

**Examination of the Impact of Speed Upon Highway Safety:
An Oregon Perspective**

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INTRODUCTION

In 2001 over 20,000 crashes occurred on the Oregon State Highway System. Excessive speed contributed to 27 percent of all crashes and 36 percent of all fatal crashes (ODOT, 2001). Speed has a strong correlation with highway crashes for numerous reasons: it reduces a driver's ability to safely navigate around curves or objects, increases the stopping distance of a vehicle, and increases driver reaction time in dangerous situations. Managing vehicle speed is necessary to improve road safety, and there are many different ways to achieve reduced speeds through engineering, enforcement, and education. Speed countermeasures include traditional warning signs, strategic pavement markings, road geometry alterations, dynamic message signs, and many other techniques.

Effective countermeasures are generally based on crash type. However, Oregon currently has no statewide system to prioritize the potential benefits of countermeasures at locations over represented by crashes with speed as a causal factor. The objective of this research is to improve the procedures used to select speed-related safety countermeasures by identifying crash types at locations. To accomplish this goal, this study analyzes 2001 Oregon crash data using Geographic Information Systems (GIS) to reveal the relationships between crash type and location.

This paper presents the first step of this research in developing a method for identifying highway locations based crash type, using speed related crashes and other important crash variables as a model. A brief look at what happened in 2001, with respect to crashes, is presented to provide a general picture of the study year. Maps and location descriptions of selected results from the research are also included. A specific site was selected for a field test of a recommended countermeasure; a summary of the description and analysis from this on-going field test is included. Study limitations, conclusions, and further study recommendations are included at the end of the paper.

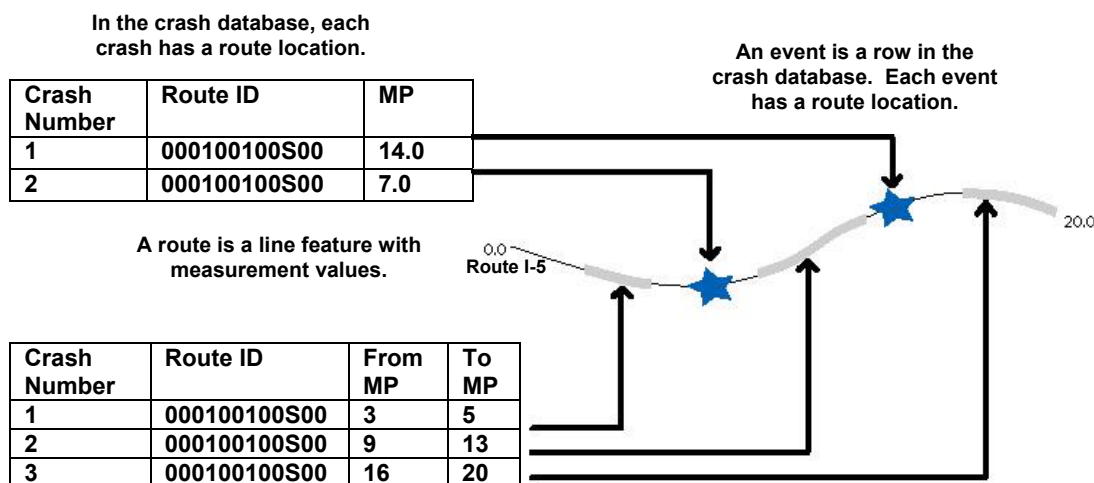
METHODS

This analysis uses crash data from the Oregon Department of Transportation (ODOT) 2001 Reported Crash Database. The database includes all 20,574 reported crashes that occurred on the state highway system in 2001. There are thirty-six field variables

for each crash; though some field variables are blank depending on the number of vehicles that were involved in a crash. In addition to a location identifier, major field variables include light, weather, surface conditions, speed involvement, fatalities, serious injuries, vehicle type(s), and collision type.

This analysis uses GIS to correlate crash type and crash location. The specific GIS process is called dynamic segmentation. Dynamic segmentation allows events (crashes) stored in a database table (Reported Crash Database) to be associated with any portion of a linear feature (highway network shapefile). For this research, dynamic segmentation is used to relate a crash by mile post (MP), and display that location on the highway network with a marker. Highway points are aggregated by the number of crashes occurring in each one-mile segment. Figure 1 helps explain the dynamic segmentation process.

