fatal (KABC) crashes stood at 68.7% and PDO crashes at 71.7%.

These statistics have been discussed in detail in the following sections.

3.2.2 Speeding-Related Crashes

Speed of motor vehicles has been known to have a strong relationship with crashes. It affects a driver's ability to safely maneuver the vehicle and increase its stopping distance. Managing speed is essential when it comes to road safety. Comparing the data for the years 2006 and 2012, it is clearly evident that there is a difference in the percentage of fatalities of speed- related crashes for the urbanized areas. The difference in the urban area has been just a little over 7% (from 26% in 2006 to 33% in 2012), the difference in the +2.5 mile buffer zone is around 13%.

Table 6: Percentages of Speed related Fatalities in Oregon – 2006, 2012

Year	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
NHTSA 2006	26%	46%	60%	68%	71%
Fatalities 2012	33%	59%	72%	85%	92%

In the year 2012, the total number of crashes took place due to speed were 504, out of which 280 non-fatal (KABC) crashes, 192 were PDO crashes, 36 were serious injuries, and 32 were fatal crashes. Figure 11 reproduced below shows the distribution of speed-related crashes in the Oregon state during the year 2012.

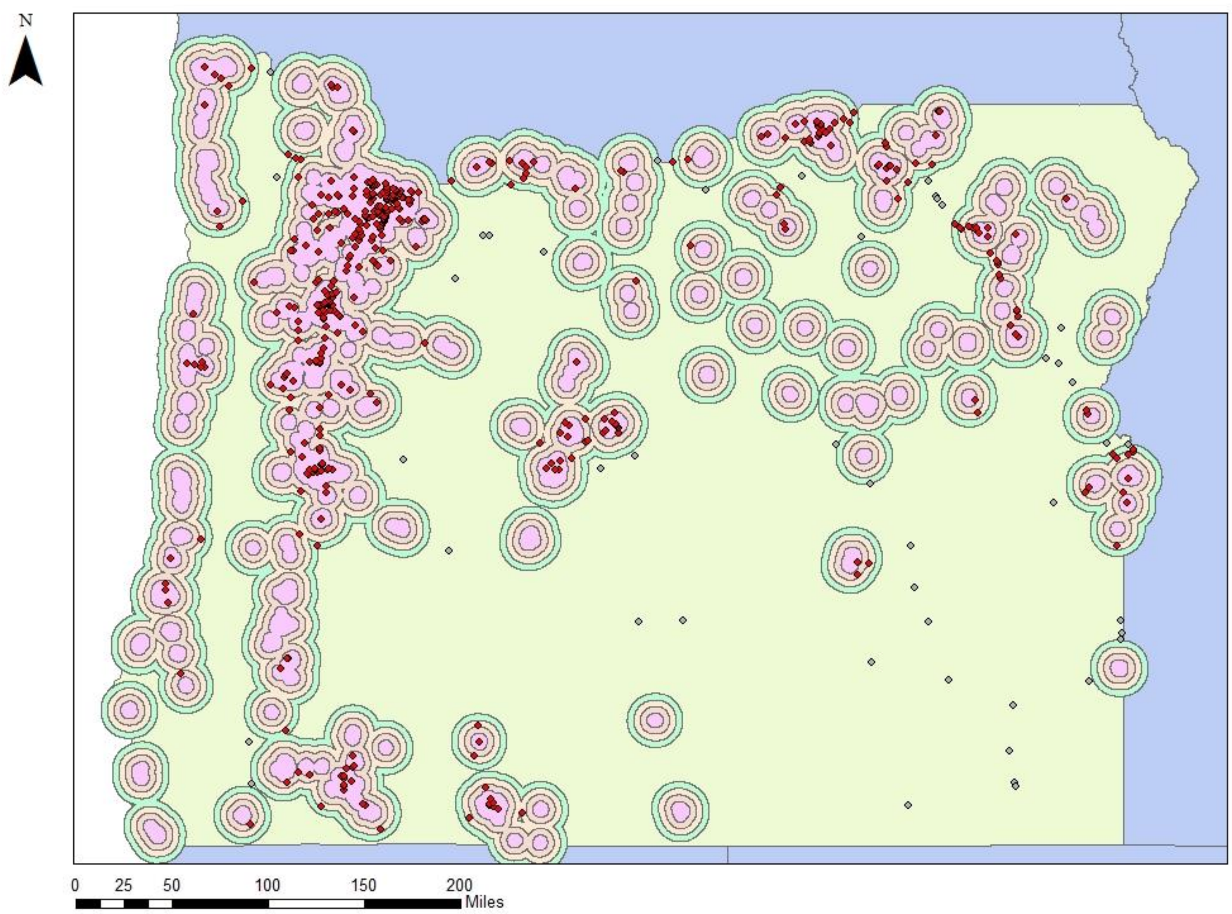

Figure 10: Speed Related Crashes (Oregon, 2012)

Table 7: Speed Related Crashes (Oregon, 2012)

Category	Total Number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	504	36.5%	67.5%	79.8%	87.5%	90.5%
Fatal Crashes	32	37.5%	65.6%	81.3%	84.4%	90.1%
Serious Injury (A)	36	41.6%	69.4%	75.0%	77.8%	83.3%
Non-Fatal (KABC)	280	33.9%	63.6%	78.2%	86.4%	89.3%
PDO Crashes	192	40.1%	73.4%	81.8%	89.6%	92.2%

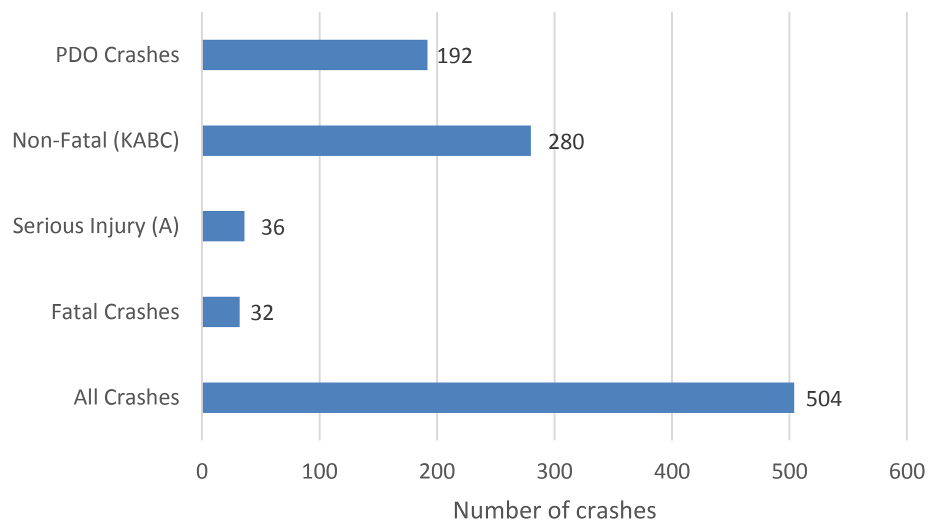

Figure 11: Speed Related Crashes (Oregon, 2012)

In the year 2012, the total number of crashes took place due to speed were 504. Out of this 36.5% were in the urban area while remaining in the buffer zones. 67.5% crashes were in the +2.5 mile zone, 79.8% in the +5.0 mile, 88% in +7.5 mile and 90% in +10 mile buffer zones. The data is represented in Table 7 above. In the urban areas, the highest percentage of crashes resulted in serious injuries (41.6%) while the percentage of the non-fatal (KABC) crashes are the lowest (33.9%). In the +2.5 buffer zone, the highest percentage of crashes are PDO crashes (73.4%), while non-fatal (KABC) crashes are the lowest at 63.6%. In the +5 mile zone, the percentage of both PDO crashes and fatal crashes are as high as 81.8% and 81.3% respectively. In the +7.5 mile zone, the percentage of the PDO crashes is again high at 89.6% while serious injury crashes were the lowest being 77.8%. In the +10 mile zone percentage of PDO crashes was the highest with 92.9% while once again, crashes leading to serious injuries were the lowest with 83.3%.

From Figure13 represented below, it is clear that in all crash types, the percentages of crashes in the +10-mile zone is the highest as it contains all crashes from previous zones.

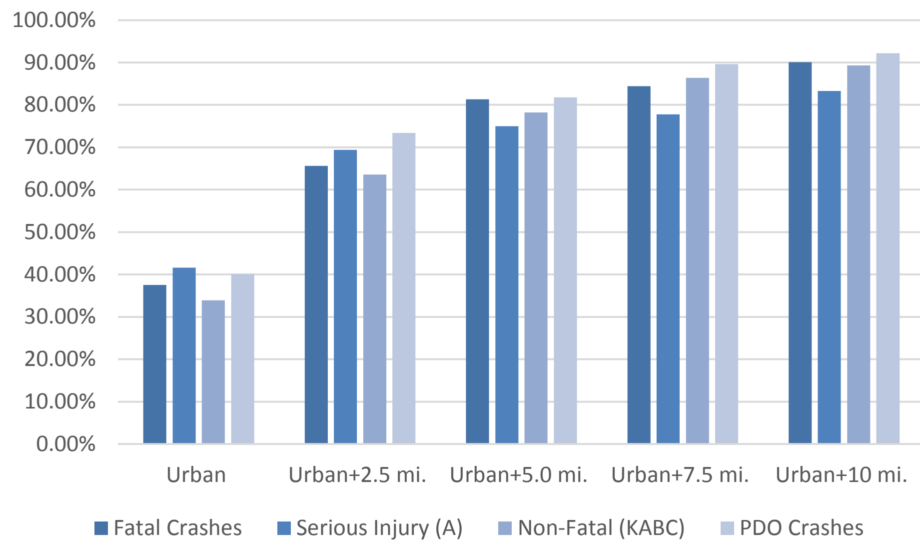

Figure 12: Speed Related Crashes (Oregon - Based on Zone and Crash Severity, 2012)

3.2.3 Crashes by Type - Pedalcyclists

Cycling can be a fun activity and can easily replace motorized vehicles for certain trips like going to school or for work. However, the streets can prove to be dangerous for cyclists, especially when they have to place themselves with trucks and cars.

Figure 14 provided below represents crashes involving cyclists in Oregon urban areas and buffer zones up to 10 miles around the city for the year 2012.

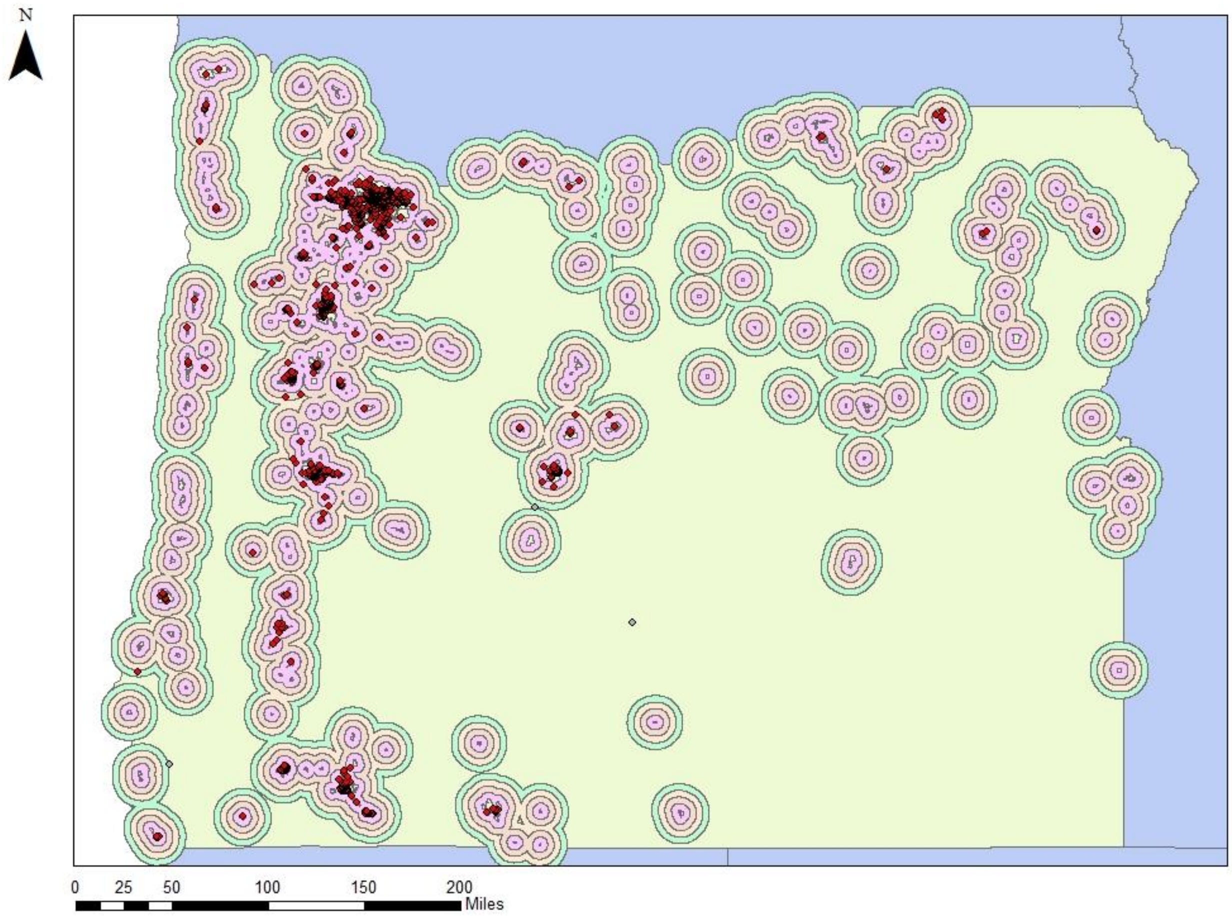

Figure 13: Crashes by Type - Pedalcyclists (Oregon 2012)

The total number of crashes involving bicyclists in the urban area and buffer zones around it stood at 1,057. Out of the total number the highest number of crashes were non-fatal (KABC) in nature and stood at 1,016. While serious injuries were 68, PDO crashes were 31 and fatal crashes were 10 in number.

Table 8: Crashes by Type - Pedalcyclists (Oregon, 2012)

Category	**Total Number**	**Urban**	**Urban+2.5 mi.**	**Urban+5.0 mi.**	**Urban+7.5 mi.**	**Urban+10 mi.**
All Crashes	1057	89.4%	98.4%	99.6%	99.6%	99.7%
Fatal Crashes	10	40.0%	70.0%	100%	100%	100%
Serious Injury (A)	68	80.9%	94.1%	100%	100%	100%
Non-Fatal (KABC)	1016	89.8%	98.6%	99.6%	99.6%	99.7%
PDO Crashes	31	93.5%	100%	100%	100%	100%

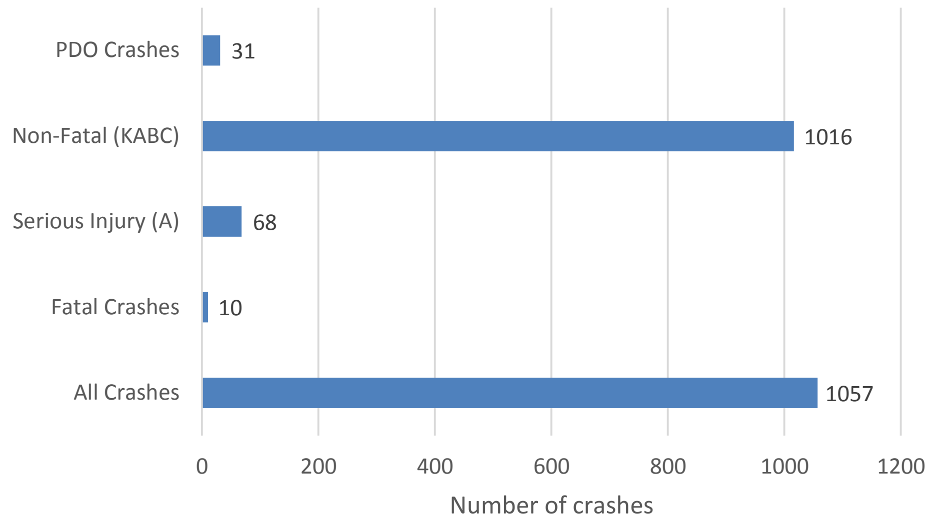

Figure 14: Crashes by Type - Pedacyclists (Oregon, 2012)

Data represented in the table and the figures above clearly indicate a high percentage of accidents involving bi-cyclists in +7.5 mile and +10 mile buffer zone. In the urban areas, the percentage of the total fatal crashes involving cyclists are the lowest at 40%, while the percentage of the total PDO crashes is the highest at 93.5%. In the +2.5 mile buffer zone around the urban areas, the percentage of total fatal crashes involving cyclists were 70%, and 100% is the percentage of the total PDO crashes. The fact that the highest jump in the percentage of crashes occurred in the +2.5 miles buffer is clearly presented in Figure 16 below.

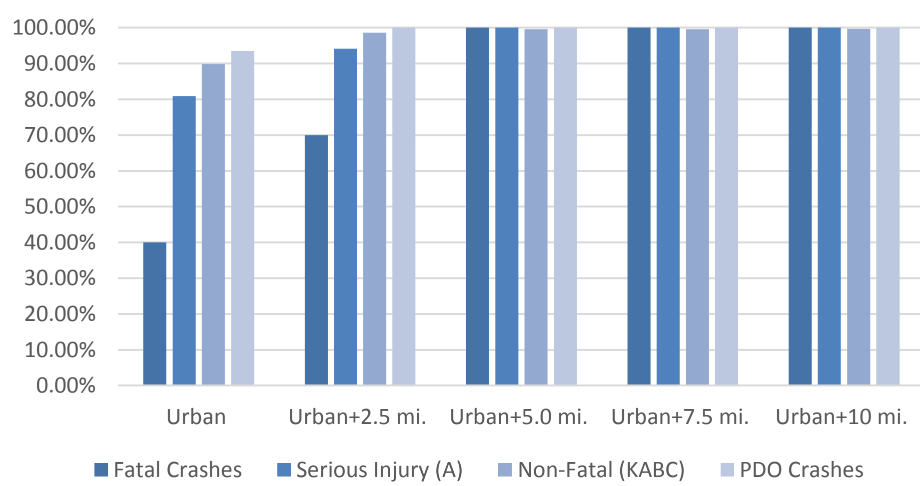

Figure 15: Crashes by Type - Pedalcyclists (Oregon, 2012 - Based on Zone and Crash Severity)

3.2.4 Crashes by Type: Pedestrians

The term pedestrian is used for people walking, running, hiking, jogging and even sitting down on the road. Precisely, any human not riding a vehicle is termed as a pedestrian. Since 2010, the number of pedestrian fatalities has gradually increased. Pedestrian deaths accounted for 14% of all traffic fatalities in the entire US (Traffic Safety Facts, 2012). It is crucial for improving road safety standards that rate of pedestrian fatalities be brought down.

On comparing the data for the years 2006 and 2012, it comes to light that the percentages of fatalities involving pedestrians within the urban boundary has a small difference by %2. The difference in the percentages of fatalities involving pedestrians is bigger for the rural buffered zones. The maximum difference recorded is (16%) has been in the + 5 mile buffer zone. The difference for the urban areas has been around 2%, in the +2.5 mile buffer zone was 14%, in +5 miles buffer zone was16%, and in the +7.5 mile buffer zone was 15% and 13% in the +10 mile buffer zone.

Table 9: Percentages of Pedestrian Fatalities in Oregon – 2006, 2012

Year	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
NHTSA 2006	72%	79%	81%	85%	87%
Fatalities 2012	70%	93%	97%	100%	100%

The figure represented below illustrates crashes involving pedestrians in the urban area of Oregon and buffer zones around urban areas.

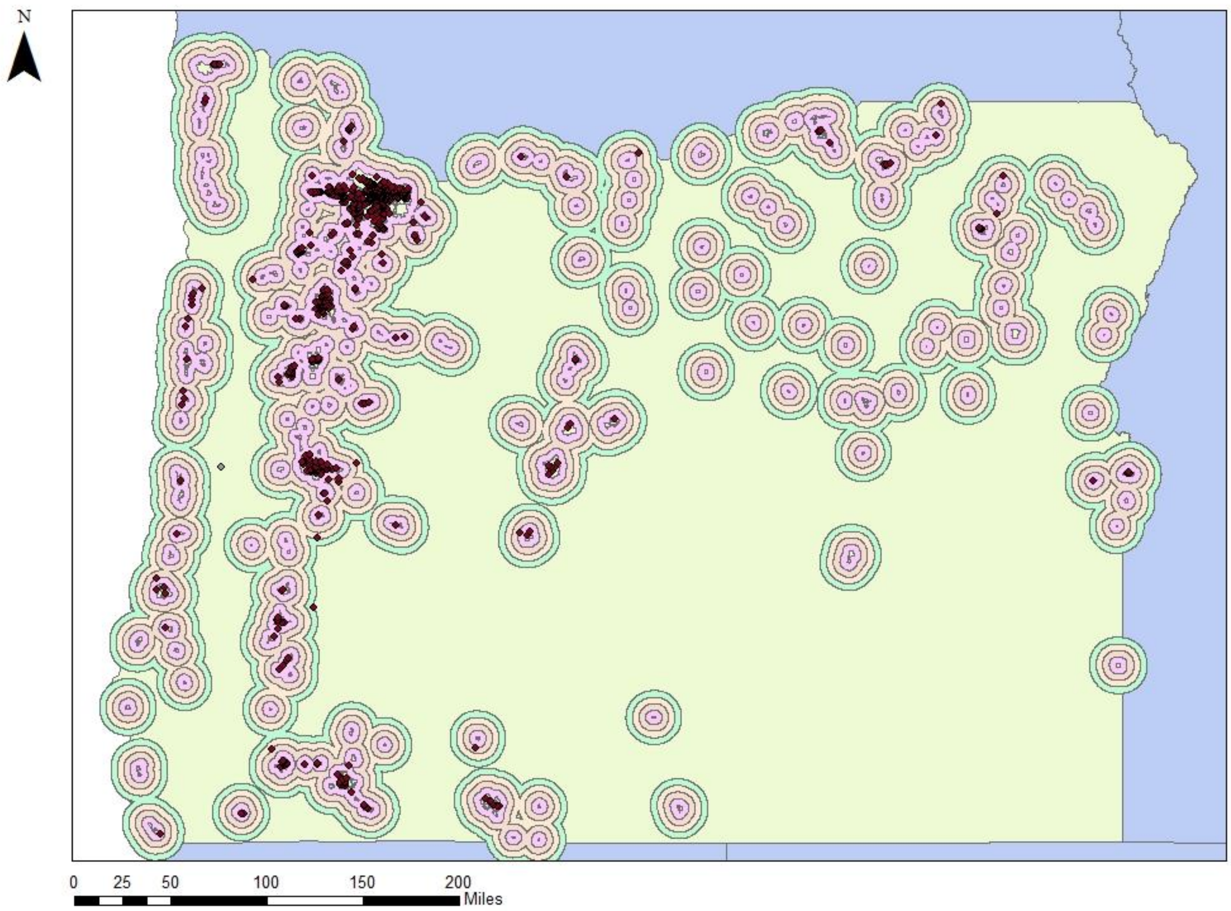

Figure 16: Crashes by Type - Pedestrians (Oregon, 2012)

The total number of crashes involving pedestrians was 887, out of which the maximum number was of non-fatal (KABC) crashes with 821. Crashes involving serious injuries stood at 103, fatal crashes were at 60 while PDO crashes were mere 6 in number. The same has been represented as figure 18 given below.

Table 10: Crashes by Type -Pedestrians (Oregon, 2012)

Category	Total Number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	887	88.3%	98.3%	99.5%	99.7%	99.8%
Fatal Crashes	60	70.0%	93.3%	96.6%	100.0%	100.0%
Serious Injury (A)	103	82.5%	97.1%	99.0%	99.0%	100.0%
Non-Fatal (KABC)	821	89.7%	98.6%	99.7%	99.7%	99.8%
PDO Crashes	6	66.6%	100%	100%	100%	100%

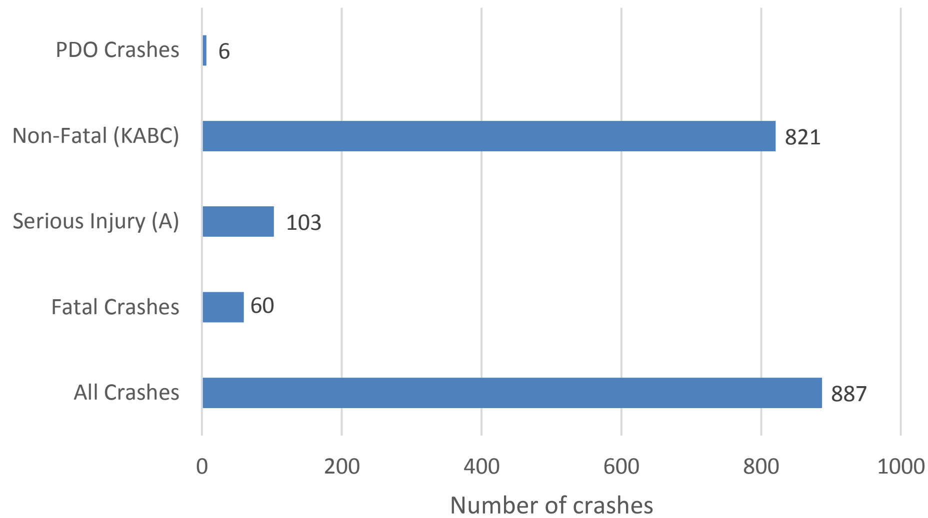

Figure 17: Pedestrian Crashes by Crash Severity (Oregon, 2012)

From an analysis of the Figure 19 illustrated below, it is clear that the percentage of fatal crashes in the urban areas is at 70%, where crashes involving serious injuries are 82.5%, non-fatal (KABC) crashes are 89.7% and PDO Crashes are 66.6%. In the buffer zones, PDO crashes have been 100% for all four zones. Non-fatal (KABC) crashes which are highest in number are between 98.5% - 100% range. Crashes involving serious injuries were 97.1%, 99%, 99% and 100% for the four zones respectively. 93.3% crashes and 96.6% crashes involved fatal crashes for +2.5 mile and +5 mile zone respectively, while for both +7.5 mile and +10 mile, the percentage stood at 100%.

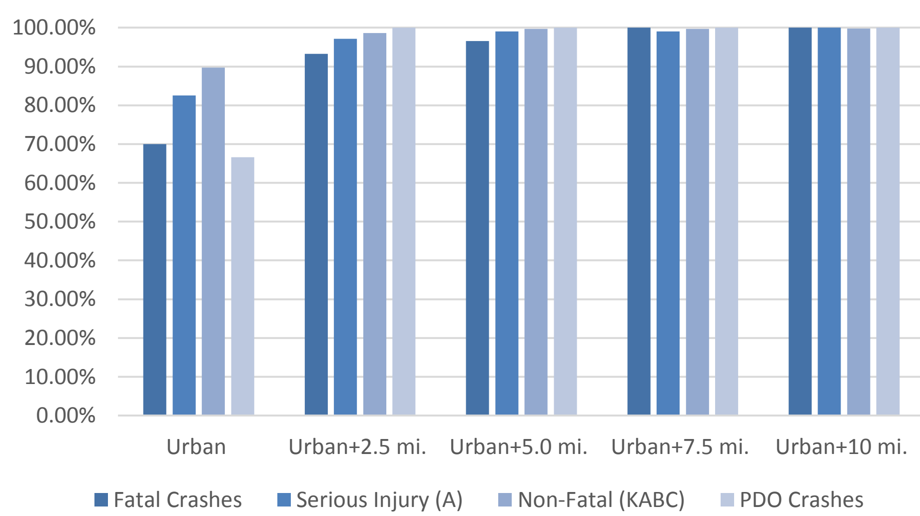

Figure 18: Pedestrian Crashes (Oregon, 2012 - Based on Zone and Crash Severity)

3.2.5 Alcohol& Drug use -Impaired Driving Crashes

Any crash that involves a driver with .08 grams per deciliter or higher blood -alcohol concentration (BAC) will be considered as an alcohol impaired driving crash and a resultant, fatality/crash is considered to be alcohol-driving fatality/crash. In 2011, in the entire US, 31% of the total traffic fatalities were alcohol impaired (Traffic Safety Facts, 2011).

Comparing the data for the years 2006 and 2012, the difference in the percentage of fatalities in all zones is obvious the difference from 2006 to 2012 can be said to be high. The percentage of alcohol impaired fatalities in urban areas for 2006 was 32% and for the year 2012 it was 36%, while in the +2.5 mile buffer zone was 59% for NHTSA 2009, and for 2012 it was 72%, in the +5.0 mile buffer zone for NHTSA 2009 was 67% , and for 2012 it was 82%, in the +7.5 mile buffer zone was 73% for NHTSA and 87% for 2012, and in the +10 mile buffer zone, from 77% for NHTSA and 90% for 2012.

Table 11: Percentage of Alcohol and drug use Impaired Fatalities in Oregon – 2006, 2012

Year	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
NHTSA 2006	32%	59%	67%	73%	77%
Fatalities 2012	36%	72%	82%	87%	90%

Figure 20 given below illustrates the distribution of alcohol or drug-use impaired driving crashes in the state of Oregon. It shows the distribution of crashes in urban areas and buffer zones around these urban areas. Table 12 given below gives the figures of alcohol or drug-use impaired driving crashes.

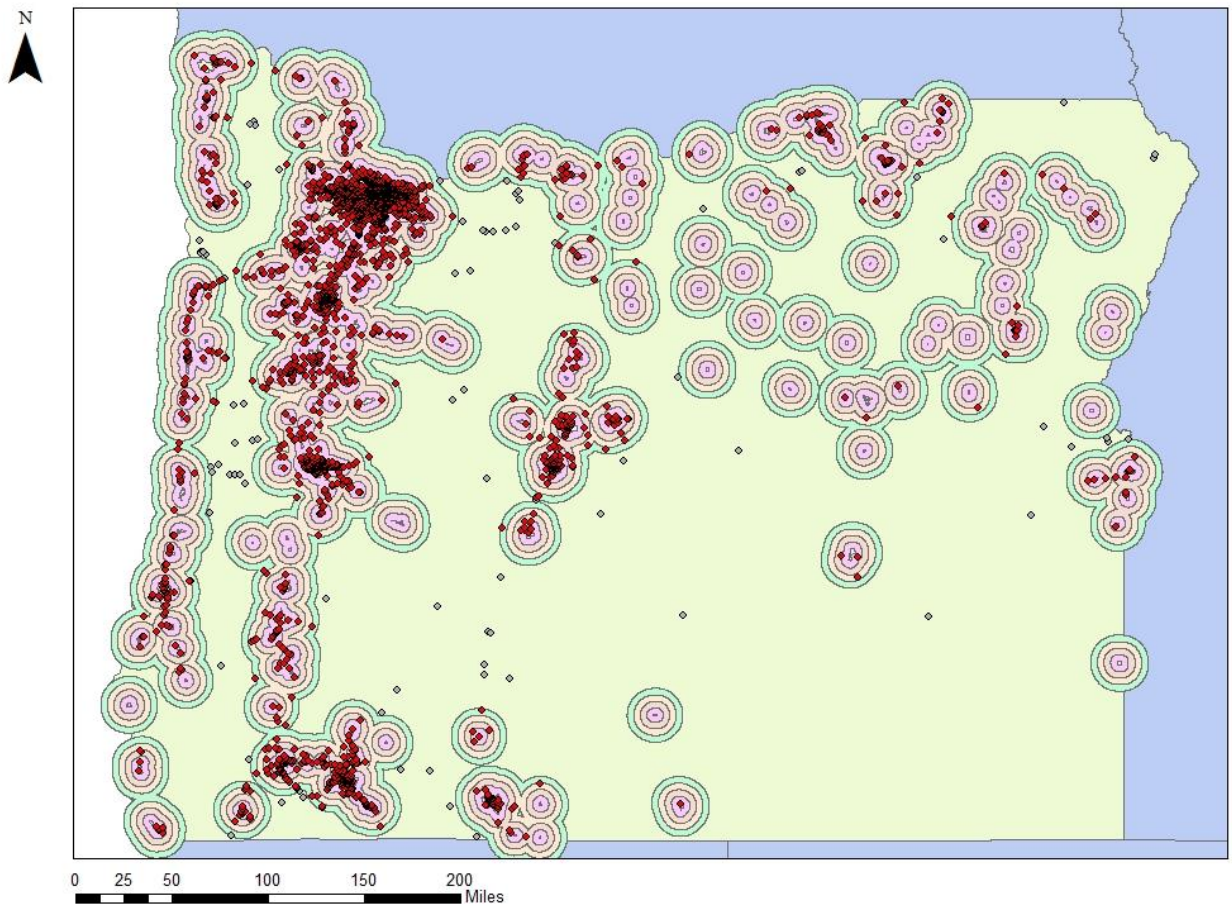

Figure 19: Alcohol or drug use Impaired Driving Crashes (Oregon, 2012)

Table 12: Alcohol or drug use Impaired Driving Crashes (Oregon, 2012)

Category	Total number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	2920	59.80%	85.5%	93.3%	95.5%	97.1%
Fatal Crashes	151	37.7%	73.5%	84.1%	89.4%	91.4%
Serious Injury (A)	276	42.0%	76.8%	88.7%	91.3%	96.0%
Non-Fatal (KABC)	1537	53.6%	82.7%	91.9%	94.7%	96.9%
PDO Crashes	1232	70.1%	90.3%	96.1%	97.3%	97.9%

It is clear from the data given above that the largest number of alcohol impaired driving crashes resulted in non-fatal (KABC) crashes to be followed closely by crashes involving PDO. While 276 of these crashes involved serious injuries, fatal crashes were 151 in number. The figure21 given below will help to compare the numbers.

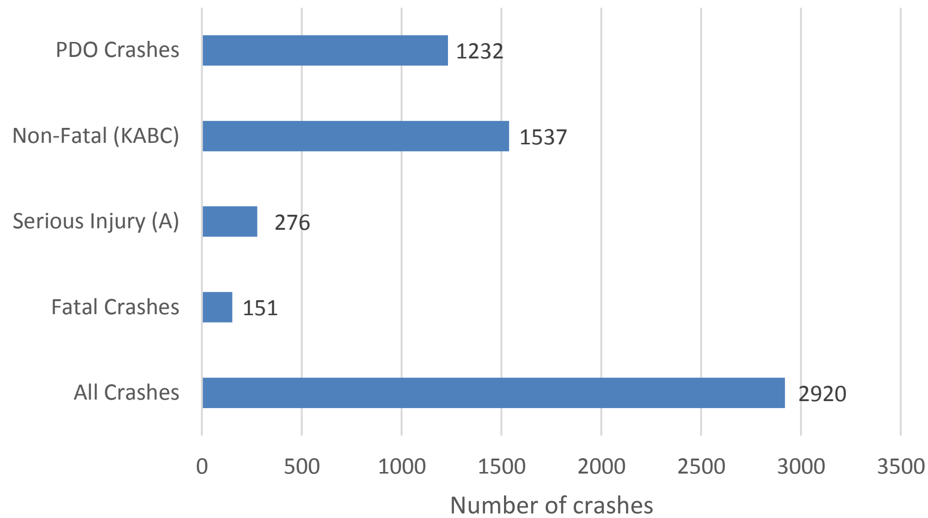

Figure 20: Alcohol or Drug use - Impaired Driving Crashes by Crash Severity (Oregon, 2012)

It is clear from the figure22 given below, that alcohol or drug use impaired crashes in urban areas were 59.8%. When Figure 13 and 14 are read in conjunction it is observed that the highest number of alcohol impaired crashes in urban areas with 70.1% resulted in PDO crashes while non-fatal (KABC) stood at 53.6%, serious injuries at 42% and fatal crashes at 37.7%. Moving towards the buffer zones, the percentage of PDO crashes occurred in the +10 mile buffer zone was 97.9%, the non-fatal (KABC) crashes (96.9%), serious injuries (96%) and fatal crashes (91.4%). Fatal crashes have been the lowest for all four zones.

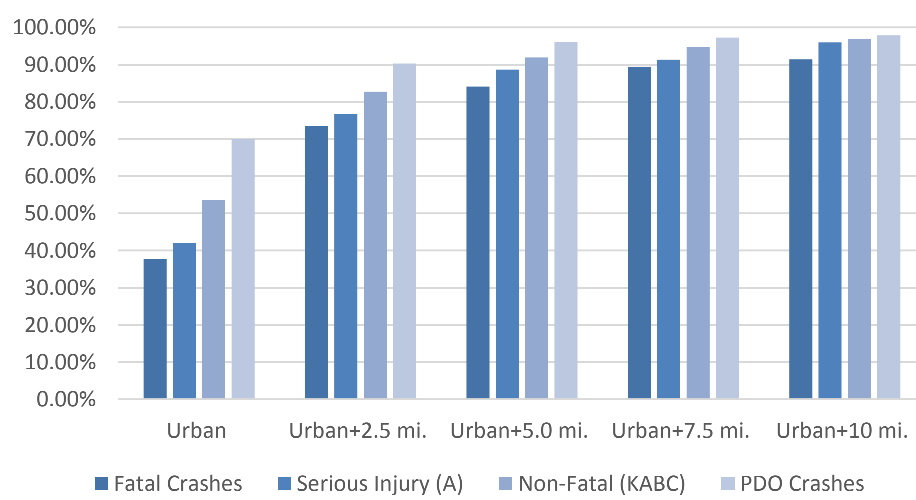

Figure 21: Alcohol or Drug use Impaired Driving Crashes (Oregon, 2012 - Based on Zone and Crash Severity)

3.2.6 Unbelted Passenger Vehicle Occupant Crashes

Seat belts have the potential of reducing the risk of critical injuries to a great extent (Safety in Numbers, 2013). What is important is that commuters should use this insignificant safety tool provided in their vehicles. Seat belts play a crucial role in holding the person in place during a crash reducing the chances of a person being ejected out from the vehicle. On comparing the data for years 2006 and 2012 for Oregon it is clear that the percentage of fatalities involving unbelted passengers is different than NHTSA 2009 in all zones except for the urban areas. The maximum difference of 10% has been in the +10 mile zone and closely followed with 8% by the +7.5 mile buffer zone. The difference in the +5 mile buffer zone has been 7% while in the +2.5 mile buffer zone the difference was 4%.

Table 13: Unbelted Passenger Vehicle Occupant Fatalities in Oregon – 2006, 2012

Year	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
NHTSA 2006	24%	49%	55%	68%	71%
Fatalities 2012	22%	53%	62%	76%	81%

Figure 23 illustrated below shows the distribution of unbelted passenger vehicle occupant crashes in the state of Oregon for the year 2012.

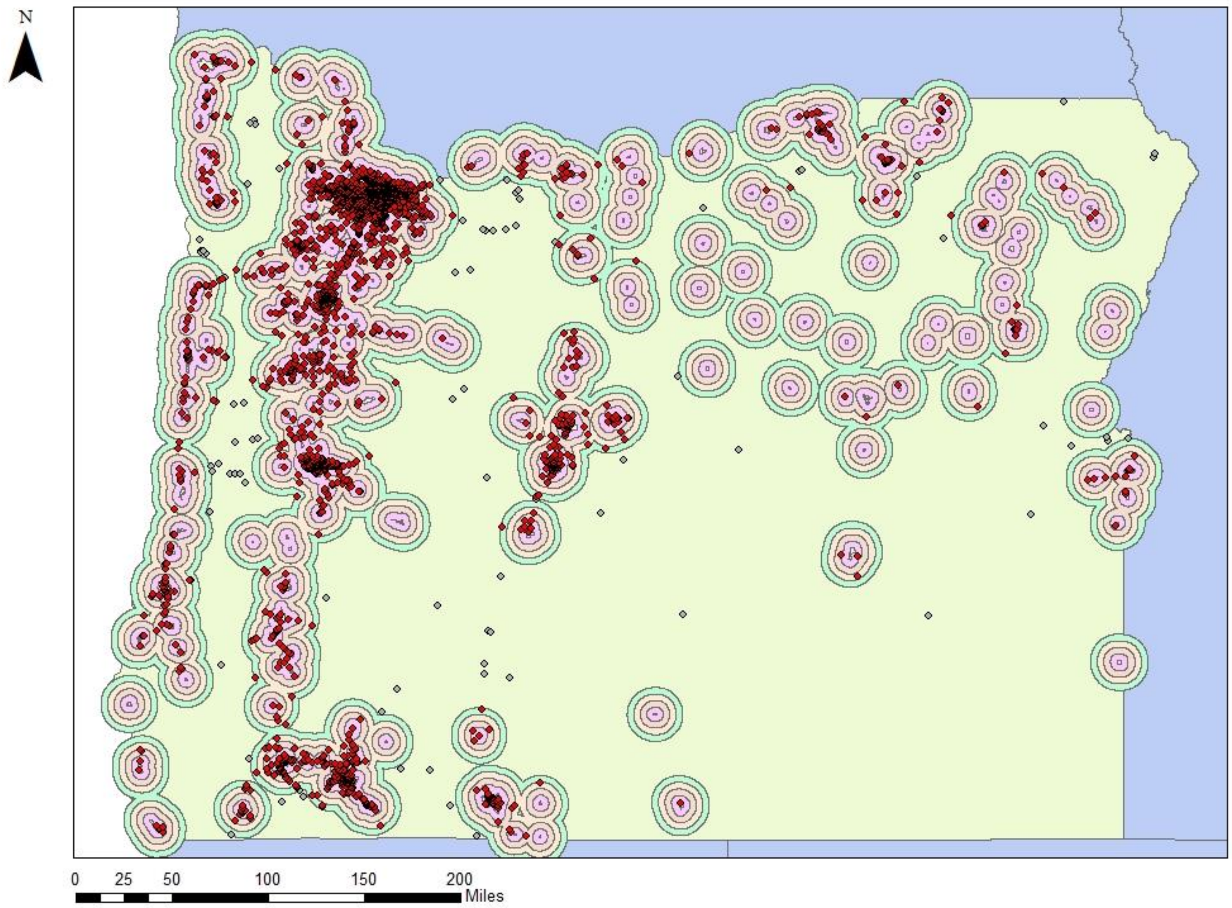

Figure 22: Unbelted Passenger Vehicle Occupant Crashes (Oregon, 2012)

The data for the same has been reduced in numbers and presented in table given below and drawn into figures 15 and 16. As it is clear from figure24 below that the total number of crashes in this category was 1,538, out of which 1116 were non-fatal (KABC) and 86 were fatal in nature. Crashes resulting in serious injuries were 187 while PDO crashes were 336.

Table 14: Unbelted Passenger Vehicle Occupant Crashes (Oregon, 2012)

Category	Total Number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	1538	58.5%	79.30%	88.20%	91.5%	94.0%
Fatal Crashes	86	25.6%	60.5%	70.9%	82.6%	87.2%
Serious Injury (A)	187	38.5%	65.4%	80.2%	83.9%	90.4%
Non-Fatal (KABC)	1116	59.8%	79.7%	89.0%	92.0%	94.5%
PDO Crashes	336	62.2%	82.7%	89.6%	91.9%	94.0%

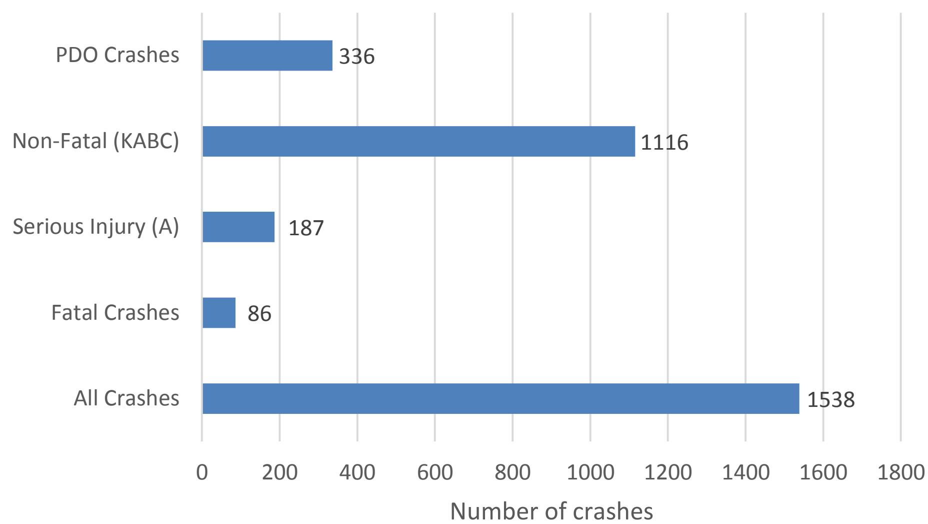

Figure 23: Unbelted Passenger Vehicle Occupant Crashes by Crash Severity (Oregon, 2012)

Figure25shows that the percentage of crashes involving unbelted passengers in urban areas was 58.5%. Non-fatal (KABC) crashes in urban areas were 59.8% while fatal crashes were 25.6%. Serious crashes in the urban areas were 38.5% while crashes involving damage to property were 62.2%.

As one moves away from urban areas into the buffer zones, the percentage of crashes gradually increases. Fatal crashes in the +2.5 mile zone were at 60.5% which is more than doubled than the percentage for urban areas. The percentage continued to increase to 70.9% for +5.0 miles, 82.6% to +7.5 miles and 87.2% for +10 miles. Crashes of non-fatal (KABC) nature with 94.5% were the highest in the +10 mile zone with 79.7 % lowest in +2.5 mile buffer zone.

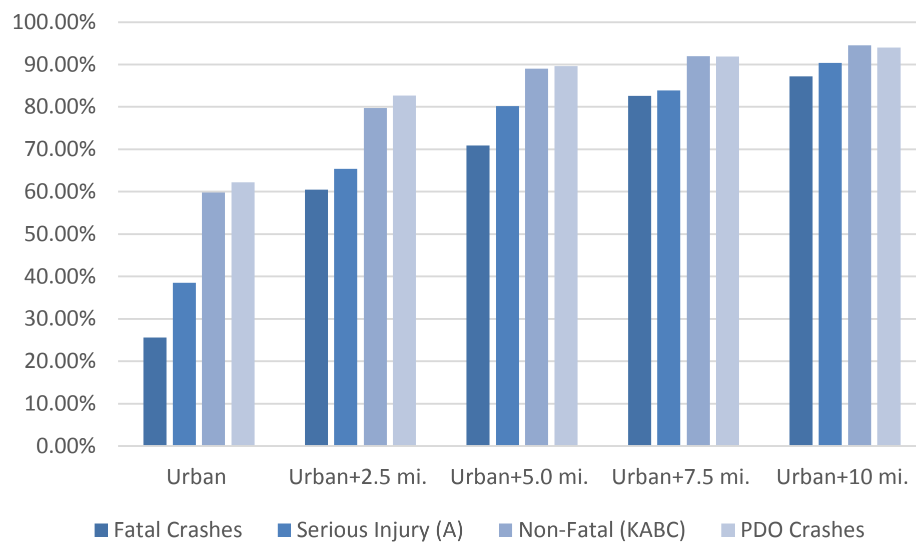

Figure 24: Unbelted Passenger Vehicle Occupant Crashes (Oregon, 2012 – Based on Zone and Crash Severity)

3.2.7 Crashes during the Weekend

Another important factor to be considered is, crashes and fatalities based on the days during the weekend. The table given below presents comparative data for fatalities during the weekend for the years 2006 and 2012. The difference in the percentage of fatalities is recorded for all zones. The percentage of fatalities for the urban zone according to NHTSA 2009 was 34% in 2006, and was 21% in 2012, and the difference in the other zones has been significant in both years. In the +5 mile zone, fatalities during the weekend has a difference of 2% in 2012 as compared to 2006, while in the +7.5 mile zone, the difference was 5%. The difference in the percentage in the +10 mile zone was 8%.

Table 15: Fatalities during the Weekend in Oregon – 2006, 2012

Year	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
NHTSA 2006	34%	56%	64%	70%	74%
Fatalities 2012	21%	49%	66%	75%	82%

Figure 26 illustrated below represents the distribution of crashes during weekend in the urban areas of Oregon and the adjoining buffer zones.

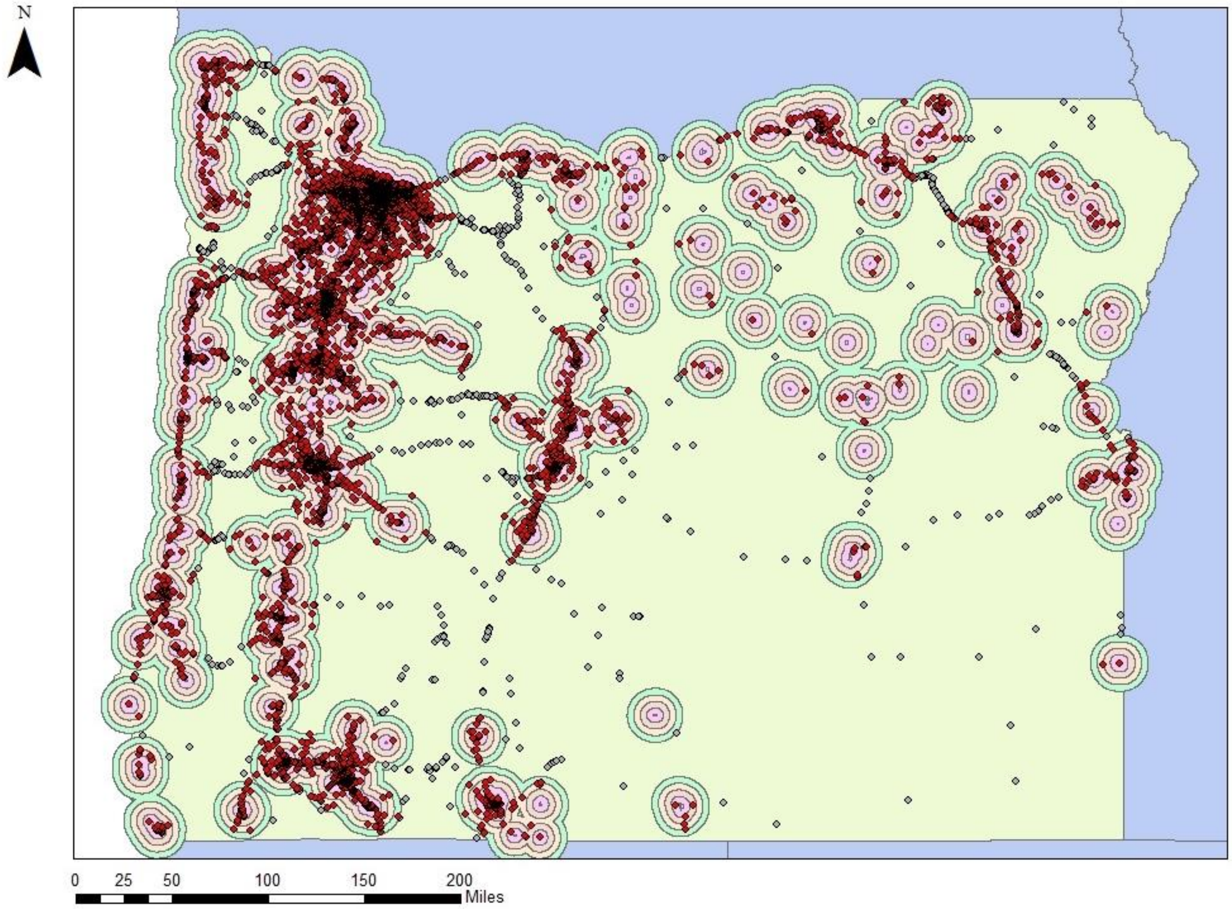

Figure 25: Crashes during the Weekend (Oregon, 2012)

Table 16: Crashes during the Weekends (Oregon, 2012)

Category	Total Number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	11468	63.5%	83.8%	90.4%	93.3%	95.1%
Fatal Crashes	113	23.9%	53.9%	72.6%	80.5%	87.6%
Serious Injury (A)	406	37.9%	69.7%	82.7%	85.9%	90.8%
Non-Fatal (KABC)	5567	61.9%	83.5%	90.7%	93.6%	95.4%
PDO Crashes	5788	65.7%	84.6%	94.0%	93.2%	95.0%

The total number of crashes during the weekends stood at 11,468 out of which 5,567 were non-fatal (KABC) in nature while 113 were fatal. 5,788 crashes were PDO in nature, while 406 involved serious injuries. The data related to different types of crashes is illustrated in Figure27 given below.