Figure 1: The Dynamic Segmentation Process*

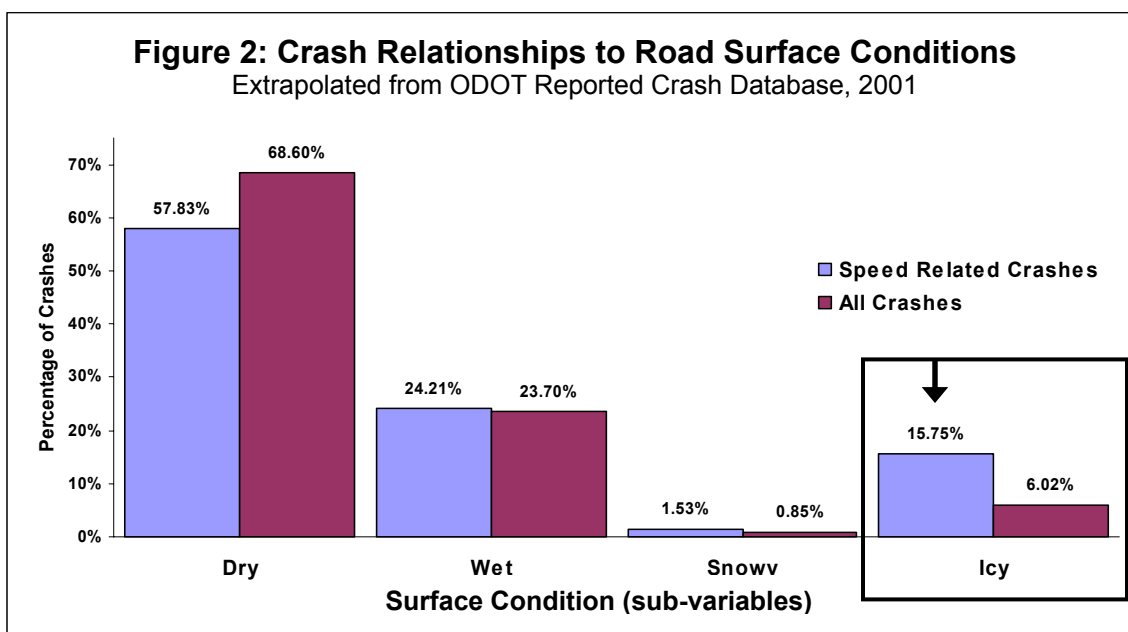


* Adapted from ArcUser, 2002

Each field variable has sub-variables in order to better describe the specific type of crash. For example, the “Road Surface” field variable is divided into the following categories: dry, wet, snowy, and icy. Crash ratios of the sub-variables are analyzed to determine which of the variables are overrepresented in speed-related crashes. Figure 2 shows how the sub-variable “icy” is overrepresented in speed-related crashes, especially when compared to the other sub-variables. In the other categories (dry, wet, and snowy) speed related crashes are approximately equal to or less than the percentages of all reported crashes. Due to the fact that icy conditions produce a notably higher rate of speed-related crashes than total crashes, a map was created

which identifies the locations of crashes where excessive speed and ice were both factors. This process is repeated for each major field variable. In this report, speed related crash maps are included for two specific types of sub-variables: Surface Conditions- Icy; and Light Conditions- Darkness without Street Lights.

The process described is what makes this research unique. Instead of identifying simply high crash locations, this method identifies high crash location by a combination of factors. Focusing on high crash locations by type allows for a much better understanding of the problem, and therefore will provide more efficient countermeasure recommendations. Excessive speed tends to lead to increased numbers of crashes and their severity; thus it is logical to experiment with this method for these types of crashes.



SUMMARY OF 2001 DATA

To provide a general picture of what happened on the Oregon State Highway System during the study year, a brief summary of the data is included in this report. As mentioned, there were 20,552 total crashes, of which 5,606 were attributed to speed (27.3 percent). Alcohol was involved in 310, or 1.5 percent of the total crashes. Although a low percentage of total crashes, alcohol does play a substantial role in fatal crashes; alcohol was involved in 18.5 percent of the 248 fatal crashes. However, there were a large number of crashes for which it was unknown whether or not alcohol was

involved. In general, alcohol often leads to increased speeds and more serious accidents. During the study year, alcohol involvement increased the likelihood of speed related crashes by a factor of two. Similarly, speed nearly doubled the chances of a serious injury; 2.8 percent of non-speed crashes resulted in serious injuries whereas 4.8 percent of speed related crashes ended in the same result. Fatal crashes were not as heavily influenced by speed; 1.1 percent of non-speed crashes resulted in one or more fatalities and 1.6 percent of speed related crashes were fatal (ODOT 2001).