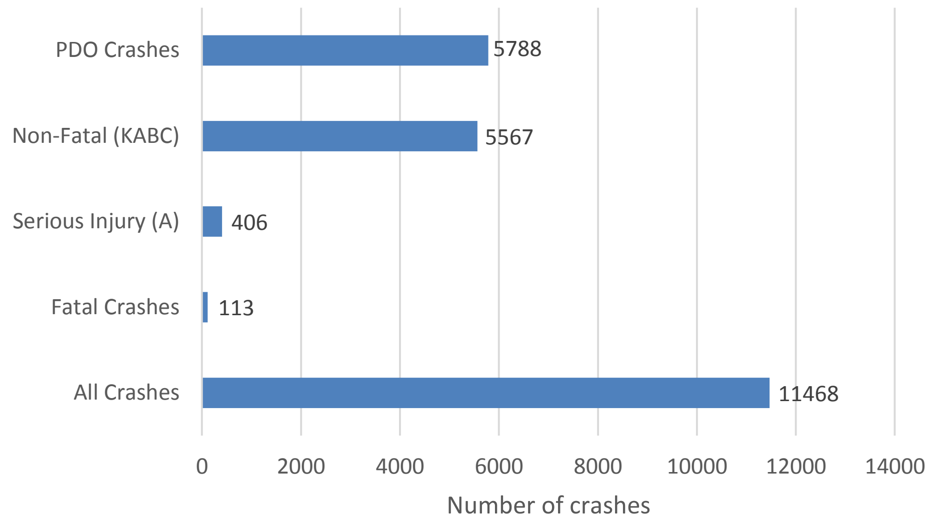

Figure 26: Crashes during the Weekends by Crash Severity (Oregon, 2012)

Data related to crashes during weekends based on zone, and the crash severity is illustrated in Figure28 given below. For all categories of crashes, the number increases rapidly as one moves from the urban to the +2.5 mile and +5 mile buffer zones as percentages accumulate. As one moves farther, the increase continues but becomes more gradual. For example, the percentage of fatal crashes in urban areas' amount to 23.9%, and in the +2.5 mile zone, these crashes amount to 53.9%, in +5 mile zone, amount to 72.6%, +7.5 mile zone 80.5% and beyond 10 miles zone, it amounted to 87.6%. The same holds true for serious injury cases also (Urban 37.9%, +2.5 mile zone 69.7%, +5 mile zone 82.7%, and +7.5 mile zone 85.9% and +10 mile zone 90.8%).

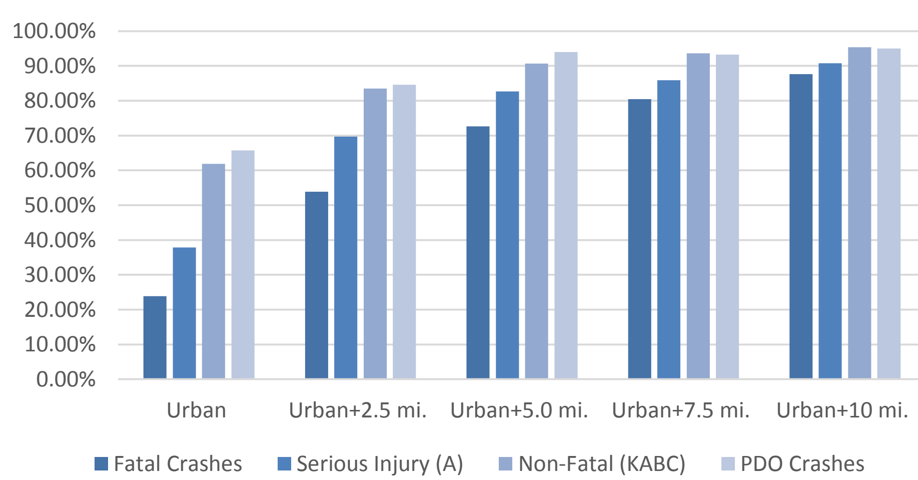

Figure 27: Crashes during the Weekends (Oregon, 2012 – Based on Zone and Crash Severity)

3.2.8 Nighttime Crashes

Nighttime driving is a high-risk activity especially for drivers with vision problems. Multiple factors are known to contribute towards nighttime Crashes. Lower visibility, glare from oncoming vehicles, inexperience with driving in low-light conditions, fatigue and alcohol are some factors that contribute towards nighttime crashes. On comparing the data for the years 2006 and 2012, a difference in the percentages of fatalities is observed for all zones. The percentage in the urban areas during 2006 was 42%, and for 2012 was 36%. Differences of 7%, 11%, 6% and 6% was observed in the +2.5, +5.0, +7.5 and +10 mile buffer zone.

Table 17: Nighttime Fatalities in Oregon – 2006, 2012

Year	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
NHTSA 2006	42%	67%	76%	84%	86%
Fatalities 2012	36%	74%	87%	90%	92%

Nighttime crashes for the state of Oregon are illustrated below in figure 29 given below. Data for the same is presented in table 18 given below.

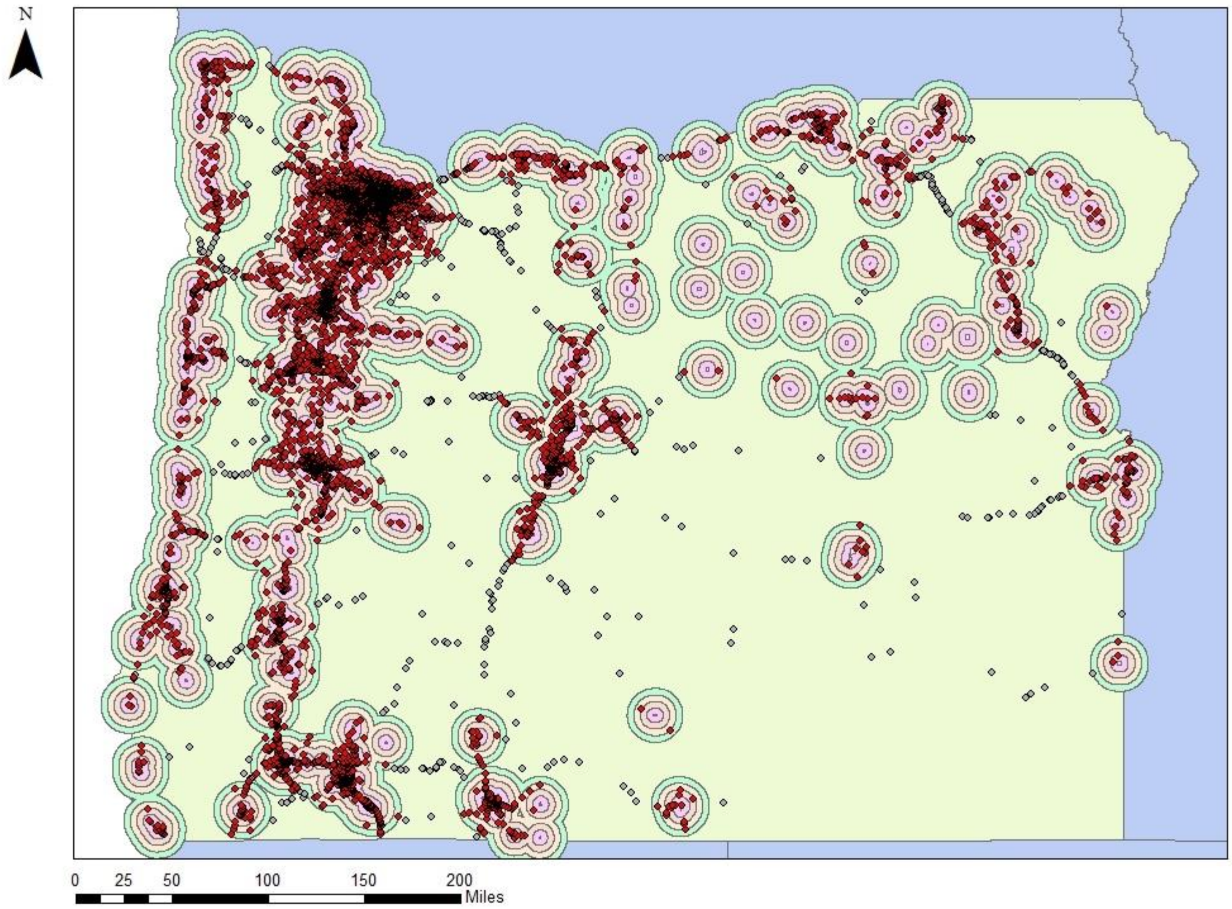

Figure 28: Nighttime Crashes (Oregon, 2012)

Table 18: Nighttime Crashes (Oregon, 2012)

Category	Total Number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	11208	62.1%	84.7%	91.9%	94.6%	96.4%
Fatal Crashes	126	38.1%	74.6%	86.5%	89.7%	92.1%
Serious Injury (A)	421	50.6%	78.8%	88.6%	93.1%	95.9%
Non-Fatal (KABC)	5394	62.1%	85.5%	92.5%	95.1%	96.9%
PDO Crashes	5688	62.6%	84.2%	91.4%	94.2%	96.0%
With street light	6244	88.1%	99.3%	99.6%	99.8%	100%
No street light	4964	29.0%	66.4%	82.1%	87.9%	92.0%

Irrespective of the zone, total nighttime crashes are represented in figure30 given below. The total number of nighttime crashes was 11,208, out of which PDO crashes were the highest at 5,688 while serious injuries' crashes were 421. Non-fatal (KABC) crashes were high at 5,394 while fatal crashes were 126 in number.

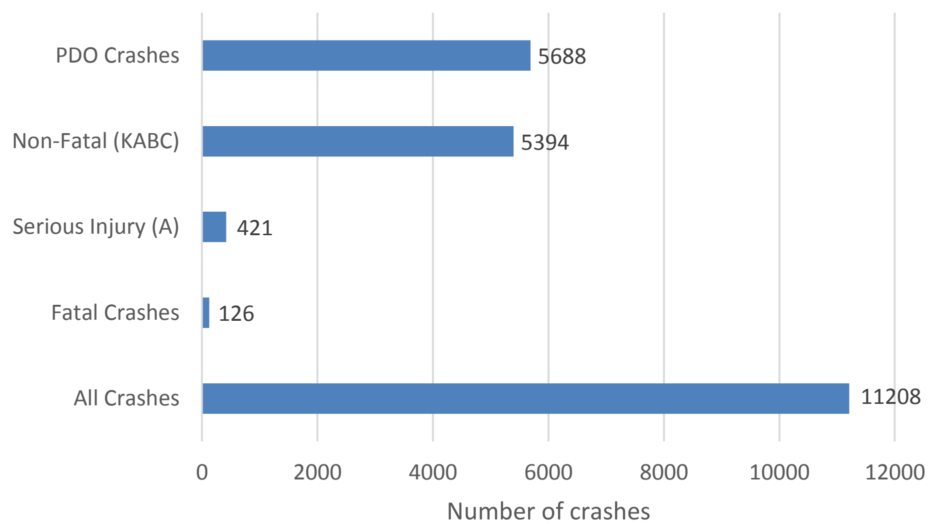

Figure 29: Nighttime Crashes by Crash Severity (Oregon, 2012)

It is also clear from the above data that a greater number of nighttime crashes occurs when the street light is there. A total of 6,244 crashes occurred when there is a street light while 4,964 crashes occurred when there is no street light. The same has been illustrated in figure31 given below.

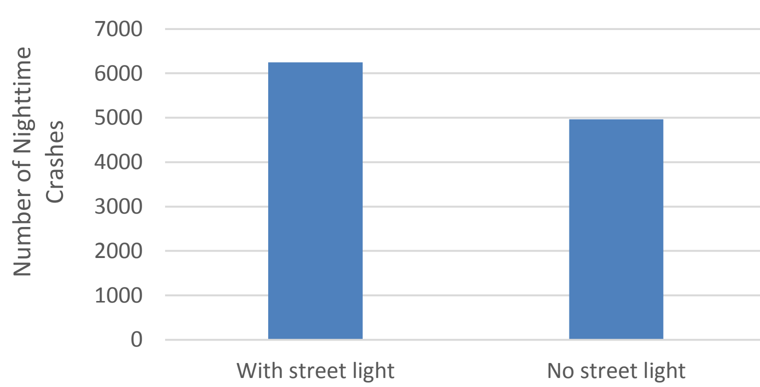

Figure 30: Nighttime Crashes based on light conditions (Oregon, 2012 – Based on Light Conditions)

Data related to urban, buffer zones and category of crashes are illustrated in figure 32 given below. The percentage of all nighttime crashes in urban areas amounted to 62.1%. This number was relatively high in the buffer zones and increased rapidly. While in the urban areas, nighttime crashes in areas with the street light were 88.1%, the percentage increased by more than 10% in the buffer zones. In the buffer zones, the percentage increased gradually, in the +2.5 mile buffer zone, the percentage was 99.3%, + 5 mile zone 99.6%, +7.5 mile buffer zone 99.8% and +10 mile zone 100%.

In the urban areas, nighttime crashes in areas with no street lights were 29.0%, the number increased rapidly in the buffer zones. In the +2.5 mile buffer zone, the percentage was 66.4%, +5 mile zone 82.1%, +7.5 mile buffer zone 87.9%, and +10 mile zone 92%.

Figure 31: Nighttime Crashes (Oregon, 2012 – Based on Zone and Crash Severity)

3.2.9 Crashes on Interstate Highways

A difference in the percentages of fatalities on interstate highways was recorded for the year 2012 as compared to year 2006 for the urbanized areas and for the buffered zones. In the urban zone, the difference between the two years was not high4%. The difference for the +2.5 mile buffer zone was 38 %, for the +5.0 mile buffer zone has been 28% while for +7.5 mile buffer zone was 20% and for the +10 mile buffer zone, it has been 22%

Table 19: Fatalities on Interstate Highways in Oregon – 2006, 2012

Year	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
NHTSA 2006	34%	76%	82%	82%	84%
Fatalities 2012	38%	38%	54%	62%	62%

The total number of crashes on interstate highways was 4,894. The number of PDO crashes and non-fatal (KABC) crashes was the highest at 2,499 and 2,378 respectively. Serious injuries were 83 in number while fatal crashes were 17. The same are represented graphically as Figure33 illustrated below.

Table 20: Crashes on Interstate Highways (Oregon, 2012)

Category	Total Number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	4894	62.7%	85.6%	91.6%	95.0%	96.6%
Fatal Crashes	17	5.0%	53.0%	76.5%	88.2%	88.2%
Serious Injury (A)	83	45.8%	75.9%	83.1%	92.8%	96.4%
Non-Fatal (KABC)	2378	64.8%	87.2%	92.6%	95.6%	97.4%
PDO Crashes	2499	61.0%	84.3%	90.7%	94.6%	96.6%

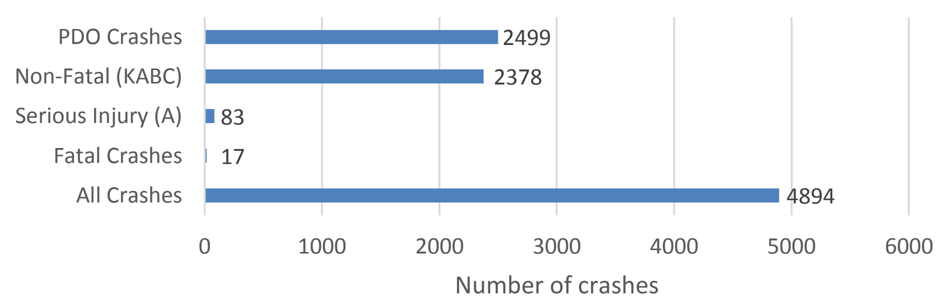

Figure 32: Crashes on Interstate Highways by Crash Severity (Oregon, 2012)

The percentage of these crashes in urban areas was 62.7%. In the buffer zones, the percentage increased gradually. It touched 85.6% in the +2.5 mile buffer zone, 91.6% in the +5.0 mile buffer zone, and 95% in the +7.5 mile buffer zone.

The number of fatal crashes in urban areas was as low as 5% but relatively high in the buffer zones. In the +2.5 mile buffer zone, it touched 53.0%, in the +5.0 mile buffer zone, it touched 76.5% and remained the same at 88.2% for both +7.5 mile buffer zone and +10 mile zone.

Crashes on Interstate Highways have been highlighted in figure 34 given below illustrates the distribution of crashes on interstate highways in the urban areas and buffer zones around urban areas in the state of Oregon.

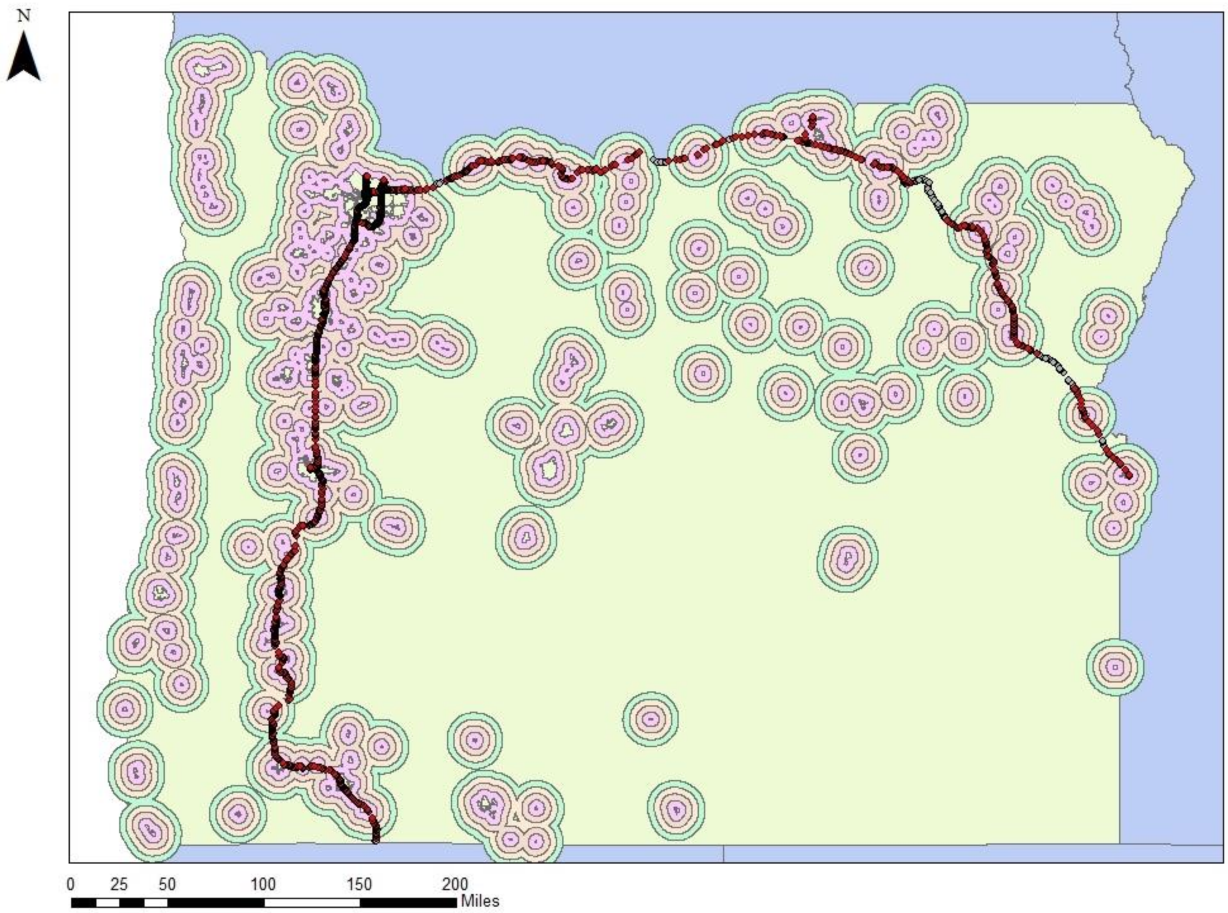

Figure 33: Crashes on Interstate Hwy (Oregon, 2012)

Non-fatal (KABC) crashes have been high in all zones. In the urban areas, non-fatal (KABC) crashes have been as high as 64.8%, it touched 87.2% in the +2.5 mile buffer zone, 92.6% for +5.0 mile buffer zone, 95.6% for +7.5 mile buffer zone and 97.4% for +10 mile buffer zone.

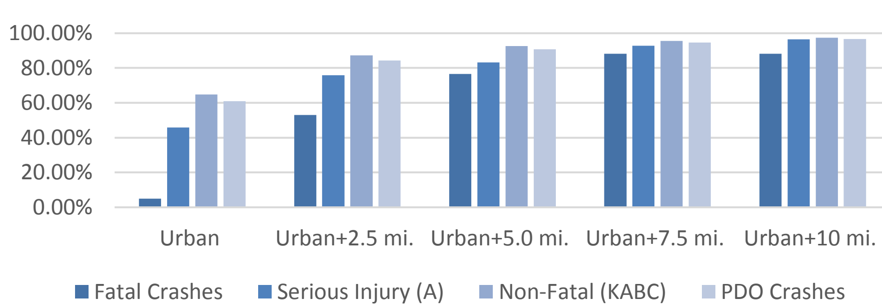

Figure 34: Crashes on Interstate Highways (Oregon, 2012 – Based on Zone and Crash Severity), 2012

3.2.10 Crashes on U.S./State Highways

A comparison of fatalities on US/State Highways for the years can be drawn from the table given below. A difference in the percentages of fatalities is observed for all zones. The percentage of fatalities in the urban areas was23% in 2012 while for 2006 it was24%. A difference of %13 in the +2.5 mile buffer zone, and %19 in the +5.0 mile buffer zone, and 22% in the +7.5 mile buffer zone and 24% in the +10 mile buffer zone.

Table 21: Fatalities on US/State Highways in Oregon – 2006, 2012

Year	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
NHTSA 2006	24%	40%	50%	58%	62%
Fatalities 2012	23%	56%	69%	80%	86%

Crashes on US/ State Highways have been high. Figure 36 given below illustrates the distribution of crashes on US/State highways in the urban areas and buffer zones around urban areas in the state of Oregon. It is clear that the gray colored crashes represent a high number of crashes outside the buffered zones.

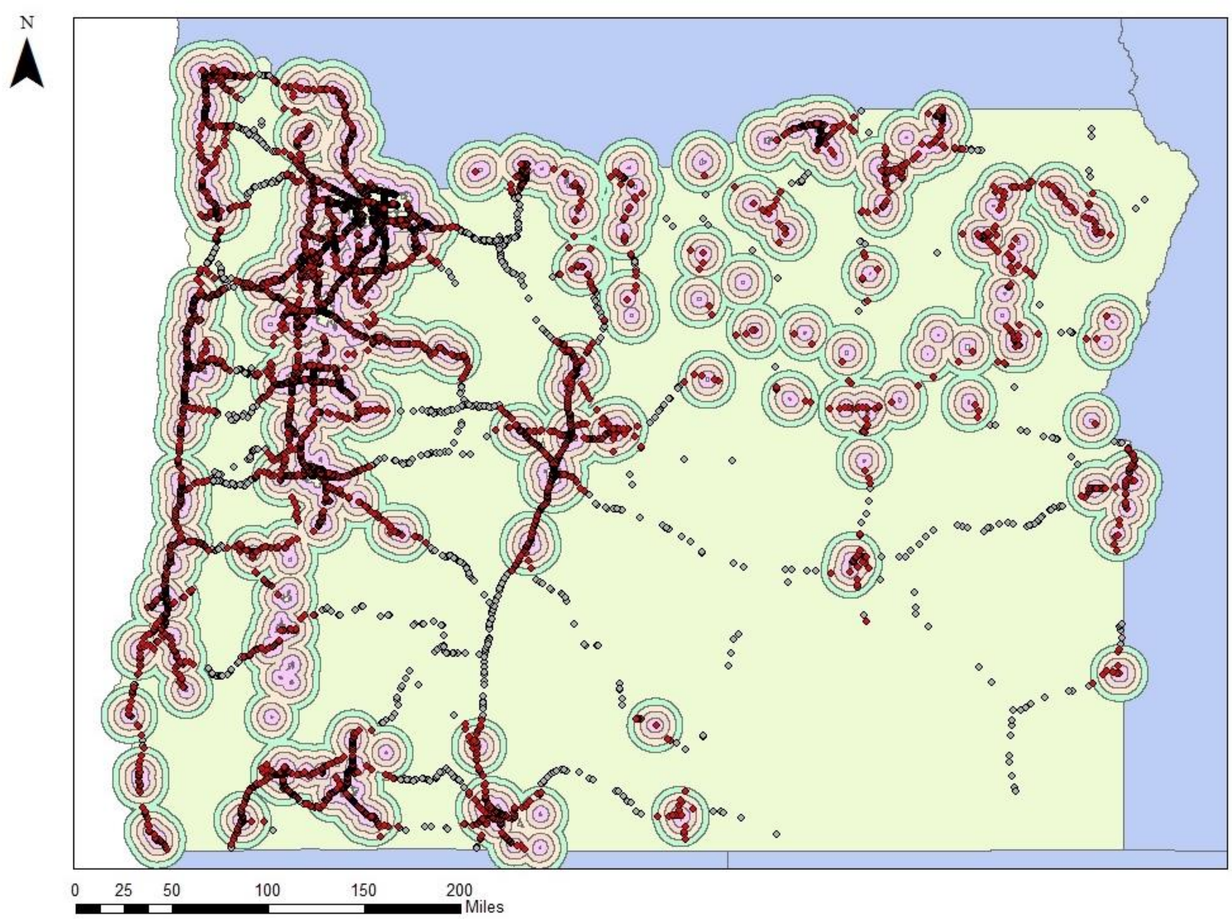

Figure 35: Crashes on U.S./State Highways (Oregon, 2012)

Data presented in table 22 clearly shows that the total number of crashes on State highways in urban areas are high. The number touches 15,233, out of which the highest number 7,862 result in non-fatal (KABC) crashes while fatal crashes are 148. Number of PDO crashes is also high at 7,213 while cases of serious injuries were 560 in number. The same has been graphically represented as Figure37 and is illustrated below.

Table 22: Crashes on US / State Highways (Oregon, 2012)

Category	Total Number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	15223	58.3%	81.4%	88.2%	91.2%	93.3%
Fatal Crashes	148	23.6%	58.8%	71.6%	81.1%	86.5%
Serious Injury (A)	560	35.3%	69.8%	80.0%	84.8%	89.3%
Non-Fatal (KABC)	7862	57.9%	78.8%	89.2%	92.0%	94.0%
PDO Crashes	7213	59.3%	80.7%	87.4%	90.6%	92.7%

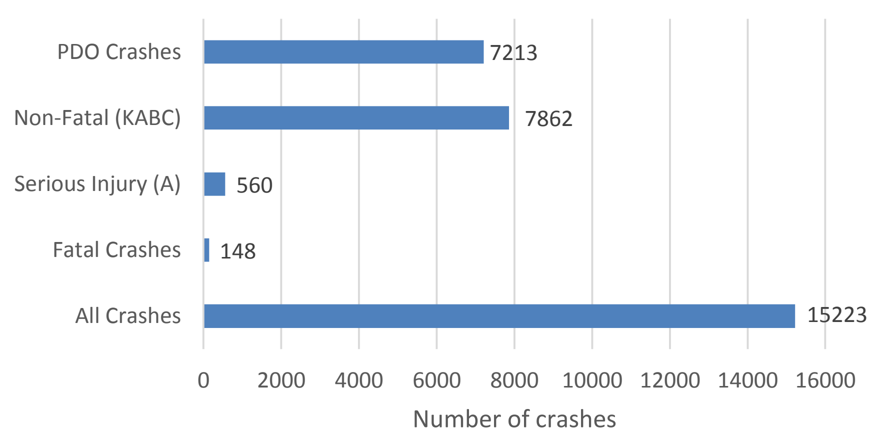

Figure 36: Crashes on US / State Highways (Oregon, 2012)

The percentage of total crashes in urban areas on state highways was 58.3%, this indicates that for the year of 2012, 42% of US/State highways crashes happened in rural areas outside the buffered zones. For the urban zone, PDO crashes were the highest in number with 59.30%, to be closely followed by 57.9% while serious injuries were 35.3% and fatal crashes 23.6%. As one moves farther away from the urban areas, the percentage increases as crashes from previous zones will be added. While a rapid increase is observed as one moves in the +2.5 mile zone from urban area, there is a gradual increase for the other three zones. Figure38 illustrates the sharp rise as one moves to the +2.5 buffer zone and a gradual increase thereon.

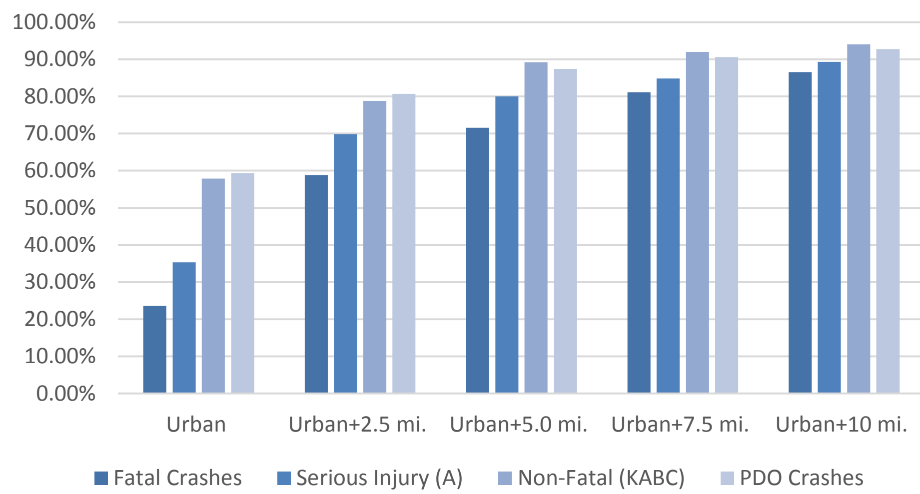

Figure 37: Crashes on US / State Highways (Oregon, 2012 – Based on Zones and Crash Severity)

3.2.11 Crashes due to Road Character (Grade /Curve)

The term "character of the road" here refers to crashes involving a horizontal curve or a vertical grade on the road. These curves/grades also can have a combination of both horizontal and vertical. While horizontal curves refer to change in alignment, vertical curves refer to a change in slope.

Figure 39 illustrated below depicts the distribution of crashes due to character of the road in urban areas of Oregon and buffered zones around the urban areas.

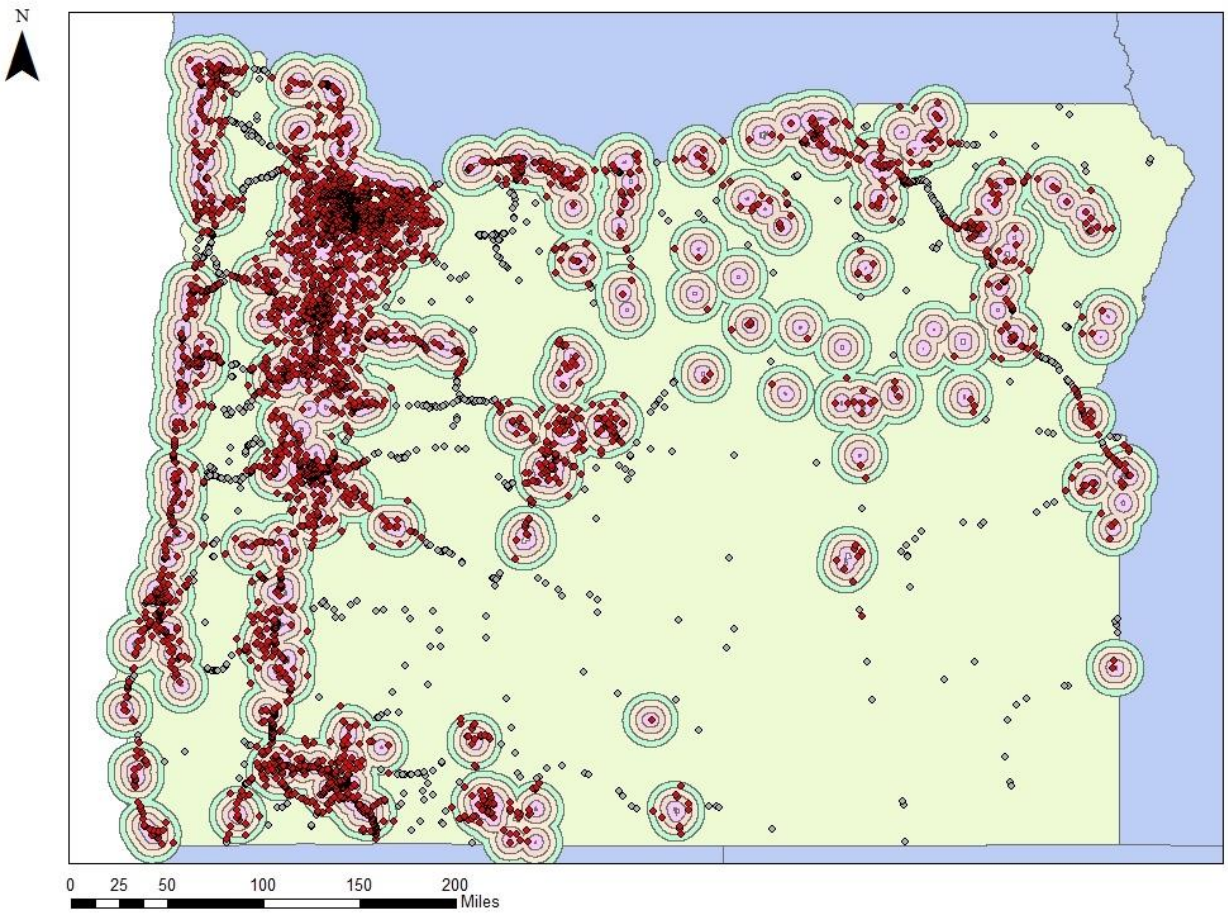

Figure 38: Crashes by Character of Road (Oregon, 2012)

Data related to this category of crashes is represented below in table 23. The total number of crashes in this category is 5,958, out of these 26.6% were in urban areas, 73.4% in rural areas. The highest number of crashes amounting to 3,037 was of non-fatal (KABC) nature while fatal crashes were 129. Crashes involving PDO were 2,792 while crashes involving serious injuries were 362 in number. Figure40 given below illustrates the total number of crashes and the different categories of crashes for comparative analysis.

Table 23: Crashes by Character of Road (Oregon, 2012)

Category	Total Number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	5958	26.6%	58.5%	73.6%	81.8%	87.1%
Fatal Crashes	129	9.3%	41.1%	60.5%	70.5%	78.3%
Serious Injury (A)	362	12.7%	50.2%	77.2%	76.9%	85.8%
Non-Fatal (KABC)	3037	24.3%	57.8%	73.9%	81.6%	87.1%
PDO Crashes	2792	29.9%	60.1%	73.9%	82.5%	87.5%

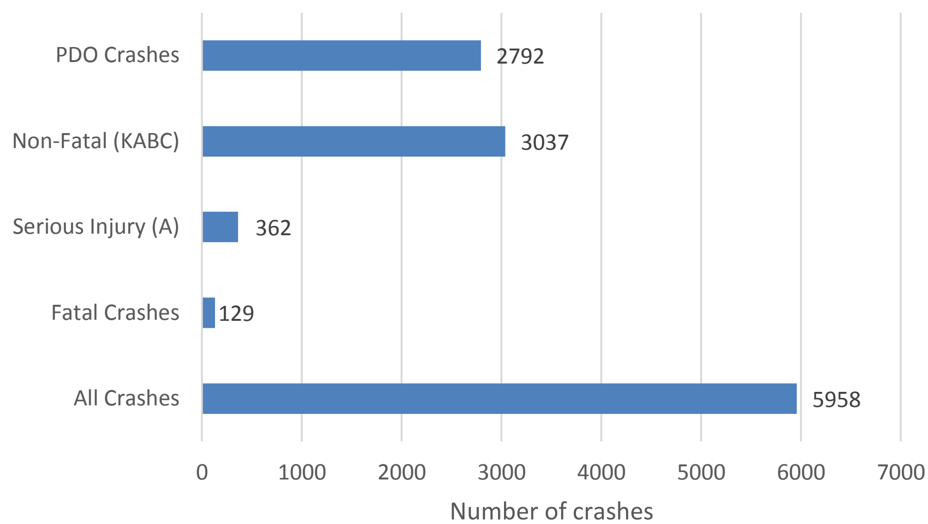

Figure 39: Crashes by Character of Road (Oregon)

Looking at the data in detail, it is clear that the percentage of crashes in urban areas is not high as compared to buffer zones around the urban areas. Fatal crashes in the urban areas were 9.3%, while non-fatal (KABC) crashes were 24.3% in number. Serious injuries in this category were 12.7% while PDO crashes were 29.9%. It is clear from Figure41 given below that as one moves into the buffer zones, the percentage of crashes' increases considerably. While all crashes in the +2.5 mile buffer zone rises up to 58.5%, it rises up to 73.6% in the +5.0 mile buffer zone, 82% in the +7.5 mile buffer zone, and 87% in the +10 mile buffer zone.

The highest percentage of crashes in the +2.5 mile buffer zone was in the category of PDO crashes, while in the +5.0 mile buffer zone crashes, serious injuries were the highest. In the +7.5 and +10 mile buffer zone PDO crashes remained at 82.5% and 87.5%, which were the highest respectively.

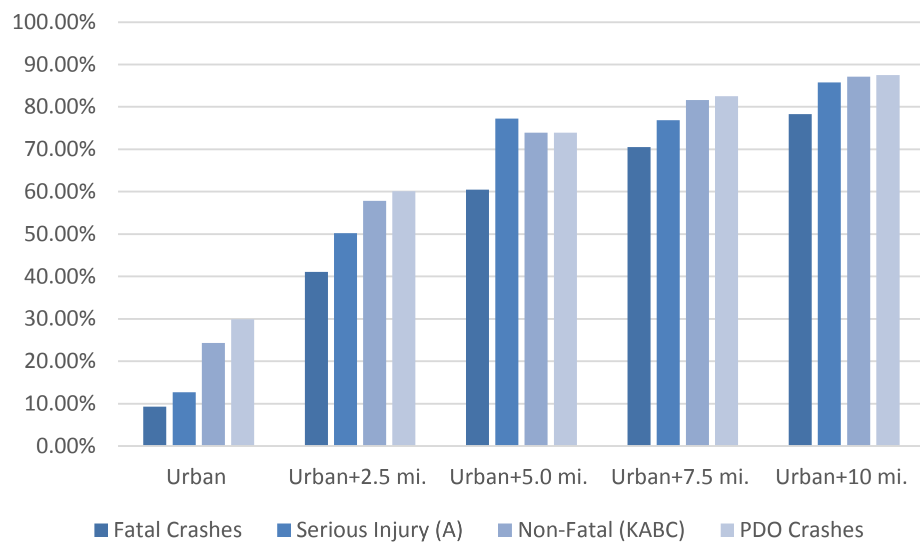

Figure 40: Crashes by Character of Road (Oregon, 2012 – Based on Zones and Crash Severity)

3.2.12 Crashes due to Road Condition

Road conditions in an area play a significant role in determining the rate of crashes. For the purposes of this report, both wet and dry road conditions were analyzed. Both road conditions are discussed in individual sections.

3.2.12.1Dry Road Condition

Map depicting distribution of crashes in urban areas and areas around urban areas depending on dry road conditions is illustrated below as figure 42.

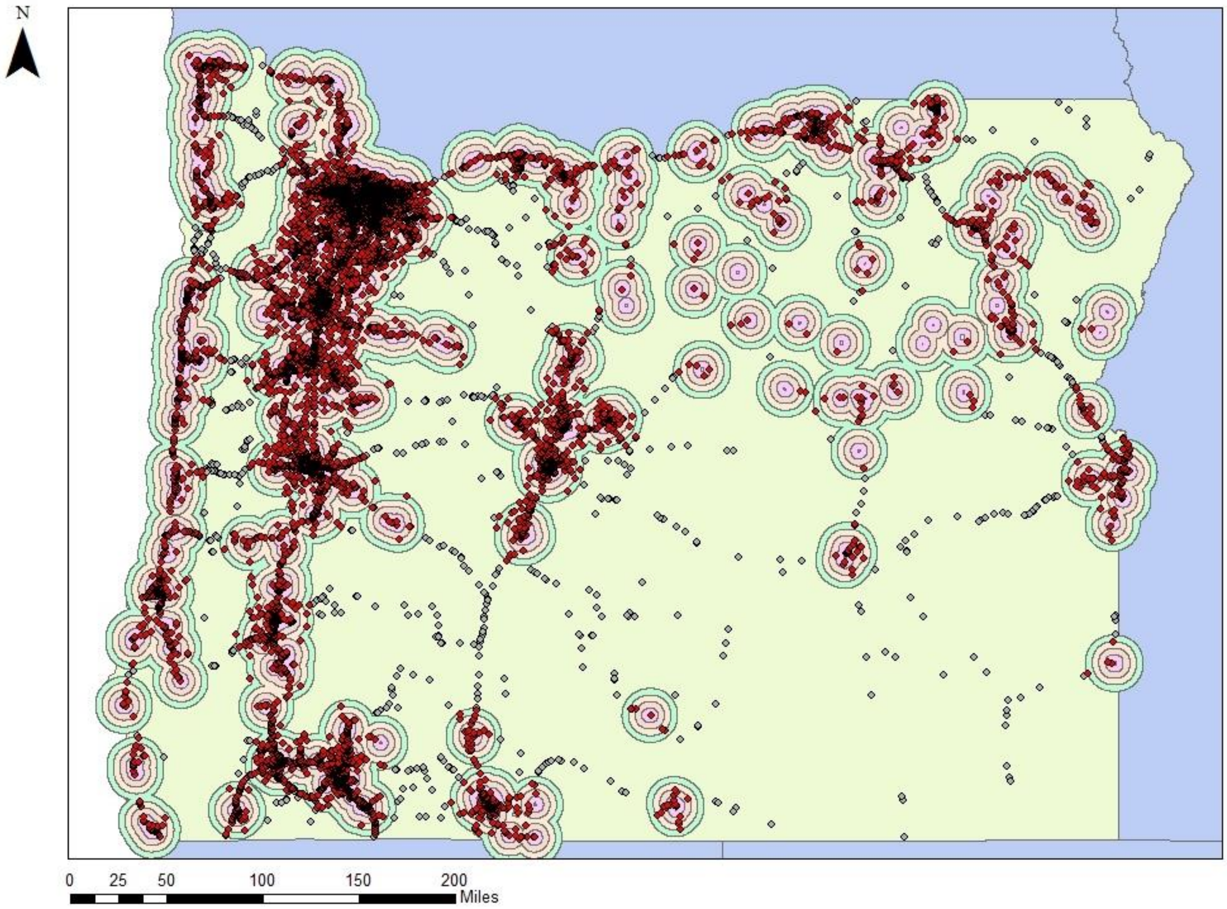

Figure 41: Crashes by Surface of the Road (Oregon, 2012– Road Condition Dry)

Data for the same is depicted in table 24 given below that the total number of crashes on dry road conditions is high. It touches 32,866 out of which non-fatal (KABC) crashes with 16,627 are the highest in number and closely followed by PDO crashes at 16,044. Serious injuries in dry road conditions are 1,012 and fatal crashes are 195 in number. The same are graphically represented as figure43 and illustrated below.

Table 24: Crashes by Surface of the Road (Oregon, 2012 – Road Condition Dry)

Category	Total Number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	32866	73.0%	90.7%	95.1%	96.8%	97.8%
Fatal Crashes	195	37.8%	62.0%	74.3%	82.6%	89.7%
Serious Injury (A)	1012	47.6%	77.2%	87.3%	90.6%	94.5%
Non-Fatal (KABC)	16627	70.0%	90.3%	95.0%	96.8%	97.9%
PDO Crashes	16044	75.6%	91.5%	95.9%	97.0%	98.0%

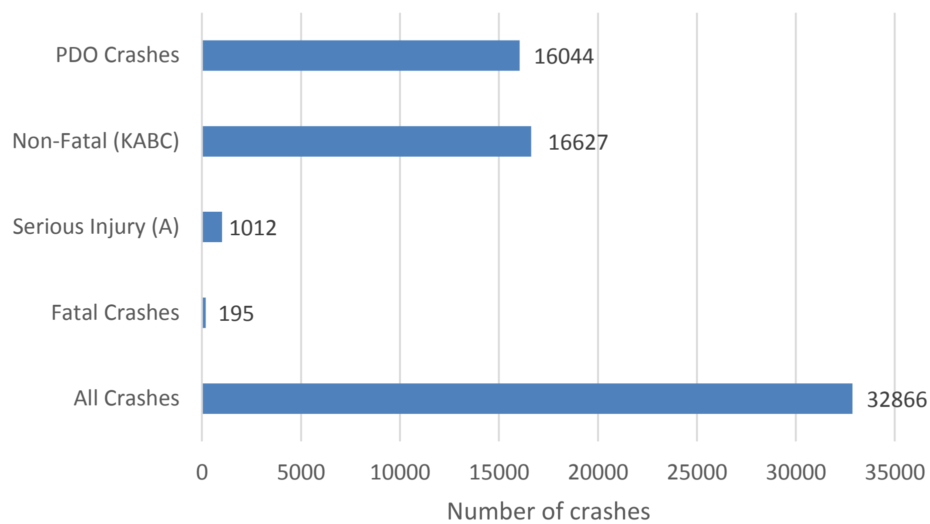

Figure 42: Crashes by Surface of the Road (Oregon, 2012 – Road Condition Dry)

Figure44 illustrated below represents the percentage of crashes for comparative analysis between urban areas and buffer zones around urban areas due to dry road conditions. Due to dry road conditions the percentage of crashes in urban areas touched 73%. As one moves out in the rural areas, the percentage rises considerably to 90.7% in the +2.5 mile buffer zone, 95.1% in the +5.0 mile buffer zone, 97% in the +7.5 mile buffer zone, and 98% in +10 mile buffer zone. The highest percentage of crashes within city boundaries in all the five zones is the highest in the PDO category and the lowest percentage of crashes within city boundaries in all five zones is the lowest for fatal crashes.

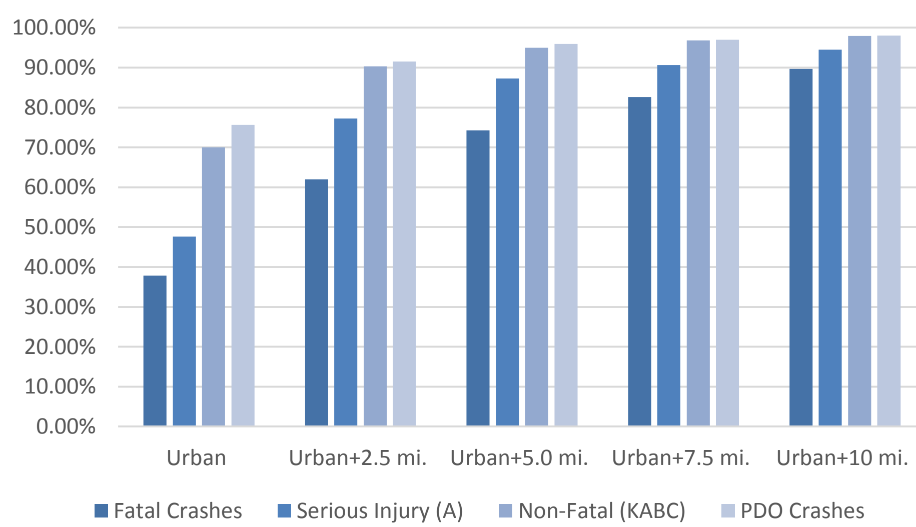

Figure 43: Crashes by Dry Road Conditions (Oregon, 2012– Based on Zone and Crash Severity)

3.2.12.2Wet Road Condition

The other aspect for analyzing crashes depend on road conditions is wet road conditions. Figure45 given below illustrates the distribution of wet road condition crashes in the urban areas of Oregon and buffer zones around urban areas.

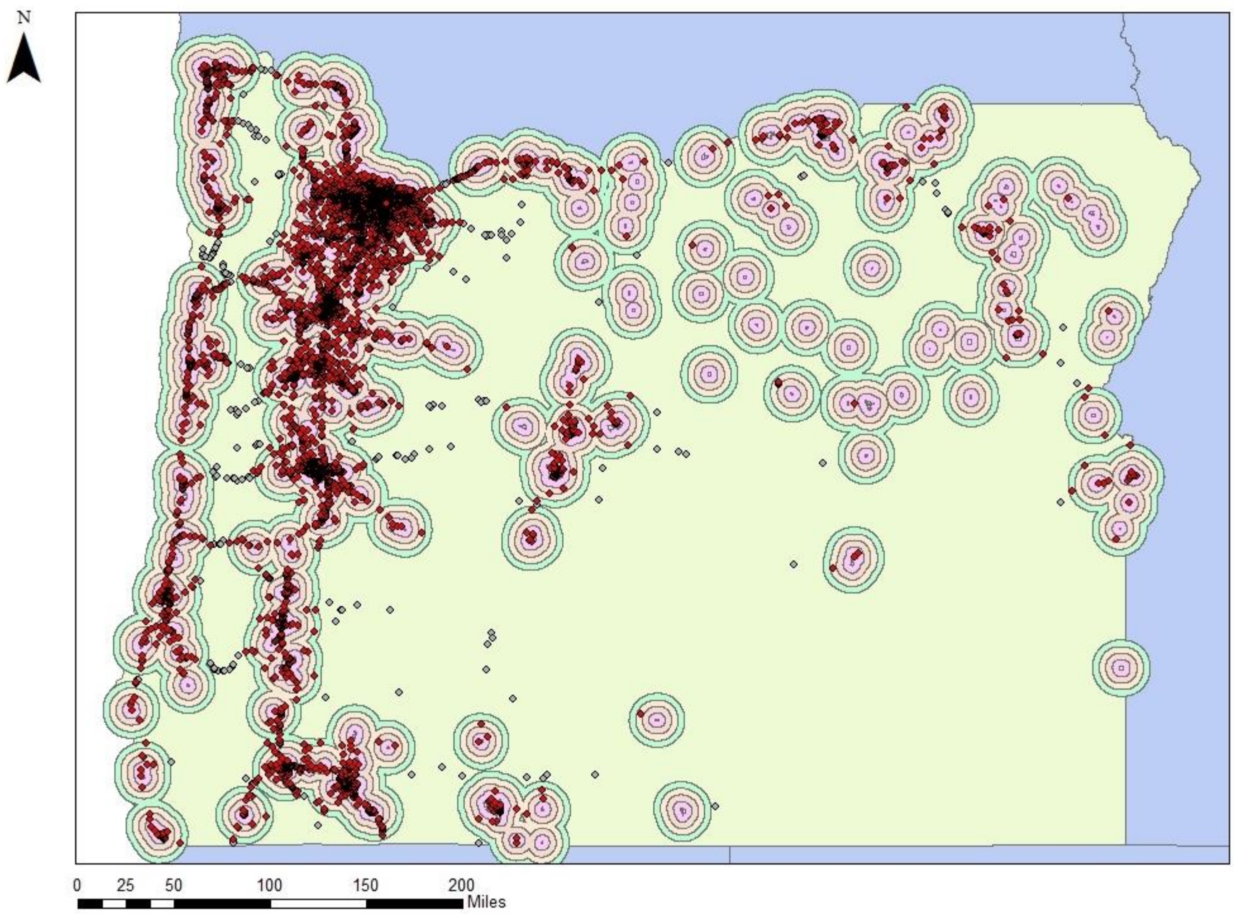

Figure 44: Crashes by Surface of the Road (Oregon, 2012 – Road Condition Wet)

Data for road crashes in wet road conditions is presented in table 25 given below. The total number of crashes in wet road conditions was 12,924, out of which the highest number of crashes is in the category of non-fatal (KABC) crashes (6,435) and PDO (6,410). Cases involving serious injury were 324 and those involving fatal crashes were 79. A graphical representation of the total number of crashes and various categories of crashes are illustrated below in figure46 below.