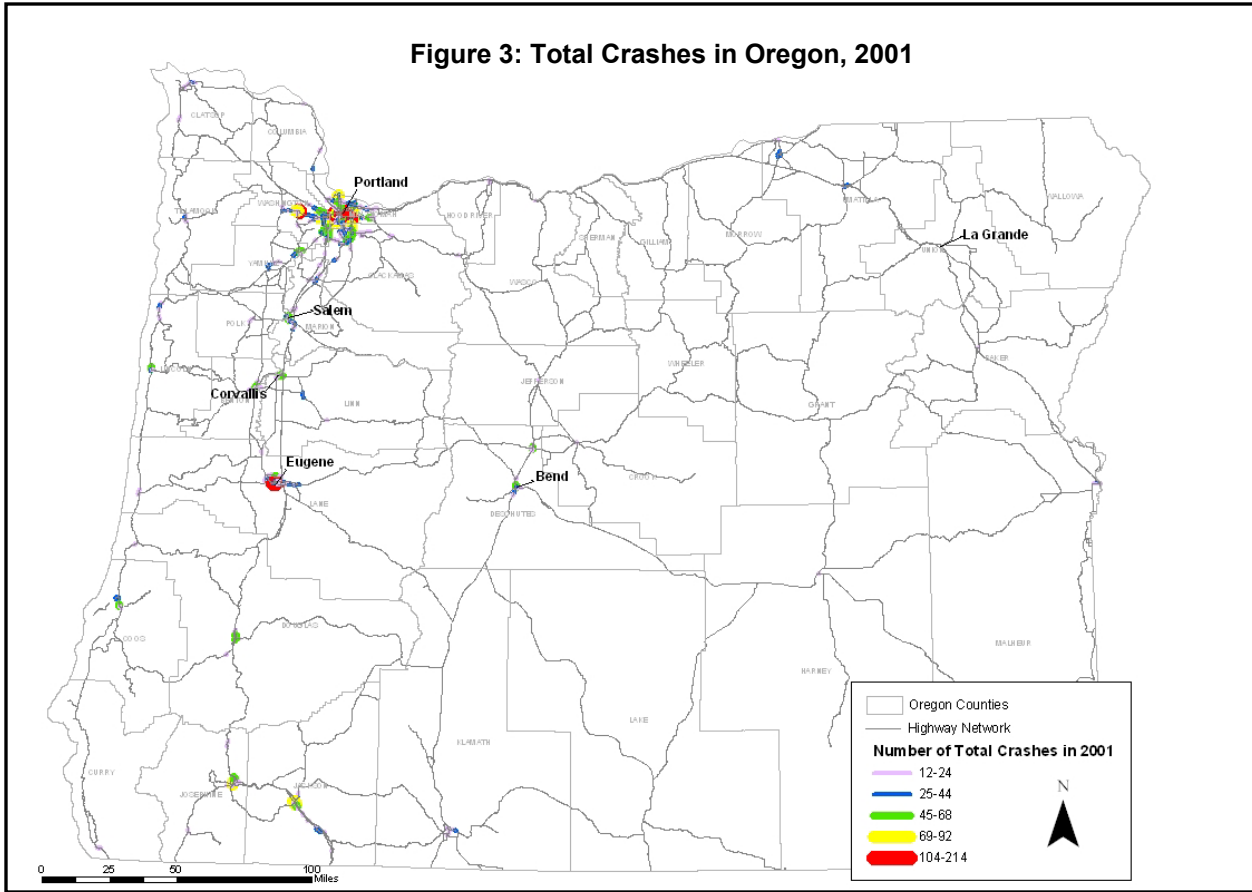
The majority of the accidents occurred during daylight hours (75 percent), which is expected because about 75 percent of driving volume also occurs during the daylight. However, when speed is considered as a crash factor, this percentage shifts slightly, decreasing the share of daylight crashes by 5 percent. When weather is considered as a factor, 68.5 percent of all crashes occurred when it was clear. Similar to the daylight example, the majority of driving occurs in clear conditions. When the weather is not clear, mainly cloudy, rainy, or snowy, speed increased as a factor by over six percent (ODOT 2001).

Lastly, examining collision type also helps to understand the relationships between speed and crash types in 2001. Rear end collisions accounted for 39.6 percent of all crashes and 43.4 percent when speed was a factor. The difference in fixed object crashes was also noteworthy; fixed objects accounted for 15.0 percent of all crashes and 43.1 percent of speed related crashes (ODOT 2001).

FINDINGS

The main finding of this study was that this method works as a system for identifying high speed crash areas on Oregon State Highways. Using GIS, it is easy to see where crashes are occurring. Figure 3 shows that by actual numbers, virtually all of the crashes in 2001 occurred in western Oregon, with the majority of those occurring in the Portland and Eugene regions. This is logical due to the relatively higher traffic volumes on highways in those areas. Figure 3 does not offer much help for improving highway safety. However, it depicts the ability of the method and is a good place to start critically thinking about crash types.

Figure 3: Total Crashes in Oregon, 2001

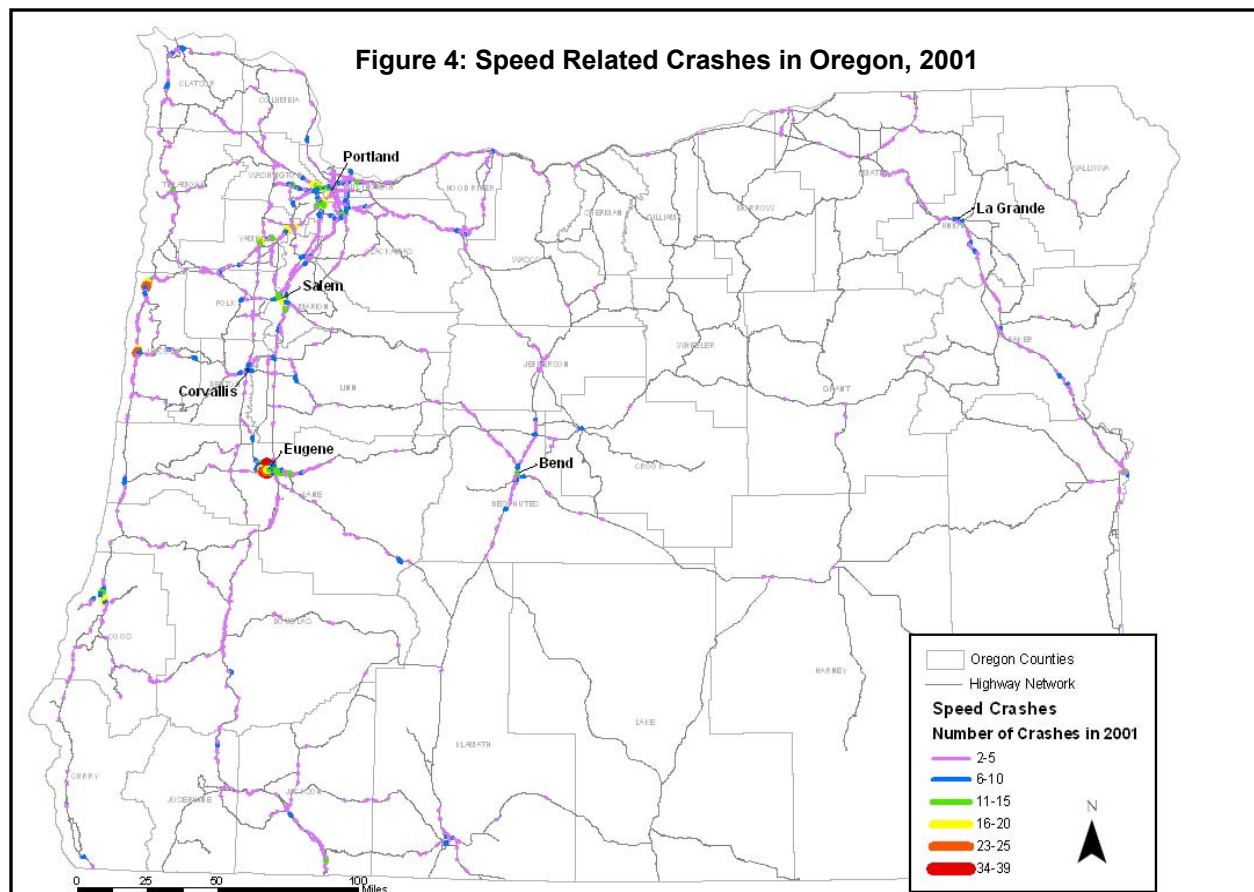


Source: Oregon State Highway Network (ODOT 2002)
2001 Reported Crash Database (ODOT 2001)
Projection: NAD 83 Oregon State Standard Transfer Lambert

Speed Related Crashes

As noted in the methodology, the first step is to filter speed crashes from all crashes in order to analyze them. Again, this is a simplified look at crash types, but it is the important first step in identifying locations that are vulnerable to speed-related crashes. Figure 4 highlights locations on the state highway system that had a high number of speed related crashes in 2001.