Table 25: Crashes by Surface of the Road (Oregon, 2012 – Road Condition Wet)

Category	Total Number	Urban	Urban+2.5 mi.	Urban+5.0 mi.	Urban+7.5 mi.	Urban+10 mi.
All Crashes	12924	71.3%	91.0%	95.5%	97.2%	98.3%
Fatal Crashes	79	39.2%	81.0%	92.0%	96.2%	97.5%
Serious Injury (A)	324	51.8%	81.2%	91.3%	95.1%	96.9%
Non-Fatal (KABC)	6435	91.0%	95.8%	97.3%	97.4%	98.3%
PDO Crashes	6410	72.7%	91.1%	95.1%	97.1%	98.3%

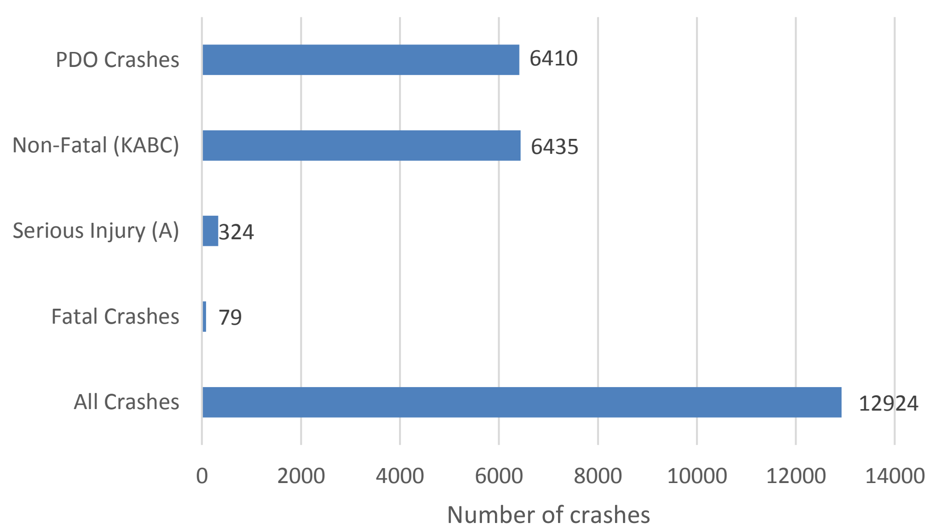

Figure 45: Crashes by Surface of the Road (Oregon, 2012 – Road Condition Wet)

From the data presented in table 25 above, the percentage of crashes in urban areas was around 71.3%, and a rapid increase is observed as one moves into the buffer zones. For +2.5 mile buffer zone, the percentage of all crashes was 91%, in the +5.0 mile buffer zone, the percentage was 95.5%, in the +7.5 mile buffer zone, the percentage was 97% and in the +10 mile buffer zone, the percentage was 98%. For all zones, including urban areas, the highest percentage of crashes is non-fatal (KABC) in nature. In the +10 mile buffer zone, the percentage of PDO crashes and non-fatal (KABC) crashes is the same i.e. 98.3%. In the urban areas, the lowest percentage of crashes was of fatal nature with 39.2%. In the +2.5 mile buffer zone, the lowest percentage of crashes was in the fatal category, while in the +5 mile buffer zone, +7.5 mile buffer zone and +10 mile buffer zone, crashes in the serious injury category have been the lowest. Figure47 given below illustrates the crashes by wet road conditions in urban areas and buffer zones based on crash severity.

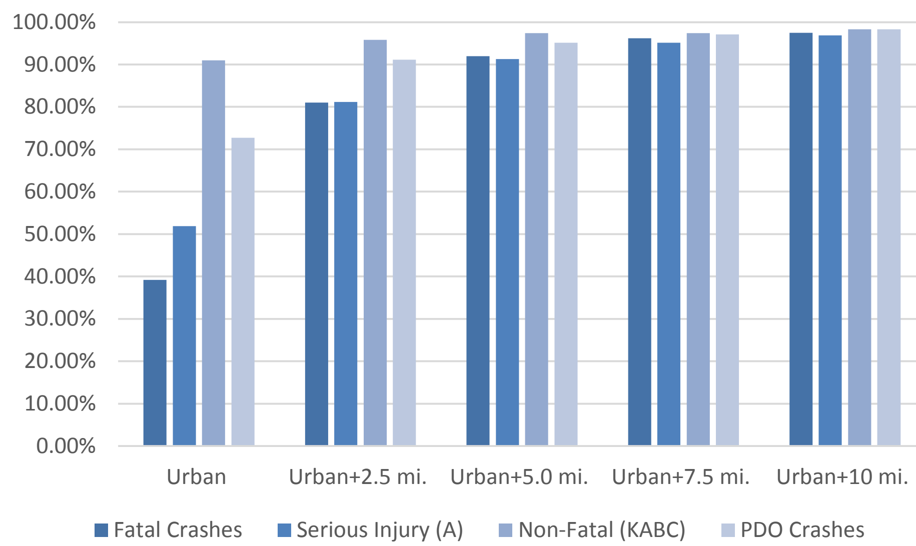

Figure 46: Crashes by Wet Road Conditions (Oregon, 2012 – Based on Zone and Crash Severity)

4. Road Density as a Measure of Urbanization

In the previous sections, cities' boundaries and buffers around cities were used as a measure of urbanization. In this section, another metric was used in order to measure the level of urbanization around each crash by counting the sum of road lengths in a 1-mile buffer around each crash (Figure48). This method was achieved using ArcGIS.

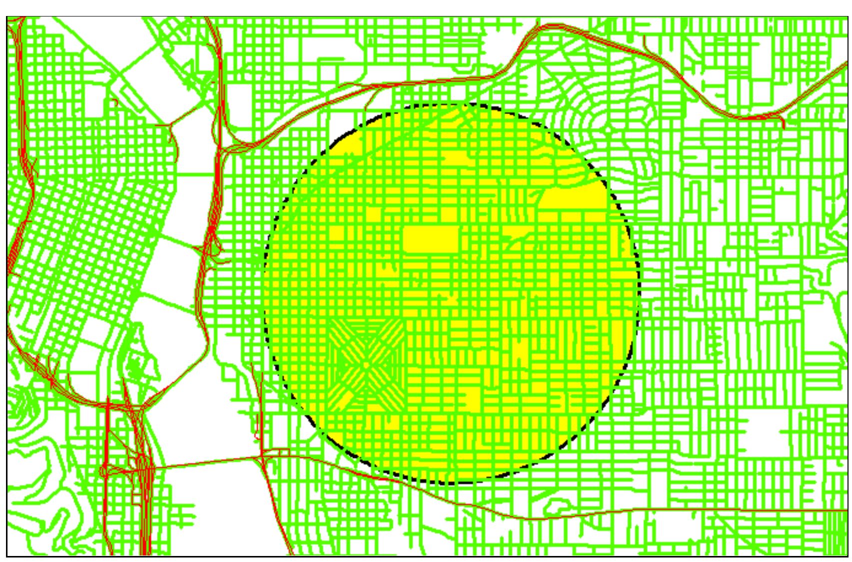

Figure 47: Buffered Crash site with the intersected roads.

4.1 Method

Two main feature class files (Geodatabase files) were used for this research:

1- All Crashes in Oregon 2012 → Obtained from ODOT FTP
2- All public Roads in Oregon → Obtained from USGS website

The size of the two files did give rise to several difficulties, therefore, a Python script was written that helped to break up the crashes' buffers into smaller sets in a geodatabase, and then to intersect the buffers with the road network file, then output the results into a separate geodatabase. Finally, will need the script to append each set of the buffers into one file. This script was written and developed to an ArcToolBox Tool (Figure 49).

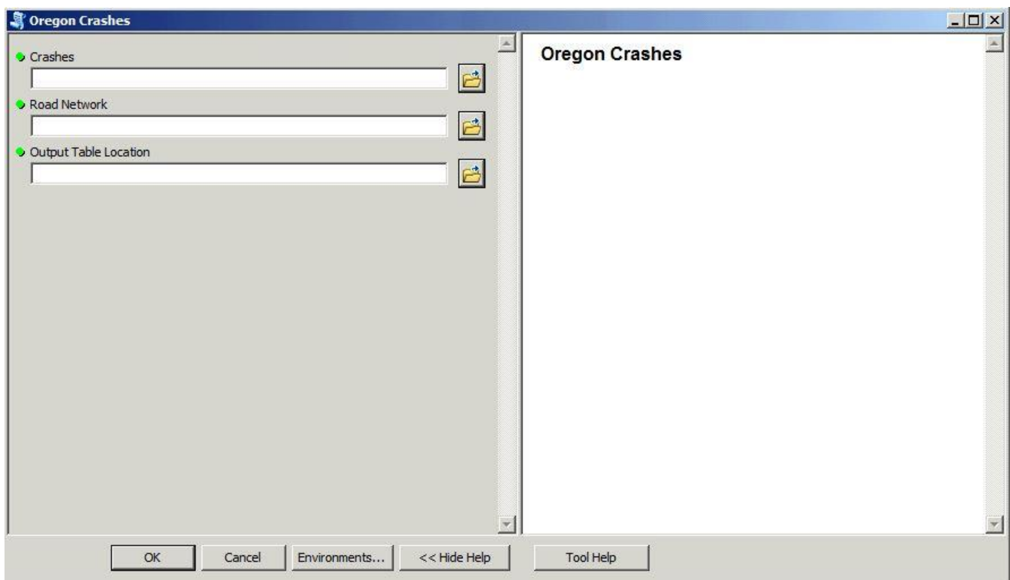

Figure 48: Screenshot of the "Miles of roads" Tool.

- The first parameter (Crashes) is for the crash points.
- The second parameter (Road Network) is for the road network.
- The third parameter (Output Table Location) is a folder location for the output geodatabase.

The functionality of this tool is as follows:

- Creates a file geodatabase in the output location.
- Buffers the crash points by 1 mile
- Takes the buffered crashes and groups by 1000. This is needed so that the intersect tool will run successfully.
- Then the tool will take each group of 1000 crashes and intersect with the road network to produce smaller outputs.
- Each smaller output is run through the 'Frequency' tool which sums up the length of all roads in the buffered crash area by each crash.
- The tool then will append all the smaller tables to a table called 'Summarized_Final'.
- The tool then will add a field named 'Total_Road_Length_in_Miles' which is the desired output.

What the tool will create in the geodatabase is listed below:

- A polygon feature class for the buffered crash points.
- All the smaller feature crashes that is produced group by group.
- A final table named 'Summarized_Final' with the results of each buffered crash and its total road length in miles.

Figure 50 gives a screenshot of the tool after running it, due to the size of the data, this should take a long time depending on how fast is the processor of the computer.

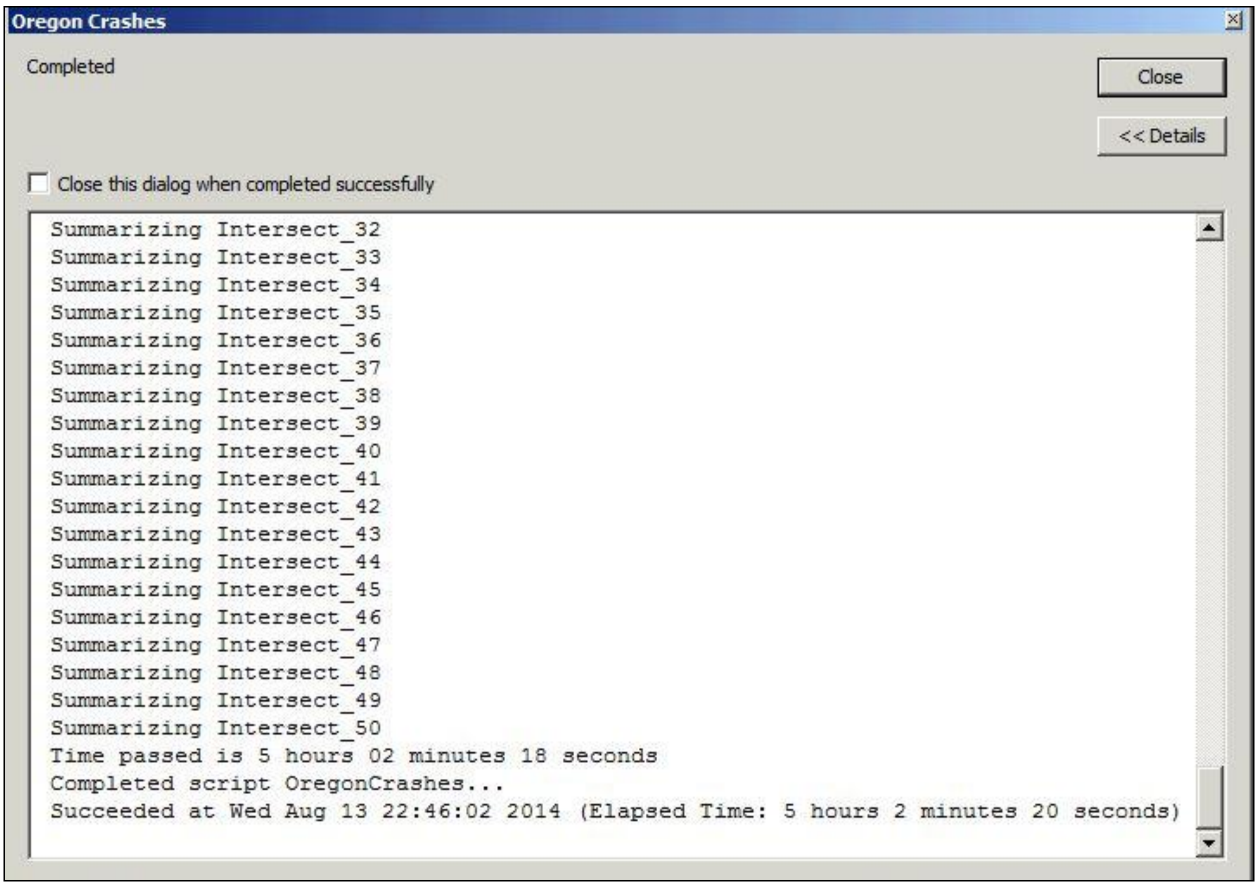

Figure 49: Tool after successfully running the script.

4.2 Results

The crashes were divided into 5 groups depending on the total miles of roads that intersect with the 1 -mile buffer. The groups are:

- Crashes with less than 25 miles of roads.
- Crashes with 25 to 50 miles of roads.
- Crashes with 50 to 100 miles of roads
- Crashes with 100 to 150 miles of roads.
- Crashes with more than 150 miles of roads.

Examples of crash sites for each group is shown on figures (### to ##) below:

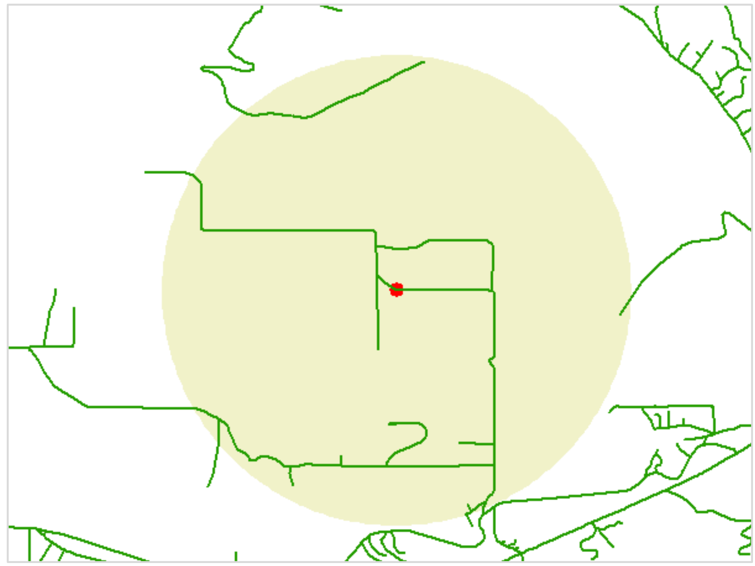

Figure 50: A crash site with less than 25 miles of road.

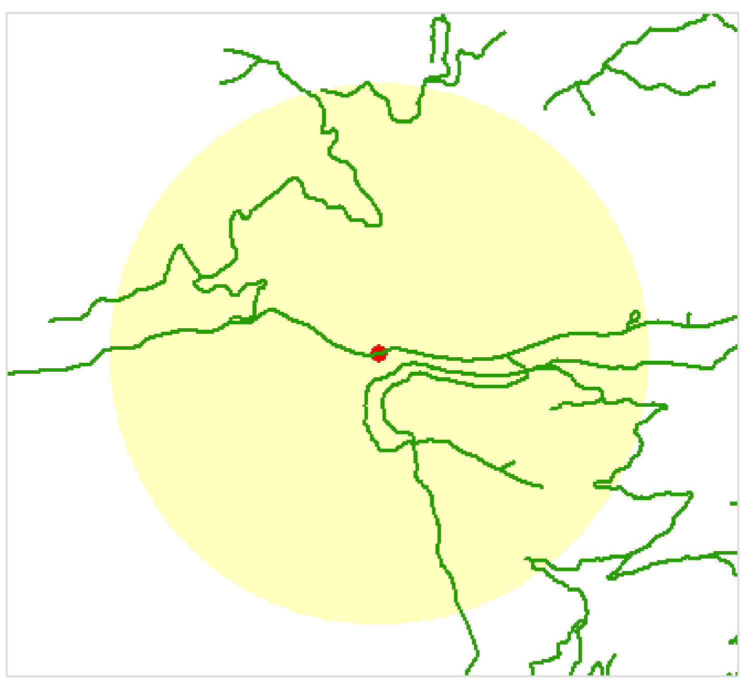

Figure 51: A crash site with less 25 - 50 miles of road.

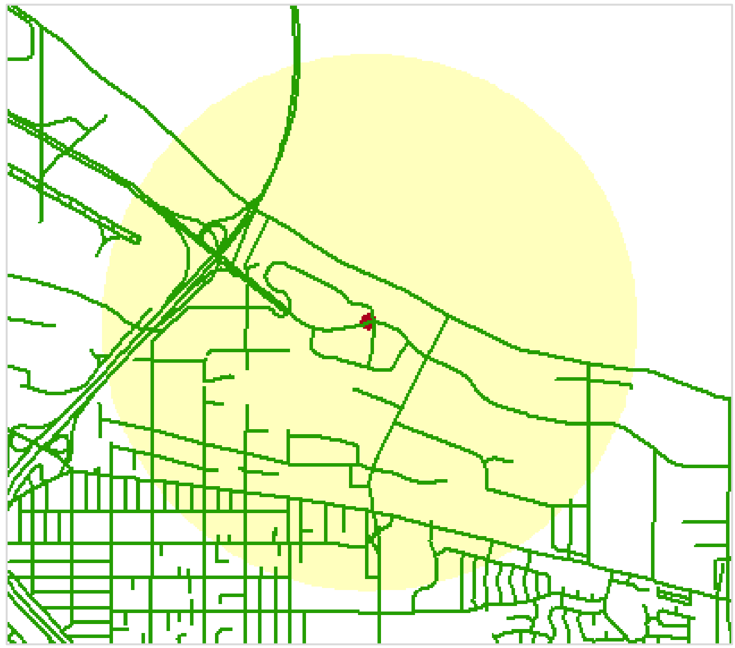

Figure 52: A crash site with 50 - 100 miles of road.

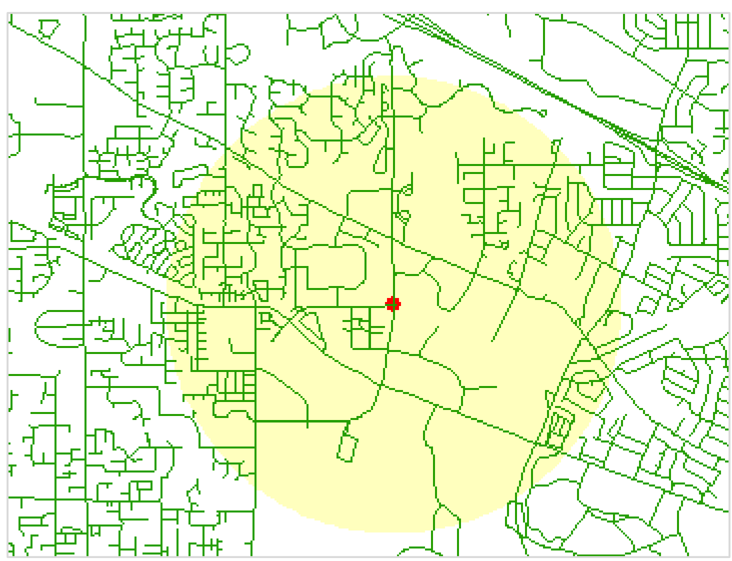

Figure 53: A crash site with 100 - 150 miles of road.

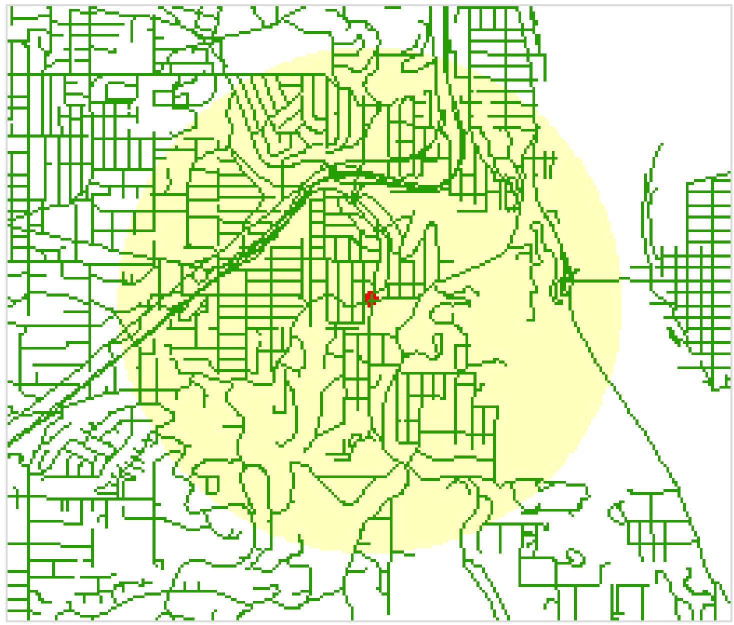

Figure 54: A crash site with more than 150 miles of road.

A sample analysis was carried out for the results as shown in the table below for each of the 5 groups.

Table 26: Analysis of 5 Groups (Non-Cumulative percentages)

Category	Total	< 25	25 - 50 mi.	50 - 100 mi.	100 - 150 mi	> 150 mi
All Crashes	49790	2.4%	9.4%	13.1%	10.50%	64.6%
Fatal Crashes	305	8.5%	27.2%	31.0%	8.7%	24.6%
Serious Injury (A)	1432	5.5%	18.5%	25.2%	10.0%	40.8%
Non-Fatal (KABC)	24455	1.8%	9.9%	13.6%	10.8%	63.9%
PDO Crashes	25030	2.3%	8.9%	12.7%	10.4%	65.7%

Figure 50 below is a histogram for the previous table:

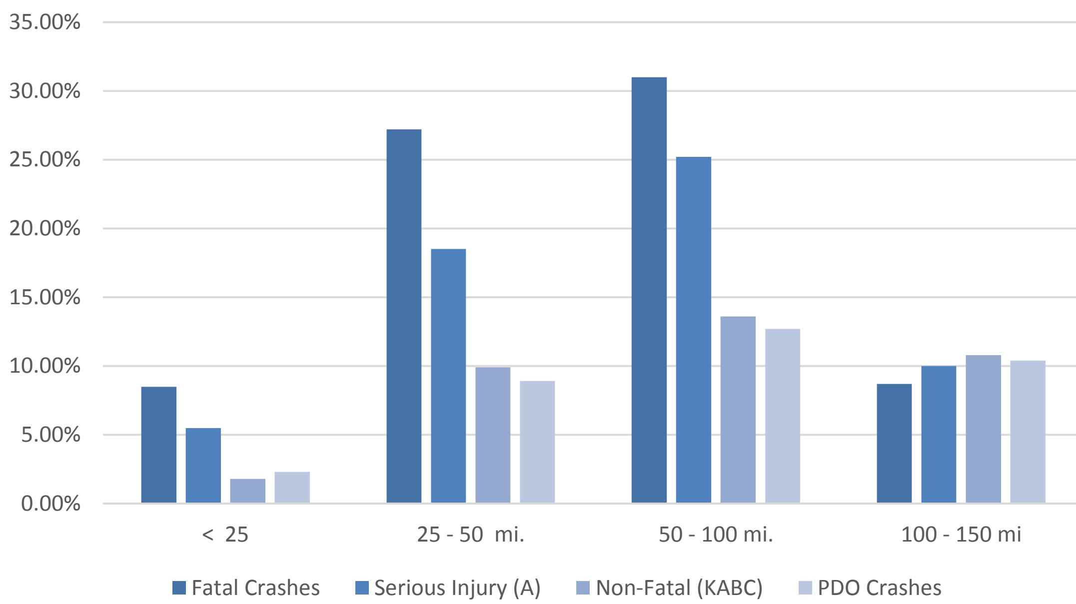

Figure 55: Miles of roads based on crash severity – non cumulative percentages. (Oregon, 2012)

Using the miles of road method, the total number of crashes that were recorded were 49790. The number of fatal crashes was 305 while non-fatal (KABC) crashes were 24455 and while 25030 crashes resulted in PDO, and 1432 crashes resulted in serious injuries. The largest number of fatal crashes were reported in the 50-100 (31%) mile buffer and lowest in the under 25 mile buffer (8.5%). The highest number of serious injuries were reported in the beyond the 150 -mile buffer zone (40.80%) while the lowest were once again in the under 25 -mile buffer zone (5.40%). Non-fatal (KABC) crashes were the highest in the beyond 150-mile buffer (63.90%) and lowest in the 25- 50- mile zone (9.60%). For PDO crashes, once again the number was the highest in the beyond the 150-mile zone (65.70%) but the lowest was in the under 25- mile buffer.