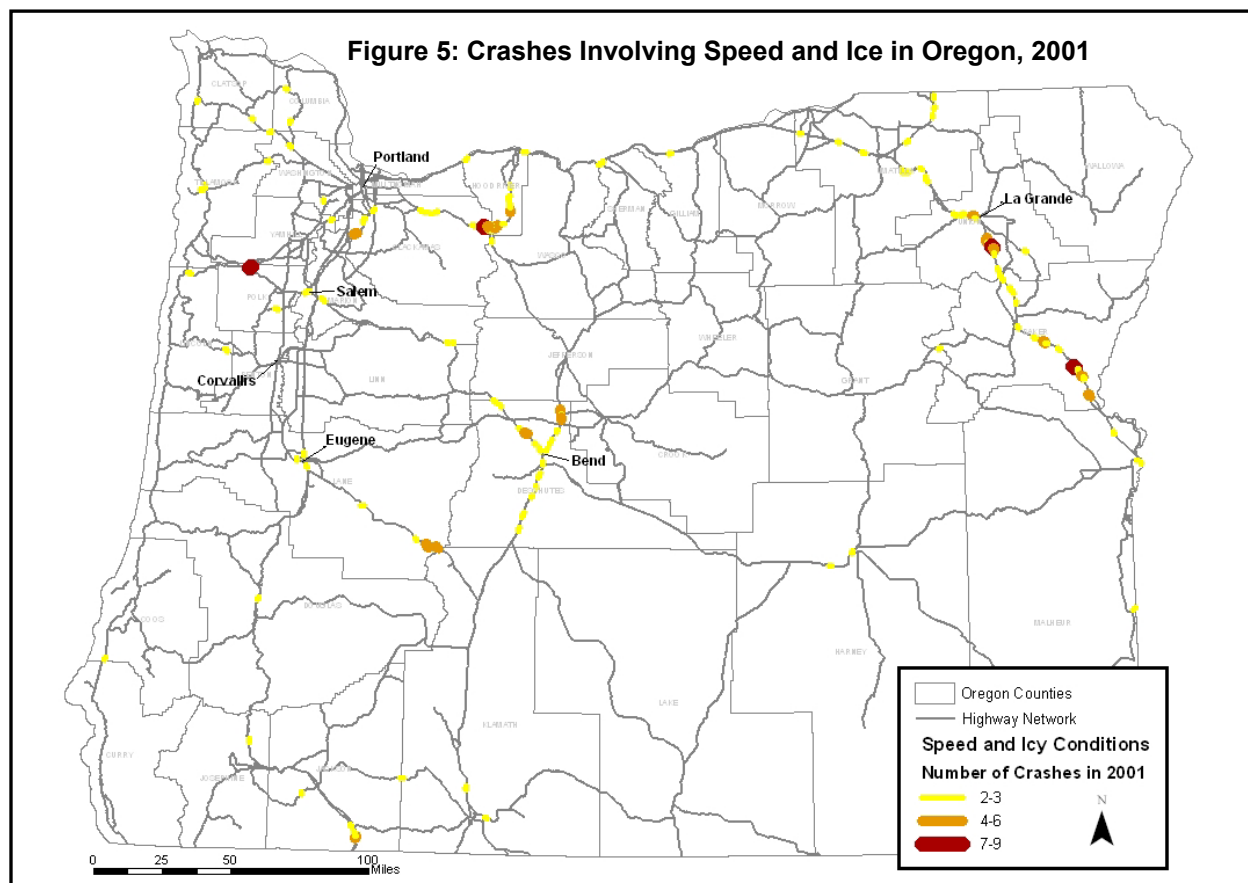
Although the majority of speed related crashes are in western Oregon, they are dispersed throughout the state. The Eugene area had the four segments with the highest numbers of speed related crashes, all on OR-126 and OR-99. One segment had 34 speed related crashes and another segment just two miles away had 39 speed related crashes. The same area produced two segments with 25 speed related crashes each. In total, six one-mile sections clustered together on these two highways were accountable for 151 speed related crashes. At this first level of analysis, the Eugene area clearly stands out as an area for further investigation and analysis.



Other regions that stand out with respect to speed related crashes include two spots on US-101, directly west of Salem. Combined, those two locations accounted for 144 speed-related crashes in twelve miles of highway. Additionally, 84 speed-related crashes occurred in a six mile cluster of highway segments five miles west of Portland, on US-26. Central Oregon had a small concentration of speed related crashes on US-97 outside of Bend. There was also a cluster of high speed crashes in northeast Oregon to the north and south of La Grande, along I-84. There was also a small cluster of speed related crashes 50 miles east of Portland on US-26, which is near the Mt. Hood ski resorts. The rest of the highway segments did not have a substantially high number of speed related crashes in 2001.