These results were compared with the previous method (City boundaries).

Table 27: Comparison of Results from Two Methods

Miles of Roads	MOR	New
City Boundaries	CB	Old

		Rural									Urban
All Crashes in Oregon	all	MOR	CB	MOR	CB	MOR	CB	MOR	CB	MOR	CB
Category	Total number	< 25	Urban + 10 mi	25 - 50 mi.	Urban + 7.5	50 - 100 mi.	Urban + 5 mi	100 - 150 mi	Urban + 2.5 mi	> 150 mi	Urban
All Crashes	49790	2.4%	1.2%	9.4%	2.1%	13.1%	4.9%	10.5%	18.7%	64.6%	70.0%
Fatal Crashes	305	8.5%	4.9%	27.2%	7.6%	31.0%	12.1%	8.7%	32.4%	24.6%	31.5%
Serious Injury (A)	1432	5.5%	3.3%	18.5%	3.7%	25.2%	10.3%	10.0%	29.9%	40.8%	46.4%
Non-Fatal Crashes	24455	1.8%	1.2%	9.9%	2.1%	13.6%	5.2%	10.8%	20.1%	63.9%	68.7%
PDO Crashes	25030	2.3%	1.4%	8.9%	2.1%	12.7%	4.6%	10.4%	17.2%	65.7%	71.7%

Moving from rural to urban areas while the highest number of crashes using the ‘CB’ method recorded in the urban areas and ‘MOR’ method in the beyond the 150 -mile zone. It is clear that the results (70% using CB and 64.60% using MOR) are close. It is clear from the above data that except for minor differences - which can be avoided by further investigation, the results for the two methods are correlated.

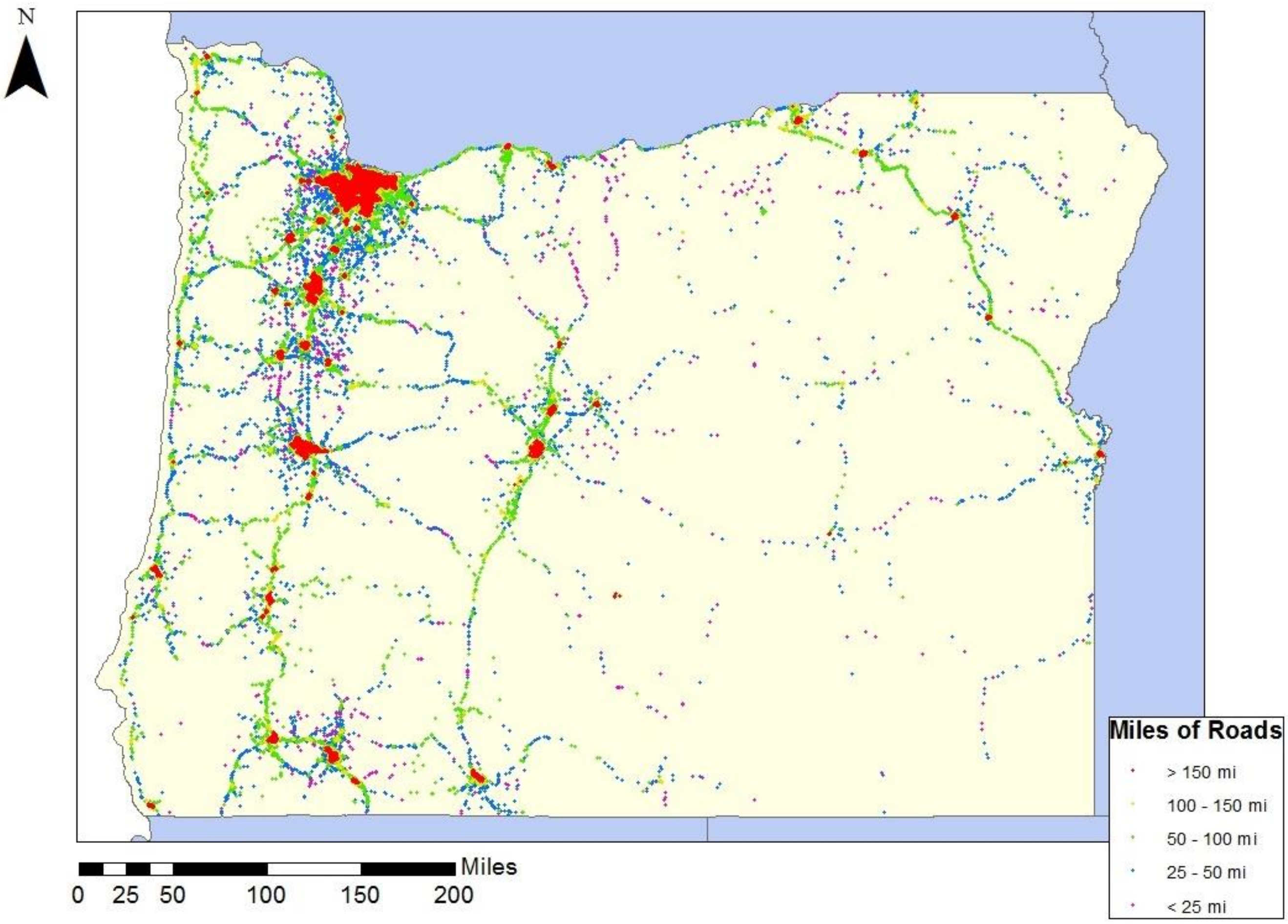

Figure 56: Crashes by Miles of Roads– 1 Mile Buffer (Oregon, 2012)

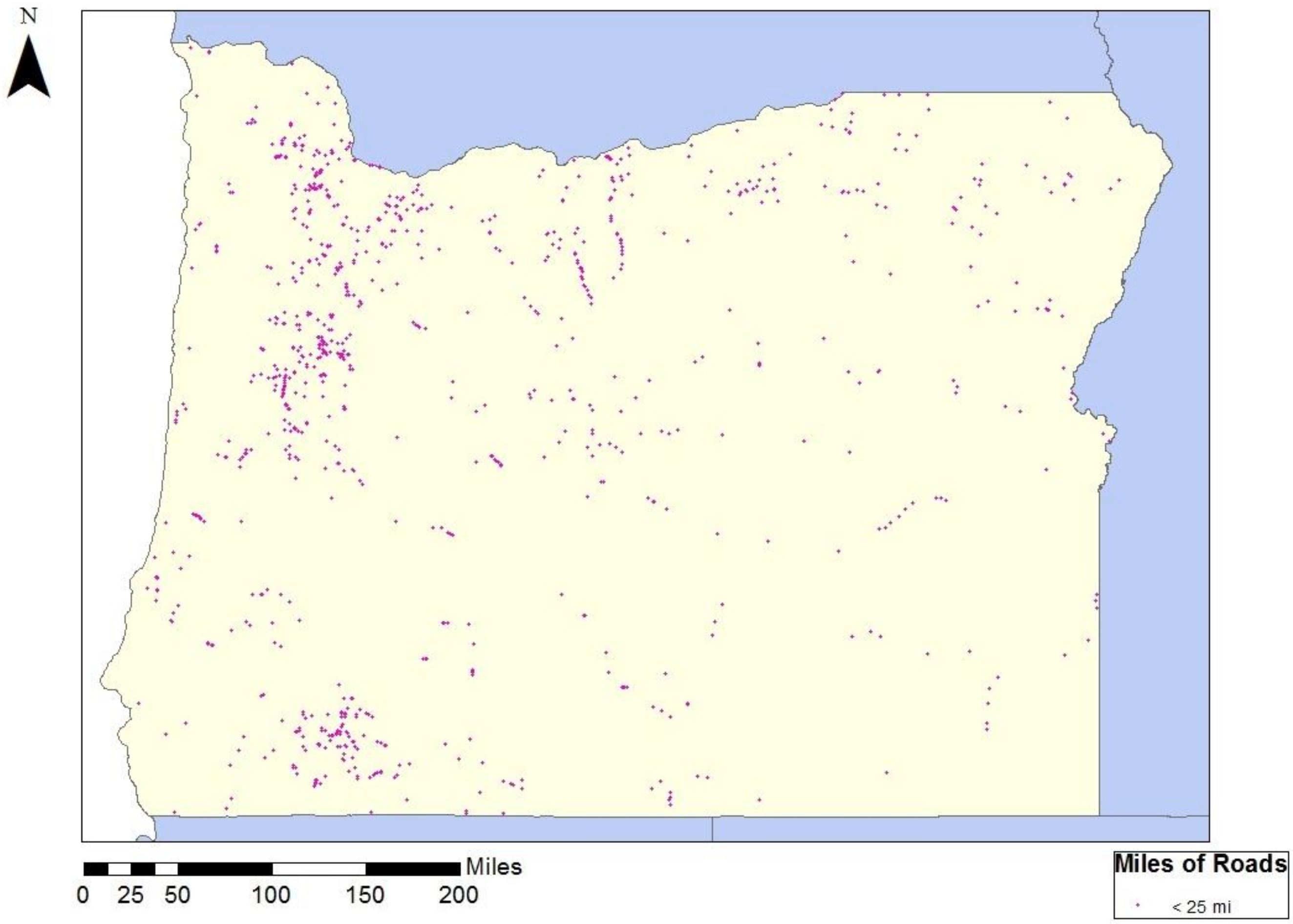

Figure 57: Crashes with less than 25 Miles of Roads – 1 Mile Buffer (Oregon, 2012)

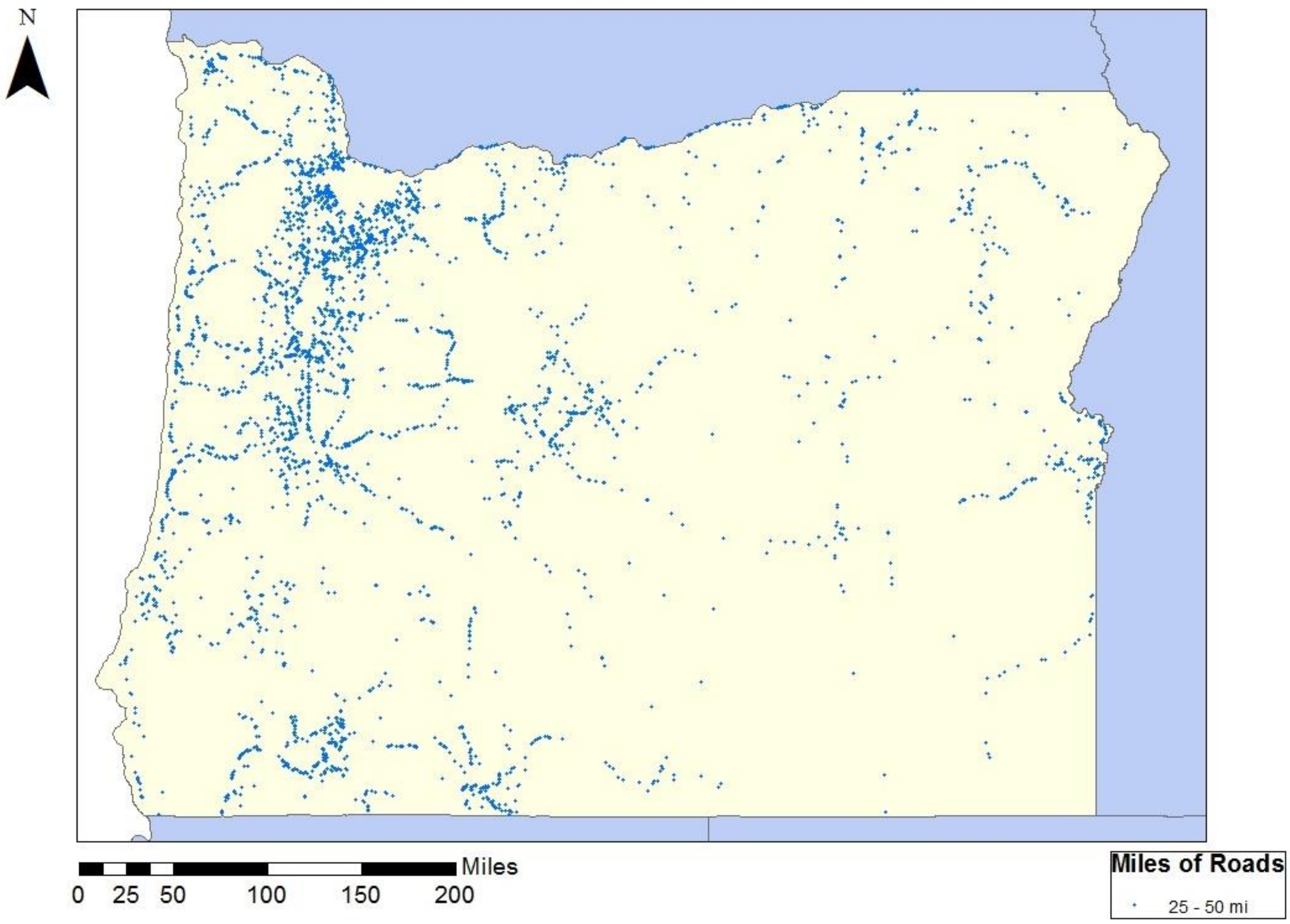

Figure 58: Crashes with 25 – 50 Miles of Roads – 1 Mile Buffer (Oregon, 2012)

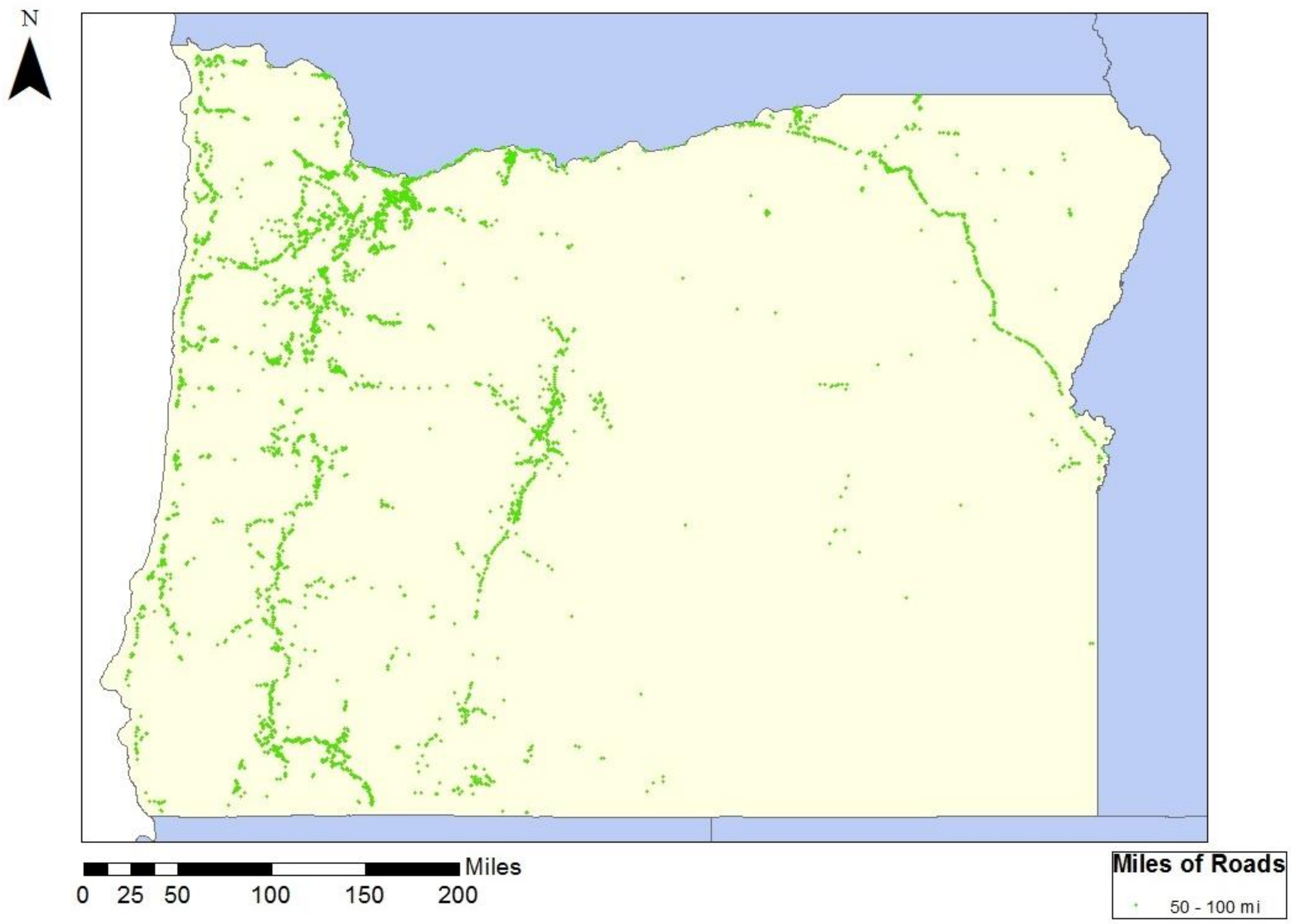

Figure 59: Crashes with 50 – 100 Miles of Roads – 1 Mile Buffer (Oregon, 2012)

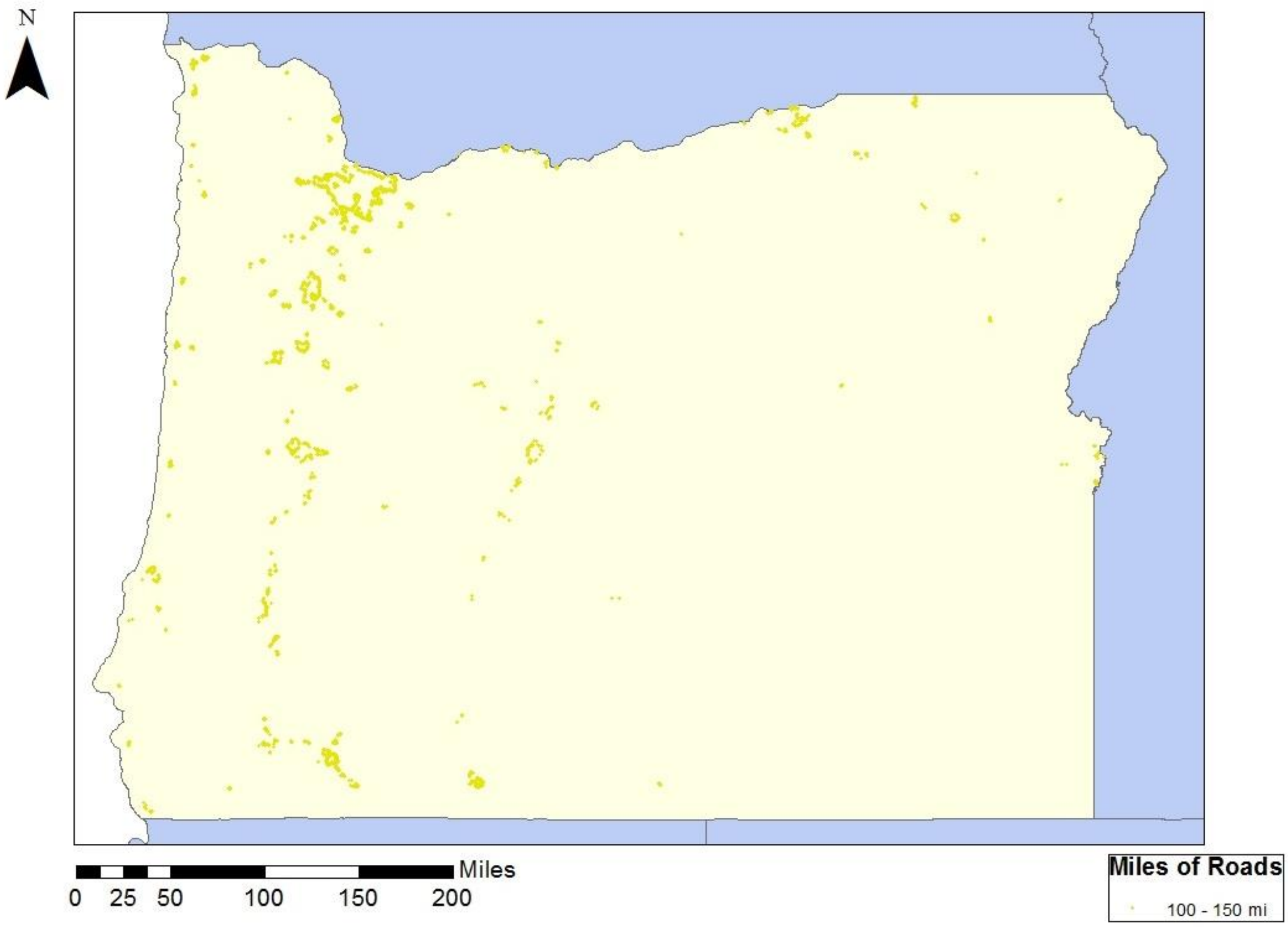

Figure 60: Crashes with 100 - 150 Miles of Roads – 1 Mile Buffer (Oregon, 2012)

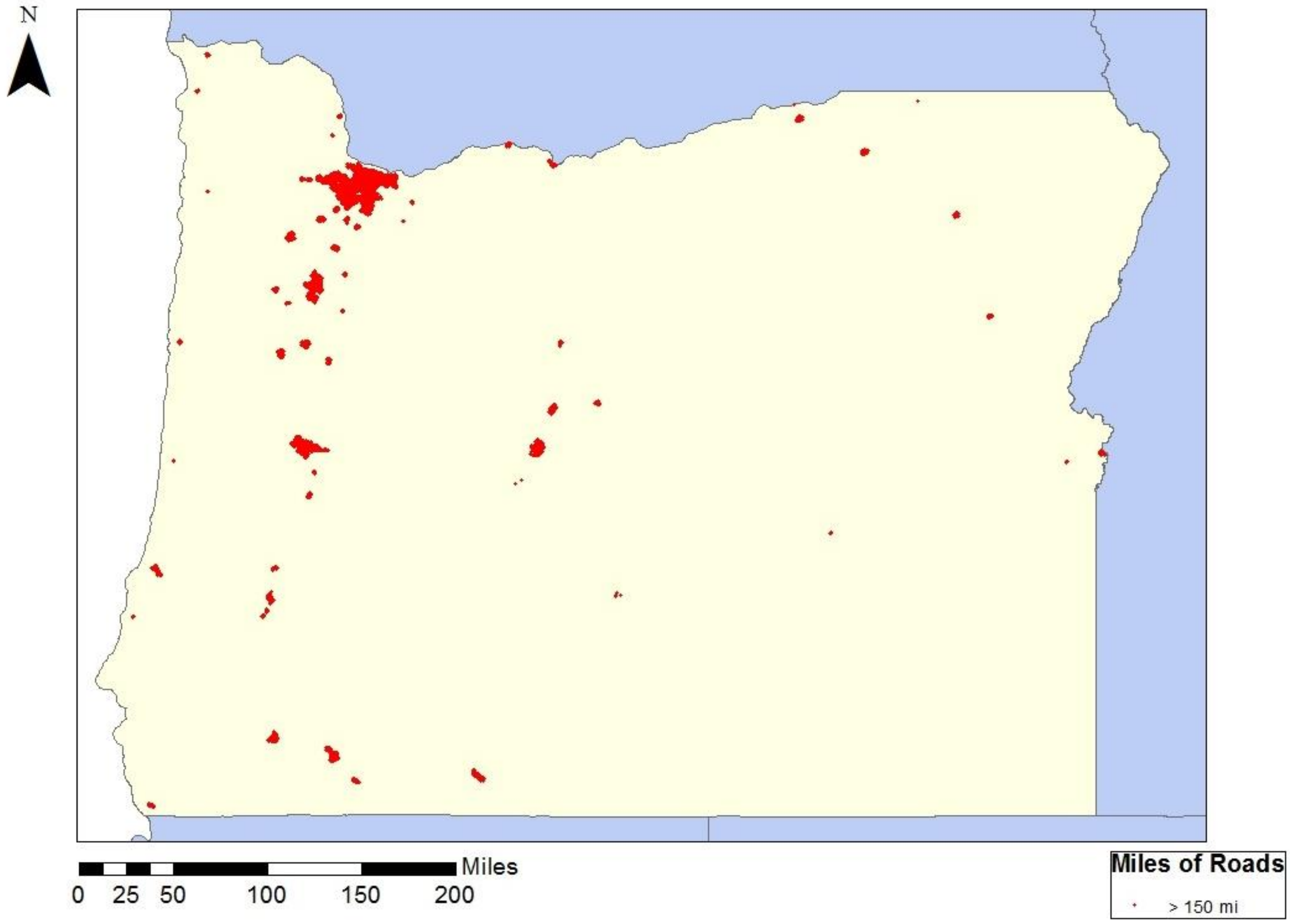

Figure 61: Crashes with more than 150 Miles of Roads – 1 Mile Buffer (Oregon, 2012)

On analyzing the figures presented above (Figures 57 – 62) and correlating the information presented in table 27, it is clear that based on the total miles of roads that intersect with the 1-mile buffer, generally speaking, the number of crashes decreases as one moves farther away cities. Figure57 represents the distribution of all crashes depending on the sum of road lengths within a 1 mile buffer around crashes. Figure61 depicts crashes with 100-150 miles of roads that intersect with the 1-mile buffer and Figure62depicts crashes with more than 150 miles of Road intersecting with 1-mile buffer. The distribution of crashes in the two figures are concentrated in specific places. The incidence of crashes in the two zones is high. As one moves away the spread of crashes through the state increase, their frequency tends to decrease.