Speed and Surface Conditions

Further analysis involves referring to the crash relationship charts that are mentioned in the methodology. Following the surface conditions example, speed-related crashes



were overrepresented in icy road conditions. Accordingly, a map was created to show highway sections that had high numbers of speed-related crashes on icy surfaces. Figure 5 shows where these problem sections were for reported crashes in 2001. This type of mapping begins to pinpoint problem areas based on a specific combination of crash causation factors.

There are four highway sections in the highest number category of speed and ice crashes. Three of these areas make logical sense for someone who is familiar with Oregon topography; they occurred in the higher elevations of mountainous terrain where ice is more likely. The first two of these high elevation segments are in northeast Oregon along I-84, south of La Grande. These two problem areas highlight a 75 mile cluster of many other problem areas for speed and ice crashes on I-84. The third problem section of speed and ice crashes occurred on Highway 26 near the Mount Hood ski resorts. This one-mile segment is part of a small cluster of speed and ice crash problem segments.

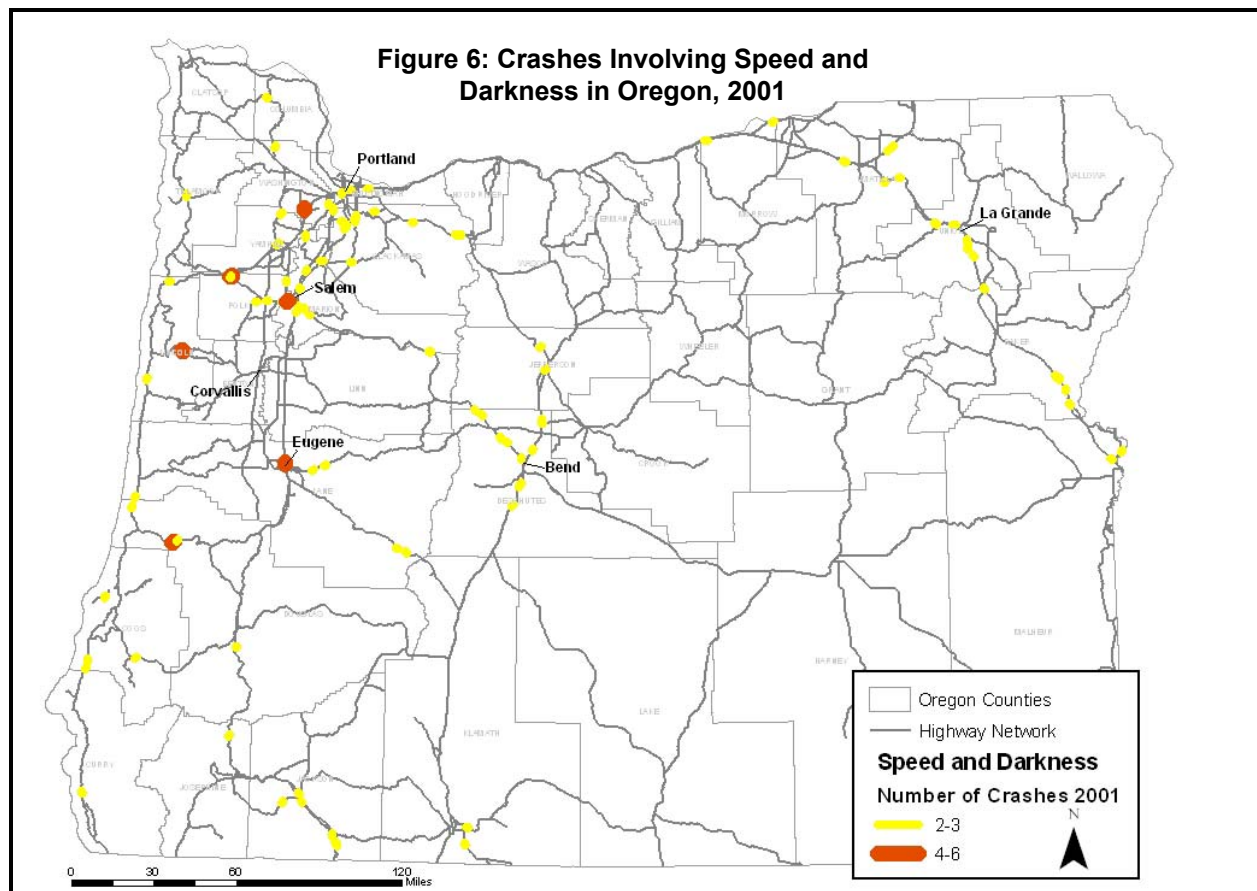
The fourth segment in the highest category of speed and ice crashes occurred approximately 25 miles northwest of Salem, at the intersection of Highways 18 and 22.