5. Conclusion

Road safety is an important concern for road safety analysts as well as policy makers. Reliable data plays a vital role in dealing with safety issues. Geographical data of road crashes is even more important as this data helps the policy makers and safety experts to arrive at customized solutions rather than general policies for prevention of crashes, especially the fatal crashes. Although human factors are highly dominant when it comes to crash causality, but the role of other factors cannot be ignored. One important factor is land use, which is classified as urban and rural. Road crashes on rural roads significantly contribute to the total count of crashes making it imperative that due attention is to be paid to rural lands in order to arrive at effective policies and safety standards. The constant objective of law enforcement agencies and safety planners remains to increase the safety standards of urban and rural highways, requiring these agencies to take crucial decisions affecting the public at large. To determine the extent and nature of rural safety issues, it is further important to analyze the exact location of the crashes. In order to understand the relationship between crash locations, extent of fatalities and nature of the crash, the rural areas have been classified in four buffer zones - +2.5 mile from urban area, +5.0 mile from urban area, +7.5 mile from urban area and +10 mile from urban area.

In U.S. 54% of road crashes took place on rural roads compared to 46% crashes on urban roads in the year 2012. There is a reported negligible decline in road crashes (Urban/Rural Comparison, 2012). In 2011, in the entire US, 31% of the total traffic fatalities were alcohol impaired (Traffic Safety Facts, 2011). It is clear from the data given above that the largest number of alcohol impaired driving crashes resulted in non-fatal (KABC) crashes to be followed closely by crashes involving PDO.

An important finding to mention is that 64% of speed related crashes were in rural areas, the remaining %36 were in urban areas. This indicates that most of the speed related crashes were in rural areas. In the other hand, seat belts have the potential of reducing the risk of critical injuries to a great extent. From the results discussed previously, around %42 of the unbelted passenger occupant crashes were in rural areas, 58% were in urban areas. On comparing the data for years 2006 and 2012 for Oregon, it is clear that the percentage of fatalities involving unbelted passenger were different compared to NHTSA 2009 in all zones except for the urban zone. Another important factor to be considered is, crashes and fatalities based on the days during the weekends have decreased for the urban and +2.5 mile buffer zones.

Nighttime driving is a high-risk activity. Multiple factors are known to contribute towards nighttime Crashes. Lower visibility, glare from oncoming vehicles, inexperience with driving in low-light conditions, fatigue and alcohol are some factors that contribute towards nighttime crashes. It is also clear from the above data that a greater number of nighttime crashes occurs when the street light is there. 6244 crashes occurred when there is a street light while 4964 crashes occurred when there is no street light. The percentage of all nighttime crashes in urban areas amounted to 62.10% than compared to rural areas in Oregon.

The percentage of fatalities on interstate highways has decreased in the year 2012 as compared to year 2006 for the urbanized areas and for the buffered zones. A comparison of fatalities on US/State Highways for the years has revealed that there has been a difference in the percentages of fatalities for all zones except for the urban zone. This indicates that for the year of 2012, 42% of US/State highways crashes happened in rural areas, 58% happened in urban areas. The number of crashes on US/ State Highways have been high and there has been a high number of crashes in the buffered rural zones (Table 22).

This research finds that the percentage of crashes within the 10 miles buffer zones of cities boundaries is high in Oregon State. Also, 69% of fatal crashes, and 54% were in rural areas or just outside cities boundaries. Talking about percentages of fatalities, it was 68% in rural areas or just outside cities boundaries. Thus, it is essential to establish safety-associated outlays and shoulder widening, making suitable alterations to the existing vertical and horizontal curves, introduction of median treatments and to introduce the resurfacing will go long way in reducing the number of road accidents in the Oregon rural roads.

6. References

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APPENDICES

APPENDIX A: R Script

```
##################################################################################
#misc
#tail(y, n=10)  #last 10 rows
#head(y, n=10) #first 10 rows

# save data to a file: #write.csv(char_allcrashes, file = "char_allcrashes.csv")

write.txt(char_allcrashes, file = "char_allcrashes.txt")
write.xls(char_allcrashes, "char_allcrashes", row.names=TRUE)
write.csv(istate_allcrashes, file = "istate_allcrashes.csv")
###############################################################################
# MAIN CATEGORIES #
#                        FATAL CRASHES                #
fatal_all <- subset(Allcrashes, CRASH_SVRT==2)
fatal_urban <- subset(Urban, CRASH_SVRT==2)
fatal_two <- subset(Twomiles, CRASH_SVRT==2)
fatal_five <- subset(Fivemiles, CRASH_SVRT==2)
fatal_seven <- subset(Sevenmiles, CRASH_SVRT==2)
fatal_ten <- subset(Tenmiles, CRASH_SVRT==2)

sum(fatal_all$TOT_FATAL_)
sum(fatal_urban$TOT_FATAL_)
sum(fatal_two$TOT_FATAL_)
sum(fatal_five$TOT_FATAL_)
sum(fatal_seven$TOT_FATAL_)
sum(fatal_ten$TOT_FATAL_)
#                       NON FATAL Injury CRASHES                #
nonfatal_all <- subset(Allcrashes, CRASH_SVRT==4)
nonfatal_urban <- subset(Urban, CRASH_SVRT==4)
nonfatal_two <- subset(Twomiles, CRASH_SVRT==4)
nonfatal_five <- subset(Fivemiles, CRASH_SVRT==4)
nonfatal_seven <- subset(Sevenmiles, CRASH_SVRT==4)
nonfatal_ten <- subset(Tenmiles, CRASH_SVRT==4)
#                       Serious Injury (tYPE A) CRASHES                #
injury_all <- subset(Allcrashes, TOT_INJ_LV!=0)
injury_urban <- subset(Urban, TOT_INJ_LV!=0)
injury_two <- subset(Twomiles, TOT_INJ_LV!=0)
injury_five <- subset(Fivemiles, TOT_INJ_LV!=0)
injury_seven <- subset(Sevenmiles, TOT_INJ_LV!=0)
injury_ten <- subset(Tenmiles, TOT_INJ_LV!=0)
#                        PDO CRASHES                #
pdo_all <- subset(Allcrashes, CRASH_SVRT==5)
pdo_urban <- subset(Urban, CRASH_SVRT==5)
pdo_two <- subset(Twomiles, CRASH_SVRT==5)
pdo_five <- subset(Fivemiles, CRASH_SVRT==5)
pdo_seven <- subset(Sevenmiles, CRASH_SVRT==5)
pdo_ten <- subset(Tenmiles, CRASH_SVRT==5)

###################################################################################


#Speeding-Related
#                       Main Categories                #
```

```
spd_allcrashes <- subset(Allcrashes, CRASH_CA_1=='Driving in excess of posted speed')
spd_allurban <- subset(Urban, CRASH_CA_1=='Driving in excess of posted speed')
spd_alltwo <- subset(Twomiles, CRASH_CA_1=='Driving in excess of posted speed')
spd_allfive <- subset(Fivemiles, CRASH_CA_1=='Driving in excess of posted speed')
spd_allseven <- subset(Sevenmiles, CRASH_CA_1=='Driving in excess of posted speed')
spd_allten <- subset(Tenmiles, CRASH_CA_1=='Driving in excess of posted speed')


#                    FATAL CRASHES              #
spd_all <- subset(fatal_all, CRASH_CA_1=='Driving in excess of posted speed')
spd_urban <- subset(fatal_urban, CRASH_CA_1=='Driving in excess of posted speed')
spd_two <- subset(fatal_two, CRASH_CA_1=='Driving in excess of posted speed')
spd_five <- subset(fatal_five, CRASH_CA_1=='Driving in excess of posted speed')
spd_seven <- subset(fatal_seven, CRASH_CA_1=='Driving in excess of posted speed')
spd_ten <- subset(fatal_ten, CRASH_CA_1=='Driving in excess of posted speed')

#                   Number of fatalities     #
sum(spd_all$TOT_FATAL_)
sum(spd_urban$TOT_FATAL_)
sum(spd_two$TOT_FATAL_)
sum(spd_five$TOT_FATAL_)
sum(spd_seven$TOT_FATAL_)
sum(spd_ten$TOT_FATAL_)
#                    Serious Inj CRASHES              #
spdinjury_all <- subset(injury_all, CRASH_CA_1=='Driving in excess of posted speed')
spdinjury_urban <- subset(injury_urban, CRASH_CA_1=='Driving in excess of posted speed')
spdinjury_two <- subset(injury_two, CRASH_CA_1=='Driving in excess of posted speed')
spdinjury_five <- subset(injury_five, CRASH_CA_1=='Driving in excess of posted speed')
spdinjury_seven <- subset(injury_seven, CRASH_CA_1=='Driving in excess of posted speed')
spdinjury_ten <- subset(injury_ten, CRASH_CA_1=='Driving in excess of posted speed')
#                   NON FATAL Injury CRASH              #
spdnonfatal_all <- subset(nonfatal_all, CRASH_CA_1=='Driving in excess of posted speed')
spdnonfatal_urban <- subset(nonfatal_urban, CRASH_CA_1=='Driving in excess of posted speed')
spdnonfatal_two <- subset(nonfatal_two, CRASH_CA_1=='Driving in excess of posted speed')
spdnonfatal_five <- subset(nonfatal_five, CRASH_CA_1=='Driving in excess of posted speed')
spdnonfatal_seven <- subset(nonfatal_seven, CRASH_CA_1=='Driving in excess of posted speed')
spdnonfatal_ten <- subset(nonfatal_ten, CRASH_CA_1=='Driving in excess of posted speed')
#                    PDO CRASH              #
spdpdo_all <- subset(pdo_all, CRASH_CA_1=='Driving in excess of posted speed')
spdpdo_urban <- subset(pdo_urban, CRASH_CA_1=='Driving in excess of posted speed')
spdpdo_two <- subset(pdo_two, CRASH_CA_1=='Driving in excess of posted speed')
spdpdo_five <- subset(pdo_five, CRASH_CA_1=='Driving in excess of posted speed')
spdpdo_seven <- subset(pdo_seven, CRASH_CA_1=='Driving in excess of posted speed')
spdpdo_ten <- subset(pdo_ten, CRASH_CA_1=='Driving in excess of posted speed')



#Pedestrian
#                   Main Categories              #
ped_allcrashes <- subset(Allcrashes, CRASH_TYP1=='Pedestrian')
ped_allurban <- subset(Urban, CRASH_TYP1=='Pedestrian')
ped_alltwo <- subset(Twomiles, CRASH_TYP1=='Pedestrian')
ped_allfive <- subset(Fivemiles, CRASH_TYP1=='Pedestrian')
```

```
ped_allseven <- subset(Sevenmiles, CRASH_TYP1=='Pedestrian')
ped_allten <- subset(Tenmiles, CRASH_TYP1=='Pedestrian')

#                    FATAL CRASH                #
ped_all <- subset(fatal_all, CRASH_TYP1=='Pedestrian')
ped_urban <- subset(fatal_urban, CRASH_TYP1=='Pedestrian')
ped_two <- subset(fatal_two, CRASH_TYP1=='Pedestrian')
ped_five <- subset(fatal_five, CRASH_TYP1=='Pedestrian')
ped_seven <- subset(fatal_seven, CRASH_TYP1=='Pedestrian')
ped_ten <- subset(fatal_ten, CRASH_TYP1=='Pedestrian')

#                   Number of fatalities      #
sum(ped_all$TOT_FATAL_)
sum(ped_urban$TOT_FATAL_)
sum(ped_two$TOT_FATAL_)
sum(ped_five$TOT_FATAL_)
sum(ped_seven$TOT_FATAL_)
sum(ped_ten$TOT_FATAL_)


#                    Serious Injury CRASH                #
pedinjury_all <- subset(injury_all, CRASH_TYP1=='Pedestrian')
pedinjury_urban <- subset(injury_urban, CRASH_TYP1=='Pedestrian')
pedinjury_two <- subset(injury_two, CRASH_TYP1=='Pedestrian')
pedinjury_five <- subset(injury_five, CRASH_TYP1=='Pedestrian')
pedinjury_seven <- subset(injury_seven, CRASH_TYP1=='Pedestrian')
pedinjury_ten <- subset(injury_ten, CRASH_TYP1=='Pedestrian')
#                  NON FATAL Injury CRASH               #
pednonfatal_all <- subset(nonfatal_all, CRASH_TYP1=='Pedestrian')
pednonfatal_urban <- subset(nonfatal_urban, CRASH_TYP1=='Pedestrian')
pednonfatal_two <- subset(nonfatal_two, CRASH_TYP1=='Pedestrian')
pednonfatal_five <- subset(nonfatal_five, CRASH_TYP1=='Pedestrian')
pednonfatal_seven <- subset(nonfatal_seven, CRASH_TYP1=='Pedestrian')
pednonfatal_ten <- subset(nonfatal_ten, CRASH_TYP1=='Pedestrian')
#                    PDO CRASH               #
pedpdo_all <- subset(pdo_all, CRASH_TYP1=='Pedestrian')
pedpdo_urban <- subset(pdo_urban, CRASH_TYP1=='Pedestrian')
pedpdo_two <- subset(pdo_two, CRASH_TYP1=='Pedestrian')
pedpdo_five <- subset(pdo_five, CRASH_TYP1=='Pedestrian')
pedpdo_seven <- subset(pdo_seven, CRASH_TYP1=='Pedestrian')
pedpdo_ten <- subset(pdo_ten, CRASH_TYP1=='Pedestrian')


#Drug or Alcohol impaired crashes
#                   Main Categories                #
alc_allcrashes <- subset(Allcrashes, ALCHL_INVL==1 | DRUG_INVLV==1)
alc_allurban <- subset(Urban, ALCHL_INVL==1 | DRUG_INVLV==1)
alc_alltwo <- subset(Twomiles, ALCHL_INVL==1 | DRUG_INVLV==1)
alc_allfive <- subset(Fivemiles, ALCHL_INVL==1 | DRUG_INVLV==1)
alc_allseven <- subset(Sevenmiles, ALCHL_INVL==1 | DRUG_INVLV==1)
alc_allten <- subset(Tenmiles, ALCHL_INVL==1 | DRUG_INVLV==1)

#                    FATAL CRASH                #
```

```
alcohol_all <- subset(fatal_all, ALCHL_INVL==1 | DRUG_INVLV==1 )
alcohol_urban <- subset(fatal_urban, ALCHL_INVL==1 | DRUG_INVLV==1)
alcohol_two <- subset(fatal_two, ALCHL_INVL==1 | DRUG_INVLV==1)
alcohol_five <- subset(fatal_five, ALCHL_INVL==1 | DRUG_INVLV==1)
alcohol_seven <- subset(fatal_seven, ALCHL_INVL==1 | DRUG_INVLV==1)
alcohol_ten <- subset(fatal_ten, ALCHL_INVL==1 | DRUG_INVLV==1)

#            Number of fatalities     #
sum(alcohol_all$TOT_FATAL_)
sum(alcohol_urban$TOT_FATAL_)
sum(alcohol_two$TOT_FATAL_)
sum(alcohol_five$TOT_FATAL_)
sum(alcohol_seven$TOT_FATAL_)
sum(alcohol_ten$TOT_FATAL_)

#            Seroius inj CRASH          #
alcoholinjury_all <- subset(injury_all, ALCHL_INVL==1 | DRUG_INVLV==1 )
alcoholinjury_urban <- subset(injury_urban, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholinjury_two <- subset(injury_two, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholinjury_five <- subset(injury_five, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholinjury_seven <- subset(injury_seven, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholinjury_ten <- subset(injury_ten, ALCHL_INVL==1 | DRUG_INVLV==1)
#           NON FATAL Injury CRASH          #
alcoholnonfatal_all <- subset(nonfatal_all, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholnonfatal_urban <- subset(nonfatal_urban, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholnonfatal_two <- subset(nonfatal_two, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholnonfatal_five <- subset(nonfatal_five, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholnonfatal_seven <- subset(nonfatal_seven, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholnonfatal_ten <- subset(nonfatal_ten, ALCHL_INVL==1 | DRUG_INVLV==1)
#            PDO CRASH          #
alcoholpdo_all <- subset(pdo_all, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholpdo_urban <- subset(pdo_urban, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholpdo_two <- subset(pdo_two, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholpdo_five <- subset(pdo_five, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholpdo_seven <- subset(pdo_seven, ALCHL_INVL==1 | DRUG_INVLV==1)
alcoholpdo_ten <- subset(pdo_ten, ALCHL_INVL==1 | DRUG_INVLV==1)

#Unbelted Passenger Vehicle Occupants
#            Main Categories          #
unbelt_allcrashes <- subset(Allcrashes, TOT_SFTY_1 > 0)
unbelt_allurban <- subset(Urban, TOT_SFTY_1 > 0)
unbelt_alltwo <- subset(Twomiles, TOT_SFTY_1 > 0)
unbelt_allfive <- subset(Fivemiles, TOT_SFTY_1 > 0)
unbelt_allseven <- subset(Sevenmiles, TOT_SFTY_1 > 0)
unbelt_allten <- subset(Tenmiles, TOT_SFTY_1 > 0)
#            FATAL CRASH          #
unbelt_all <- subset(fatal_all, TOT_SFTY_1 > 0 )
unbelt_urban <- subset(fatal_urban, TOT_SFTY_1 > 0)
unbelt_two <- subset(fatal_two, TOT_SFTY_1 > 0)
unbelt_five <- subset(fatal_five, TOT_SFTY_1 > 0)
unbelt_seven <- subset(fatal_seven, TOT_SFTY_1 > 0)
unbelt_ten <- subset(fatal_ten, TOT_SFTY_1 > 0)
#            Number of fatalities     #
```

```
sum(unbelt_all$TOT_FATAL_)
sum(unbelt_urban$TOT_FATAL_)
sum(unbelt_two$TOT_FATAL_)
sum(unbelt_five$TOT_FATAL_)
sum(unbelt_seven$TOT_FATAL_)
sum(unbelt_ten$TOT_FATAL_)

#                    Serious inj CRASH              #
unbeltinjury_all <- subset(injury_all, TOT_SFTY_1 > 0 )
unbeltinjury_urban <- subset(injury_urban, TOT_SFTY_1 > 0)
unbeltinjury_two <- subset(injury_two, TOT_SFTY_1 > 0)
unbeltinjury_five <- subset(injury_five, TOT_SFTY_1 > 0)
unbeltinjury_seven <- subset(injury_seven, TOT_SFTY_1 > 0)
unbeltinjury_ten <- subset(injury_ten, TOT_SFTY_1 > 0)
#                   NON FATAL Injury CRASH              #
unbeltnonfatal_all <- subset(nonfatal_all, TOT_SFTY_1 > 0)
unbeltnonfatal_urban <- subset(nonfatal_urban, TOT_SFTY_1 > 0)
unbeltnonfatal_two <- subset(nonfatal_two, TOT_SFTY_1 > 0)
unbeltnonfatal_five <- subset(nonfatal_five, TOT_SFTY_1 > 0)
unbeltnonfatal_seven <- subset(nonfatal_seven, TOT_SFTY_1 > 0)
unbeltnonfatal_ten <- subset(nonfatal_ten, TOT_SFTY_1 > 0)
#                    PDO CRASH              #
unbeltpdo_all <- subset(pdo_all, TOT_SFTY_1 > 0)
unbeltpdo_urban <- subset(pdo_urban, TOT_SFTY_1 > 0)
unbeltpdo_two <- subset(pdo_two, TOT_SFTY_1 > 0)
unbeltpdo_five <- subset(pdo_five, TOT_SFTY_1 > 0)
unbeltpdo_seven <- subset(pdo_seven, TOT_SFTY_1 > 0)
unbeltpdo_ten <- subset(pdo_ten, TOT_SFTY_1 > 0)


# Crashes during Weekend
#                   Main Categories              #
Weekend_allcrashes <- subset(Allcrashes, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekend_allurban <- subset(Urban, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekend_alltwo <- subset(Twomiles, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekend_allfive <- subset(Fivemiles, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekend_allseven <- subset(Sevenmiles, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekend_allten <- subset(Tenmiles, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
#                    FATAL CRASH              #
Weekend_all <- subset(fatal_all, WEEKDAY=='Saturday' | WEEKDAY=='Sunday' )
Weekend_urban <- subset(fatal_urban, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekend_two <- subset(fatal_two, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekend_five <- subset(fatal_five, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekend_seven <- subset(fatal_seven, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekend_ten <- subset(fatal_ten, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
#                   Number of fatalities      #
sum(Weekend_all$TOT_FATAL_)
sum(Weekend_urban$TOT_FATAL_)
sum(Weekend_two$TOT_FATAL_)
sum(Weekend_five$TOT_FATAL_)
sum(Weekend_seven$TOT_FATAL_)
sum(Weekend_ten$TOT_FATAL_)
#                    Seroius Injury CRASH              #
```

```
Weekendinjury_all <- subset(injury_all, WEEKDAY=='Saturday' | WEEKDAY=='Sunday' )
Weekendinjury_urban <- subset(injury_urban, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendinjury_two <- subset(injury_two, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendinjury_five <- subset(injury_five, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendinjury_seven <- subset(injury_seven, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendinjury_ten <- subset(injury_ten, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
#          NON FATAL Injury CRASH          #
Weekendnonfatal_all <- subset(nonfatal_all, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendnonfatal_urban <- subset(nonfatal_urban, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendnonfatal_two <- subset(nonfatal_two, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendnonfatal_five <- subset(nonfatal_five, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendnonfatal_seven <- subset(nonfatal_seven, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendnonfatal_ten <- subset(nonfatal_ten, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
#           PDO CRASH          #
Weekendpdo_all <- subset(pdo_all, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendpdo_urban <- subset(pdo_urban, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendpdo_two <- subset(pdo_two, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendpdo_five <- subset(pdo_five, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendpdo_seven <- subset(pdo_seven, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')
Weekendpdo_ten <- subset(pdo_ten, WEEKDAY=='Saturday' | WEEKDAY=='Sunday')

# Light Conditions - Nighttime cRASHES
#           Main Categories          #
light_allcrashes <- subset(Allcrashes, LGT_COND_C==2 | LGT_COND_C==3 )
light_allurban <- subset(Urban, LGT_COND_C==2 | LGT_COND_C==3)
light_alltwo <- subset(Twomiles, LGT_COND_C==2 | LGT_COND_C==3)
light_allfive <- subset(Fivemiles, LGT_COND_C==2 | LGT_COND_C==3)
light_allseven <- subset(Sevenmiles,LGT_COND_C==2 | LGT_COND_C==3)
light_allten <- subset(Tenmiles, LGT_COND_C==2 | LGT_COND_C==3)
#           FATAL CRASH          #
light_all <- subset(fatal_all, LGT_COND_C==2 | LGT_COND_C==3 )
light_urban <- subset(fatal_urban, LGT_COND_C==2 | LGT_COND_C==3)
light_two <- subset(fatal_two, LGT_COND_C==2 | LGT_COND_C==3)
light_five <- subset(fatal_five, LGT_COND_C==2 | LGT_COND_C==3)
light_seven <- subset(fatal_seven, LGT_COND_C==2 | LGT_COND_C==3)
light_ten <- subset(fatal_ten, LGT_COND_C==2 | LGT_COND_C==3)
#           Number of fatalities      #
sum(light_all$TOT_FATAL_)
sum(light_urban$TOT_FATAL_)
sum(light_two$TOT_FATAL_)
sum(light_five$TOT_FATAL_)
sum(light_seven$TOT_FATAL_)
sum(light_ten$TOT_FATAL_)

#           Serious Injury CRASH          #
lightinjury_all <- subset(injury_all, LGT_COND_C==2 | LGT_COND_C==3 )
lightinjury_urban <- subset(injury_urban, LGT_COND_C==2 | LGT_COND_C==3)
lightinjury_two <- subset(injury_two, LGT_COND_C==2 | LGT_COND_C==3)
lightinjury_five <- subset(injury_five, LGT_COND_C==2 | LGT_COND_C==3)
lightinjury_seven <- subset(injury_seven, LGT_COND_C==2 | LGT_COND_C==3)
lightinjury_ten <- subset(injury_ten, LGT_COND_C==2 | LGT_COND_C==3)
#          NON FATAL Injury CRASH          #
lightnonfatal_all <- subset(nonfatal_all, LGT_COND_C==2 | LGT_COND_C==3)
```

```
lightnonfatal_urban <- subset(nonfatal_urban, LGT_COND_C==2 | LGT_COND_C==3)
lightnonfatal_two <- subset(nonfatal_two, LGT_COND_C==2 | LGT_COND_C==3)
lightnonfatal_five <- subset(nonfatal_five, LGT_COND_C==2 | LGT_COND_C==3)
lightnonfatal_seven <- subset(nonfatal_seven, LGT_COND_C==2 | LGT_COND_C==3)
lightnonfatal_ten <- subset(nonfatal_ten, LGT_COND_C==2 | LGT_COND_C==3)
#                PDO CRASH            #
lightpdo_all <- subset(pdo_all, LGT_COND_C==2 | LGT_COND_C==3)
lightpdo_urban <- subset(pdo_urban, LGT_COND_C==2 | LGT_COND_C==3)
lightpdo_two <- subset(pdo_two, LGT_COND_C==2 | LGT_COND_C==3)
lightpdo_five <- subset(pdo_five, LGT_COND_C==2 | LGT_COND_C==3)
lightpdo_seven <- subset(pdo_seven, LGT_COND_C==2 | LGT_COND_C==3)
lightpdo_ten <- subset(pdo_ten, LGT_COND_C==2 | LGT_COND_C==3)
#              Nighttime  with street light            #
wlight_allcrashes <- subset(Allcrashes, LGT_COND_C==2)
wlight_allurban <- subset(Urban, LGT_COND_C==2)
wlight_alltwo <- subset(Twomiles, LGT_COND_C==2)
wlight_allfive <- subset(Fivemiles, LGT_COND_C==2)
wlight_allseven <- subset(Sevenmiles,LGT_COND_C==2)
wlight_allten <- subset(Tenmiles, LGT_COND_C==2)
#                no street light            #
nlight_allcrashes <- subset(Allcrashes, LGT_COND_C==3)
nlight_allurban <- subset(Urban, LGT_COND_C==3)
nlight_alltwo <- subset(Twomiles, LGT_COND_C==3)
nlight_allfive <- subset(Fivemiles, LGT_COND_C==3)
nlight_allseven <- subset(Sevenmiles,LGT_COND_C==3)
nlight_allten <- subset(Tenmiles, LGT_COND_C==3)


# Crashes on Interstate highways
#               Main Categories            #
istate_allcrashes <- subset(Allcrashes, RTE_TYP_CD=='IS' )
istate_allurban <- subset(Urban, RTE_TYP_CD=='IS' )
istate_alltwo <- subset(Twomiles, RTE_TYP_CD=='IS' )
istate_allfive <- subset(Fivemiles, RTE_TYP_CD=='IS' )
istate_allseven <- subset(Sevenmiles,RTE_TYP_CD=='IS' )
istate_allten <- subset(Tenmiles, RTE_TYP_CD=='IS' )
#                FATAL CRASH            #
istate_all <- subset(fatal_all, RTE_TYP_CD=='IS' )
istate_urban <- subset(fatal_urban, RTE_TYP_CD=='IS')
istate_two <- subset(fatal_two, RTE_TYP_CD=='IS')
istate_five <- subset(fatal_five, RTE_TYP_CD=='IS')
istate_seven <- subset(fatal_seven, RTE_TYP_CD=='IS')
istate_ten <- subset(fatal_ten, RTE_TYP_CD=='IS')
#               Number of fatalities     #
sum(istate_all$TOT_FATAL_)
sum(istate_urban$TOT_FATAL_)
sum(istate_two$TOT_FATAL_)
sum(istate_five$TOT_FATAL_)
sum(istate_seven$TOT_FATAL_)
sum(istate_ten$TOT_FATAL_)


#                Serious Injury CRASH            #
```

```
istateinjury_all <- subset(injury_all, RTE_TYP_CD=='IS' )
istateinjury_urban <- subset(injury_urban, RTE_TYP_CD=='IS')
istateinjury_two <- subset(injury_two, RTE_TYP_CD=='IS')
istateinjury_five <- subset(injury_five, RTE_TYP_CD=='IS')
istateinjury_seven <- subset(injury_seven, RTE_TYP_CD=='IS')
istateinjury_ten <- subset(injury_ten, RTE_TYP_CD=='IS')
#                    NON FATAL Injury CRASH              #
istatenonfatal_all <- subset(nonfatal_all, RTE_TYP_CD=='IS')
istatenonfatal_urban <- subset(nonfatal_urban, RTE_TYP_CD=='IS')
istatenonfatal_two <- subset(nonfatal_two, RTE_TYP_CD=='IS')
istatenonfatal_five <- subset(nonfatal_five, RTE_TYP_CD=='IS')
istatenonfatal_seven <- subset(nonfatal_seven, RTE_TYP_CD=='IS')
istatenonfatal_ten <- subset(nonfatal_ten, RTE_TYP_CD=='IS')
#                     PDO CRASH                #
istatepdo_all <- subset(pdo_all, RTE_TYP_CD=='IS')
istatepdo_urban <- subset(pdo_urban, RTE_TYP_CD=='IS')
istatepdo_two <- subset(pdo_two, RTE_TYP_CD=='IS')
istatepdo_five <- subset(pdo_five, RTE_TYP_CD=='IS')
istatepdo_seven <- subset(pdo_seven, RTE_TYP_CD=='IS')
istatepdo_ten <- subset(pdo_ten, RTE_TYP_CD=='IS')

# Crashes on sTATE / US highways -
#                     Main Categories                 #
state_allcrashes <- subset(Allcrashes, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR' )
state_allurban <- subset(Urban, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR' )
state_alltwo <- subset(Twomiles, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR' )
state_allfive <- subset(Fivemiles, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR' )
state_allseven <- subset(Sevenmiles,RTE_TYP_CD=='US' | RTE_TYP_CD=='OR' )
state_allten <- subset(Tenmiles, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR' )
#                     FATAL CRASH                #
state_all <- subset(fatal_all, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR' )
state_urban <- subset(fatal_urban, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
state_two <- subset(fatal_two, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
state_five <- subset(fatal_five, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
state_seven <- subset(fatal_seven, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
state_ten <- subset(fatal_ten, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')

#                     Number of fatalities      #
sum(state_all$TOT_FATAL_)
sum(state_urban$TOT_FATAL_)
sum(state_two$TOT_FATAL_)
sum(state_five$TOT_FATAL_)
sum(state_seven$TOT_FATAL_)
sum(state_ten$TOT_FATAL_)

#                     Serious injury CRASH                #
stateinjury_all <- subset(injury_all, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR' )
stateinjury_urban <- subset(injury_urban, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
stateinjury_two <- subset(injury_two, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
stateinjury_five <- subset(injury_five, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
stateinjury_seven <- subset(injury_seven, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
stateinjury_ten <- subset(injury_ten, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
#                    NON FATAL Injury CRASH              #
```

```
statenonfatal_all <- subset(nonfatal_all, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
statenonfatal_urban <- subset(nonfatal_urban, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
statenonfatal_two <- subset(nonfatal_two, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
statenonfatal_five <- subset(nonfatal_five, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
statenonfatal_seven <- subset(nonfatal_seven, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
statenonfatal_ten <- subset(nonfatal_ten, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
#                PDO CRASH             #
statepdo_all <- subset(pdo_all, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
statepdo_urban <- subset(pdo_urban, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
statepdo_two <- subset(pdo_two, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
statepdo_five <- subset(pdo_five, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
statepdo_seven <- subset(pdo_seven, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')
statepdo_ten <- subset(pdo_ten, RTE_TYP_CD=='US' | RTE_TYP_CD=='OR')


# Crashes based on the CHARECTER OF the road (Curve / Grade)
#               Main Categories             #
char_allcrashes <- subset(Allcrashes, RD_CHAR_CD=='5' | RD_CHAR_CD=='7' )
char_allurban <- subset(Urban, RD_CHAR_CD=='5' | RD_CHAR_CD=='7' )
char_alltwo <- subset(Twomiles, RD_CHAR_CD=='5' | RD_CHAR_CD=='7' )
char_allfive <- subset(Fivemiles, RD_CHAR_CD=='5' | RD_CHAR_CD=='7' )
char_allseven <- subset(Sevenmiles,RD_CHAR_CD=='5' | RD_CHAR_CD=='7' )
char_allten <- subset(Tenmiles, RD_CHAR_CD=='5' | RD_CHAR_CD=='7' )
#                FATAL CRASH            #
char_all <- subset(fatal_all, RD_CHAR_CD=='5' | RD_CHAR_CD=='7' )
char_urban <- subset(fatal_urban, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
char_two <- subset(fatal_two, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
char_five <- subset(fatal_five, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
char_seven <- subset(fatal_seven, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
char_ten <- subset(fatal_ten, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
#               Number of fatalities      #

sum(char_all$TOT_FATAL_)
sum(char_urban$TOT_FATAL_)
sum(char_two$TOT_FATAL_)
sum(char_five$TOT_FATAL_)
sum(char_seven$TOT_FATAL_)
sum(char_ten$TOT_FATAL_)


#                Serious injury CRASH            #
charinjury_all <- subset(injury_all, RD_CHAR_CD=='5' | RD_CHAR_CD=='7' )
charinjury_urban <- subset(injury_urban, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charinjury_two <- subset(injury_two, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charinjury_five <- subset(injury_five, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charinjury_seven <- subset(injury_seven, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charinjury_ten <- subset(injury_ten, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
#              NON FATAL Injury CRASH            #
charnonfatal_all <- subset(nonfatal_all, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charnonfatal_urban <- subset(nonfatal_urban, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charnonfatal_two <- subset(nonfatal_two, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charnonfatal_five <- subset(nonfatal_five, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charnonfatal_seven <- subset(nonfatal_seven, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
```

```
charnonfatal_ten <- subset(nonfatal_ten, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
#                        PDO CRASH                  #
charpdo_all <- subset(pdo_all, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charpdo_urban <- subset(pdo_urban, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charpdo_two <- subset(pdo_two, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charpdo_five <- subset(pdo_five, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charpdo_seven <- subset(pdo_seven, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')
charpdo_ten <- subset(pdo_ten, RD_CHAR_CD=='5' | RD_CHAR_CD=='7')

# Crashes based on the surface OF the road (Dry / wet)
#Dry
#                       Main Categories                   #
dry_allcrashes <- subset(Allcrashes, RD_SURF_CO==1 )
dry_allurban <- subset(Urban, RD_SURF_CO==1  )
dry_alltwo <- subset(Twomiles, RD_SURF_CO==1  )
dry_allfive <- subset(Fivemiles, RD_SURF_CO==1  )
dry_allseven <- subset(Sevenmiles,RD_SURF_CO==1  )
dry_allten <- subset(Tenmiles, RD_SURF_CO==1  )
#                        FATAL CRASH                  #
dry_all <- subset(fatal_all, RD_SURF_CO==1  )
dry_urban <- subset(fatal_urban, RD_SURF_CO==1 )
dry_two <- subset(fatal_two, RD_SURF_CO==1 )
dry_five <- subset(fatal_five, RD_SURF_CO==1 )
dry_seven <- subset(fatal_seven, RD_SURF_CO==1 )
dry_ten <- subset(fatal_ten, RD_SURF_CO==1 )
#                       Number of fatalities       #
sum(dry_all$TOT_FATAL_)
sum(dry_urban$TOT_FATAL_)
sum(dry_two$TOT_FATAL_)
sum(dry_five$TOT_FATAL_)
sum(dry_seven$TOT_FATAL_)
sum(dry_ten$TOT_FATAL_)

#                        Serious injury CRASH                  #
dryinjury_all <- subset(injury_all, RD_SURF_CO==1  )
dryinjury_urban <- subset(injury_urban, RD_SURF_CO==1 )
dryinjury_two <- subset(injury_two, RD_SURF_CO==1 )
dryinjury_five <- subset(injury_five, RD_SURF_CO==1 )
dryinjury_seven <- subset(injury_seven, RD_SURF_CO==1 )
dryinjury_ten <- subset(injury_ten, RD_SURF_CO==1 )
#                      NON FATAL Injury CRASH                 #
drynonfatal_all <- subset(nonfatal_all, RD_SURF_CO==1 )
drynonfatal_urban <- subset(nonfatal_urban, RD_SURF_CO==1 )
drynonfatal_two <- subset(nonfatal_two, RD_SURF_CO==1 )
drynonfatal_five <- subset(nonfatal_five, RD_SURF_CO==1 )
drynonfatal_seven <- subset(nonfatal_seven, RD_SURF_CO==1 )
drynonfatal_ten <- subset(nonfatal_ten, RD_SURF_CO==1 )
#                        PDO CRASH                  #
drypdo_all <- subset(pdo_all, RD_SURF_CO==1 )
drypdo_urban <- subset(pdo_urban, RD_SURF_CO==1 )
drypdo_two <- subset(pdo_two, RD_SURF_CO==1 )
drypdo_five <- subset(pdo_five, RD_SURF_CO==1 )
drypdo_seven <- subset(pdo_seven, RD_SURF_CO==1 )
```

```
drypdo_ten <- subset(pdo_ten, RD_SURF_CO==1 )
#WET
#                    Main Categories                 #
wet_allcrashes <- subset(Allcrashes, RD_SURF_CO==2 )
wet_allurban <- subset(Urban, RD_SURF_CO==2  )
wet_alltwo <- subset(Twomiles, RD_SURF_CO==2  )
wet_allfive <- subset(Fivemiles, RD_SURF_CO==2  )
wet_allseven <- subset(Sevenmiles,RD_SURF_CO==2  )
wet_allten <- subset(Tenmiles, RD_SURF_CO==2  )
#                     FATAL CRASH                 #
wet_all <- subset(fatal_all, RD_SURF_CO==2  )
wet_urban <- subset(fatal_urban, RD_SURF_CO==2 )
wet_two <- subset(fatal_two, RD_SURF_CO==2 )
wet_five <- subset(fatal_five, RD_SURF_CO==2 )
wet_seven <- subset(fatal_seven, RD_SURF_CO==2 )
wet_ten <- subset(fatal_ten, RD_SURF_CO==2 )
#                    Number of fatalities      #
sum(wet_all$TOT_FATAL_)
sum(wet_urban$TOT_FATAL_)
sum(wet_two$TOT_FATAL_)
sum(wet_five$TOT_FATAL_)
sum(wet_seven$TOT_FATAL_)
sum(wet_ten$TOT_FATAL_)

#                     Serious injury CRASH                 #
wetinjury_all <- subset(injury_all, RD_SURF_CO==2  )
wetinjury_urban <- subset(injury_urban, RD_SURF_CO==2 )
wetinjury_two <- subset(injury_two, RD_SURF_CO==2 )
wetinjury_five <- subset(injury_five, RD_SURF_CO==2 )
wetinjury_seven <- subset(injury_seven, RD_SURF_CO==2 )
wetinjury_ten <- subset(injury_ten, RD_SURF_CO==2 )
#                   NON FATAL Injury CRASH                #
wetnonfatal_all <- subset(nonfatal_all, RD_SURF_CO==2 )
wetnonfatal_urban <- subset(nonfatal_urban, RD_SURF_CO==2 )
wetnonfatal_two <- subset(nonfatal_two, RD_SURF_CO==2 )
wetnonfatal_five <- subset(nonfatal_five, RD_SURF_CO==2 )
wetnonfatal_seven <- subset(nonfatal_seven, RD_SURF_CO==2 )
wetnonfatal_ten <- subset(nonfatal_ten, RD_SURF_CO==2 )
#                     PDO CRASH                 #
wetpdo_all <- subset(pdo_all, RD_SURF_CO==2 )
wetpdo_urban <- subset(pdo_urban, RD_SURF_CO==2 )
wetpdo_two <- subset(pdo_two, RD_SURF_CO==2 )
wetpdo_five <- subset(pdo_five, RD_SURF_CO==2 )
wetpdo_seven <- subset(pdo_seven, RD_SURF_CO==2 )
wetpdo_ten <- subset(pdo_ten, RD_SURF_CO==2 )

# Bicycle Involved Crashes
#                    Main Categories                 #
bicy_allcrashes <- subset(Allcrashes, CRASH_TYP1=='Pedalcyclist' )
bicy_allurban <- subset(Urban, CRASH_TYP1=='Pedalcyclist' )
bicy_alltwo <- subset(Twomiles, CRASH_TYP1=='Pedalcyclist' )
bicy_allfive <- subset(Fivemiles, CRASH_TYP1=='Pedalcyclist' )
bicy_allseven <- subset(Sevenmiles,CRASH_TYP1=='Pedalcyclist' )
```

```
bicy_allten <- subset(Tenmiles, CRASH_TYP1=='Pedalcyclist' )
#                    FATAL CRASH              #
bicy_all <- subset(fatal_all, CRASH_TYP1=='Pedalcyclist' )
bicy_urban <- subset(fatal_urban,CRASH_TYP1=='Pedalcyclist' )
bicy_two <- subset(fatal_two, CRASH_TYP1=='Pedalcyclist' )
bicy_five <- subset(fatal_five, CRASH_TYP1=='Pedalcyclist')
bicy_seven <- subset(fatal_seven, CRASH_TYP1=='Pedalcyclist' )
bicy_ten <- subset(fatal_ten, CRASH_TYP1=='Pedalcyclist' )
#                   Number of fatalities      #

sum(bicy_all$TOT_FATAL_)
sum(bicy_urban$TOT_FATAL_)
sum(bicy_two$TOT_FATAL_)
sum(bicy_five$TOT_FATAL_)
sum(bicy_seven$TOT_FATAL_)
sum(bicy_ten$TOT_FATAL_)


#                    Serious injury CRASH              #
bicyinjury_all <- subset(injury_all, CRASH_TYP1=='Pedalcyclist'  )
bicyinjury_urban <- subset(injury_urban, CRASH_TYP1=='Pedalcyclist' )
bicyinjury_two <- subset(injury_two, CRASH_TYP1=='Pedalcyclist')
bicyinjury_five <- subset(injury_five, CRASH_TYP1=='Pedalcyclist')
bicyinjury_seven <- subset(injury_seven, CRASH_TYP1=='Pedalcyclist' )
bicyinjury_ten <- subset(injury_ten, CRASH_TYP1=='Pedalcyclist' )
#                  NON FATAL Injury CRASH             #
bicynonfatal_all <- subset(nonfatal_all, CRASH_TYP1=='Pedalcyclist' )
bicynonfatal_urban <- subset(nonfatal_urban, CRASH_TYP1=='Pedalcyclist' )
bicynonfatal_two <- subset(nonfatal_two, CRASH_TYP1=='Pedalcyclist')
bicynonfatal_five <- subset(nonfatal_five, CRASH_TYP1=='Pedalcyclist' )
bicynonfatal_seven <- subset(nonfatal_seven, CRASH_TYP1=='Pedalcyclist' )
bicynonfatal_ten <- subset(nonfatal_ten, CRASH_TYP1=='Pedalcyclist')
#                    PDO CRASH              #
bicypdo_all <- subset(pdo_all, CRASH_TYP1=='Pedalcyclist' )
bicypdo_urban <- subset(pdo_urban, CRASH_TYP1=='Pedalcyclist' )
bicypdo_two <- subset(pdo_two, CRASH_TYP1=='Pedalcyclist' )
bicypdo_five <- subset(pdo_five,CRASH_TYP1=='Pedalcyclist' )
bicypdo_seven <- subset(pdo_seven, CRASH_TYP1=='Pedalcyclist' )
bicypdo_ten <- subset(pdo_ten, CRASH_TYP1=='Pedalcyclist' )




###########################################
write.csv(roadmore200, file = "roadmore200.csv")
#all crashes with Road lengths in miles
allroadlengths<- read.csv("extension.csv", header=TRUE)

#convert lengths to numeric values
allroadlengths$LENGTH = as.numeric(allroadlengths$LENGTH)
is.numeric(allroadlengths$LENGTH)
noroads<- subset(allroadlengths, LENGTH==0 )
roadexist<- subset(allroadlengths, LENGTH != 0 )
```

```
roadless25 <- subset(roadexist, LENGTH <= 25 )
roadless50 <- subset(roadexist, LENGTH > 25 & LENGTH <= 50 )
roadless100 <- subset(roadexist, LENGTH > 50 & LENGTH <= 100)
roadless150 <- subset(roadexist, LENGTH > 100 & LENGTH <= 150 )
roadless200 <- subset(roadexist, LENGTH > 150 & LENGTH <= 200)
roadmore150 <- subset(roadexist, LENGTH > 150)
roadmore200 <- subset(roadexist, LENGTH > 200)
```

APPENDIX B: Python Script

```
# ------------------------------------------------------------------------
# Oregon_Crash_Statistics.py
# Created on: 2014-08-12
# By Saad N Q AlMutairi
# Description: The tool buffers point locations by 1 mile and intersects with a
#           road network to produce a final table with road lengths (in miles)
#           that lie within each buffered point area.
# ------------------------------------------------------------------------



# Pull in python modules needed for the script
import arcpy, time, os
from arcpy import env

#Set a timer to time the length of the whole script
tic = time.clock()

# Apply some logic to overwrite outputs
env.overwriteOutput = True

# Set parameters from the GUI
crashes = arcpy.GetParameterAsText(0)
roads = arcpy.GetParameterAsText(1)
outpath = arcpy.GetParameterAsText(2)

arcpy.AddMessage("Create a geodatabase to store outputs")
# Create a new geodatabse to store the outputs from the tool
arcpy.CreateFileGDB_management(outpath, "Stats_Table")

# Set the workspace environment to the new geodatabase
env.workspace = os.path.join(outpath, "Stats_Table.gdb")

arcpy.AddMessage("Buffering crashes by 1 mile")

# Buffer the crashes by 1 mile
arcpy.Buffer_analysis(crashes, "Crashes_1mile_buffer", "1 Miles")

# set a varaible to the length field name from the roads feature class
length_field_name = arcpy.Describe(roads).LengthFieldName

# get a count of the number of records in the crashes feature class.
# We will use this to break up the amount of records that will be processed during each iteration of the crashes
feature class
result = int(arcpy.GetCount_management(crashes).getOutput(0))
```

```
# Get the remainder of the count of records.
# the intersect tool can process
remainder = result % 1000

# Round off the total count of records to the lowest 1000th
rounded = result - remainder

# Find the number of iterations will will use by dividing the rounded count by 1000
iterations = rounded/1000

arcpy.AddMessage("Number of iterations that will be needed to process crashes = " + str(iterations))

# Create layer files of the crashes and roads feature classes to access layer properties (Definition Query)
lyrFile = arcpy.mapping.Layer(roads)
lyrFile2 = arcpy.mapping.Layer("Crashes_1mile_buffer")

# Set some counter variables. These will be used to apply a definition query to the crashes layer
pStart = 1
pEnd = 1000

# Set another counter to use in a while loop to allow the loop to end when it has run out of groups of 1000
records to process
counter = 1

# Set a while loop. this will be used to compare the 'counter' increments to the number of total iterations that
have been calculated above
while counter <= iterations:

   # Set a new timer to time each iteration of crashes. This will allow to print out how long it takes for each
group of 1000 crashes it takes to process
   tic2 = time.clock()

   # Apply a definition query to the crashes layer, to query down to each group of 1000 crashes (i.e. OBJECTID
BETWEEN 1 AND 1000)
   lyrFile2.definitionQuery = '"OBJECTID" BETWEEN {0} AND {1}'.format(pStart,pEnd)

arcpy.AddMessage("Processing crashes where " + str(lyrFile2.definitionQuery))

   # Use a select by location to select the roads that intersect with the groups of crashes. by doing this, we
increase performance of the tool
   arcpy.SelectLayerByLocation_management(lyrFile, "intersect", lyrFile2)

arcpy.AddMessage("Intersecting roads with crashes")

   # intersect the selected roads with the groups of crashes
   arcpy.Intersect_analysis([[lyrFile,1],[lyrFile2,2]], "Intersect_" + str(counter))
```

```
    # Increase each counter for the next iteration
pStart += 1000
pEnd += 1000
counter += 1

    # Calculate the time it took to process each group of 1000 crashes and print to a message.
    toc2 = time.clock()
    timeLapse2 = toc2-tic2
m,s = divmod(timeLapse2, 60)
h,m = divmod(m,60)

arcpy.AddMessage("This iteration took %d hours %02d minutes %02d seconds" % (h,m,s))

# Now we need to handle the remaining records left. Use an if/else statement to test if there is a remainder
if remainder <> 0:

    # Set a new timer to time each iteration of crashes. This will allow us to print out how long it takes for each
group of 1000 crashes it takes to process
    tic2 = time.clock()

    # Update the counters to the final group of crashes
pStart = pEnd + 1 - 1000
pEnd = pEnd + remainder - 1000

    # Apply a definition query to the crashes layer, to query down to each group of 1000 crashes (i.e. OBJECTID
BETWEEN 1 AND 1000)
    lyrFile2.definitionQuery = '"OBJECTID" BETWEEN {0} AND {1}'.format(pStart,pEnd)

arcpy.AddMessage("Processing final crashes where " + str(lyrFile2.definitionQuery))

    # Use a select by location to select the roads that intersect with the groups of crashes. by doing this, we
increase performance of the tool
    arcpy.SelectLayerByLocation_management(lyrFile, "intersect", lyrFile2)

arcpy.AddMessage("Intersecting roads with crashes")

    # intersect the selected roads with the groups of crashes
    arcpy.Intersect_analysis([[lyrFile2,1],[lyrFile,2]], "Intersect_" + str(counter))

    # Calculate the time it took to process each group of 1000 crashes and print to a message.
    toc2 = time.clock()
    timeLapse2 = toc2-tic2
m,s = divmod(timeLapse2, 60)
h,m = divmod(m,60)

arcpy.AddMessage("Time passed is %d hours %02d minutes %02d seconds" % (h,m,s))
```

```
else:
pass

# Create an empty list to be used in build a list of temporary tables names. The list will be used to delete these temporary tables names at the end of the script
table_list = []

# Iterate over the intersected feature classes and use the freuncy tool to summarize by CRASH_ID and the length field name (Shape_Length)
for fc in arcpy.ListFeatureClasses():

   # Use an if statement to make sure the tool only summarizes the intersected roads, not the crash buffers.
if fc <> "Crashes_1mile_buffer":

arcpy.AddMessage("Summarizing " + str(fc))
      arcpy.Frequency_analysis(fc, fc + "_summarized", "CRASH_ID", length_field_name)
      table_list.append(fc + "_summarized")



##arcpy.AddMessage(table_list)

# now need to append all the tables into one table. First we create a template feature class to be used in the append tool.
arcpy.CreateTable_management(env.workspace, "Summarized_Final", fc + "_summarized")

# Use the append tool to append all the summarized tables together.
arcpy.Append_management(table_list, "Summarized_Final")

# Add a field to be used to calculate miles from the Shape_Length field. Shape Length is in meters by default.
arcpy.AddField_management("Summarized_Final", "Total_Road_Length_in_Miles", "DOUBLE")

# Use the Caluclate Field tool to calculate the new field in order to get miles (1 meter is equal to 0.000621371 miles)
arcpy.CalculateField_management("Summarized_Final", "Total_Road_Length_in_Miles", "!Shape_Length! * 0.000621371", "PYTHON")

# Iterate over the temporary tables in the workspace and delete
for table in arcpy.ListTables():

   # Use an if statement to make sure we do not delete the final sumamrized table
if table <> "Summarized_Final":
      arcpy.Delete_management(table)

# Calculate the time it took to process the whole tool and print a message.
toc = time.clock()
timeLapse = toc-tic
m,s = divmod(timeLapse, 60)
```

```
h,m = divmod(m,60)

arcpy.AddMessage("Time passed is %d hours %02d minutes %02d seconds" % (h,m,s))
```