Ice is infrequent in this area and this may highlight the limitations of using one year of data for this preliminary analysis. One bad ice storm could have caused the crashes that put that segment on the map. Further investigation and analysis is needed to better understand that section of highway. Speed related crashes on ice are more frequent in a section of central Oregon as well. A cluster of medium and low frequency crashes occurred within 25 miles of Bend on Highways 20 and 97.

Speed and Light Conditions

Looking at speed related crashes and lighting conditions serves as a second example of using this method for identifying highway locations based on crash type. The sub-variable darkness (without street lights) was identified as being overrepresented in speed related crashes. Figure 6 shows locations where crashes caused by both speed and darkness were prevalent in 2001.

Six locations stand out from the rest as problem segments. All six of these one-mile segments are in western Oregon: just north of Eugene at the intersection of Highway 69 and I-5, 50 miles southwest of Eugene on Highway 38; 30 miles west of



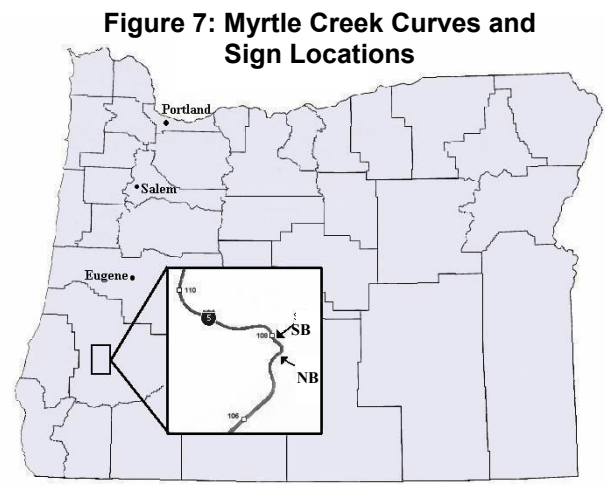
Source: Oregon State Highway Network (ODOT 2002)
2001 Reported Crash Database (ODOT 2001)
Projection: NAD 83 Oregon State Standard Transfer Lambert

Corvallis on Highway 20; just west of Salem on Highway 22; approximately 25 miles northwest of Salem, at the intersection of Highways 18 and 22 (this overlaps with an identified speed and ice location); and approximately 16 miles southwest of Portland on Highway 219.

Other problem areas with respect to speed and darkness were scattered across a few regions of the state. Numerous crash locations were identified throughout the Portland and Salem regions. Another region with multiple locations identified was the area around Bend. Lastly, I-84 near La Grande and again approximately 80 miles southeast of La Grande were both identified as areas that had clusters of speed related crashes occurring in dark conditions without street lights.

FIELD TEST: MYRTLE CREEK ADVANCED CURVE WARNING SYSTEM

The methodology explained above will lead to the identification of specific locations where speeding-related crashes are problems. One such location is the Myrtle Creek Curves, located in both northbound and southbound travel lanes, near MP 108 on I-5 in southwest Oregon. This location was identified as having a high frequency of speed related crashes on a curve. Accordingly, dynamic speed warning signs were installed at the curves. Figure 7 shows the curve and sign placements. A study is currently being conducted to evaluate the effectiveness of these signs in reducing speeds approaching and through the curve. The main measurements of effectiveness for the study include analysis of crash data (number of crashes over time) and speed data (vehicle speeds collected by radar) before and after system installation, as well as driver awareness of the system after installation.



detector. Speed data are not recorded for enforcement or analysis purposes. The CMS displays a default message when there are no vehicles traveling at or above 50 mph, a warning message is displayed when one or more vehicles are traveling at or above 50 mph, and an excessive speed message is displayed when any vehicle is detected at or above 70 mph. Figures 8 and 9 display how the northbound site looked before and after installation of the Advanced Curve Warning System.

For evaluation, vehicle speed and location data were recorded in the field using a handheld laser speed detector and stored in a portable computer. Travel lanes were divided into three zones and the average speeds within each zone were calculated for the time period before CMS installation. The three zones are Zone 1: before influence of warning system treatment, Zone 2: after treatment has been recognized but before start of curve, and Zone 3: after treatment influence and in the curve. When the After Treatment data collection is complete, changes in the mean speeds of each zone will be tested for statistical significance.

Figure 8: Northbound, Before Treatment



Figure 9: Northbound, After Treatment



To better understand the influence of the treatment, vehicles were separated into two classes for data collection purposes: passenger and commercial vehicles. Passenger vehicles refer to cars, pickups, buses, and motorcycles. Commercial vehicles refer to commercial trucks (single trailer and multi trailer). Table 1 displays the basic statistical summaries of vehicle speeds from the before data collection.

The other two measurements of effectiveness for this study are crash data and driver surveys. There were twenty-three crashes in the Myrtle Creek curves in the three years prior to installation of the Advanced Curve Warning System. Due to the short time period between installation of system and the writing of this paper, sufficient after-

data is not yet available for analysis. Likewise, the collection and analysis of the driver surveys has not yet been completed.

The Myrtle Creek Advance Curve Warning System is an ODOT pilot project. If the results of the analysis are encouraging, more locations may be considered for speed related countermeasures in the future. Using the method presented in this report with multiple years' crash data will help to identify the best locations for countermeasures.

Table 1: Statistical Summaries of Vehicle Speeds, Before Treatment

Southbound				Northbound			
Passenger Vehicles	Zone 1	Zone 2	Zone 3	Passenger Vehicles	Zone 1	Zone 2	Zone 3
Mean Speed, mph	58.2	55.4	54.6	Mean Speed, mph	60.2	58.2	55.5
Standard Deviation	5.6	5.5	5.1	Standard Deviation	5.1	5.4	5.0
Count, <i>n</i>	445	861	976	Count, <i>n</i>	49	310	916
95% Confidence Interval (+/-)	0.53	0.37	0.23	95% Confidence Interval (+/-)	1.45	0.60	0.32
Commercial Vehicles	Zone 1	Zone 2	Zone 3	Commercial Vehicles	Zone 1	Zone 2	Zone 3
Mean Speed, mph	52.8	50.0	48.4	Mean Speed, mph	53.4	52.7	49.3
Standard Deviation	4.0	4.1	3.9	Standard Deviation	3.5	3.7	3.9
Count, <i>n</i>	326	684	778	Count, <i>n</i>	59	327	1031
95% Confidence Interval (+/-)	0.43	0.30	0.27	95% Confidence Interval (+/-)	0.92	0.40	0.24

STUDY LIMITATIONS

This study has described a powerful method to improve the ability of state departments of transportation to identify specific crash types and their locations. However, there are a few limitations. First, this study uses only one year of crash data. Due to the random occurrence of crashes, trends must be used to identify trouble spots. When only one year of data is analyzed, the number of crashes in that year may not represent the typical number of crashes in any given year. Therefore this method should be applied to several years of crash data to better determine high crash rate locations over a period of time. This will allow for the identification of trends and more site specific analysis of crashes.

A second limitation is that the number of crashes at each location have not yet been normalized by the Annual Average Daily Traffic (AADT) for each road segment. Therefore it seems as though there are a substantially higher number of crashes in the western Oregon and around mountain passes as compared to the rest of the state. Although this may be true, there is more traffic in those areas and the rate of crashes may be relatively low when the amount of traffic is considered.

FURTHER STUDY

There are several opportunities for further study of speed-related crash locations on the Oregon State Highway System in this continuing project. The first priority of all safety research is to study crash trends. Therefore the methodology applied to the 2001 Reported Crash Database must be applied to crash data for multiple years.

For all years of crash data explored, the crash rates should be determined. This will ensure that crash frequency and crash rates are studied and patterns noted. The locations that are identified as having high crash frequency and high crash rates for crashes involving speed will lend themselves to further analysis of specific sites.

Another opportunity for further investigation is to explore the types of vehicles that are involved in speed related crashes. Once the locations of speed related high crash sites and the types of vehicles involved in crashes are identified then a further more in-depth analysis of the site must take place. The analysis will determine specific road characteristics that may be influencing high crash rates. With information on road geometry and driver behavior, specific speed countermeasures can be recommended, deployed and their effectiveness studied.

CONCLUSIONS

The method proposed in this report can be a very effective tool in determining locations based on a combination of crash causation factors. The preliminary analysis shows that specific locations can be identified by crashes that have multiple characteristics, such as speed involvement, road surface conditions, and light conditions at the time of the crash. However, in order to fully understand trends in crash types, multiple years' of crash data should be integrated into the method. Furthermore, AADT and highway

geometry should be incorporated into the analysis in order to best compare locations identified by the method.

ACKNOWLEDGEMENTS

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REFERENCES

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2. Jennifer Cadkin and Patrick Brennan, Dynamic Segmentation in ArcGIS, ArcUser, July-September, 2002, p. 52-54.