OREGON RAIL SAFETY ANALYSIS

March 13. 2020

ABSTRACT

The objective of this project is to perform a railway safety analysis in the state of Oregon by using the GIS methods. The railway incident data was used to determine the distribution and trends of the crashes in Oregon. In addition, incident analysis will be conducted to determine some characteristics of the crashes. Then, the analysis will then focus on determining the causes of the crashes including human factors and potential environmental hazards that might cause the rail crashes. Lastly, prevention recommendations will then be provided based on the analysis results.

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CE 560 Advanced GIS Winter 2020

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Story Map Title: Oregon Rail Safety Analysis

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Introduction

Railway transport is a transportation mode that delivers passengers or goods from one place to another place by using trains that run on the track. Although American is not the leading country in developing railway transportation systems, it is still “connected by the best freight rail system in the world” (Association of American Railroads, n.d.).

Figure 1 Rail Transportation System http://angelo-cs.com/portfolio/metra-englewood-flyover-project/

Rail crashes do not occur as often as other transportation crashes. However, it still deserves high attention. This is because rail crashes will often cause serious injuries or fatalities, and might bring a negative impact to the community and environment. In addition, the interrupted rail activity will also bring a large impact including economic impact to the community.

For example, in 2016, a train that was delivering oil derailed near Moiser, OR. This derailment caused a fire that affected the environment and brought serious damage to the train. In addition, the incident brought negative impact to the surrounding cities as the city services were not functional. Also, rail activities were interrupted that affected the normal rail schedule and caused economic loss (The Guardian, 2016). Besides, there was a teenager killed by a freight train as he was taking a photo and not paying attention to the incoming train at Troutdale, OR in 2019 (Fedschun, 2019).

The purpose of this project is to perform a railway safety analysis in the state of Oregon by using the GIS methods. The railway incident data was used to determine the distribution and trends of the crashes in Oregon. In addition, incident analysis will be conducted to determine some other characteristics of the crashes. Next, the analysis will then focus on determining the causes of the crashes including human factors and potential environmental hazards that might cause the rail crashes. Lastly, prevention recommendations will then be provided based on the analysis results.

Site Description

The site of the rail safety analysis is located in the state of Oregon. Oregon State has a size of 98,379 square miles with a population over 4.3 million, and is the 27th most populous state in the country (World Population Review, 2020). The railroads system in the state of Oregon is similar to the country, which has been used by freights and passengers.

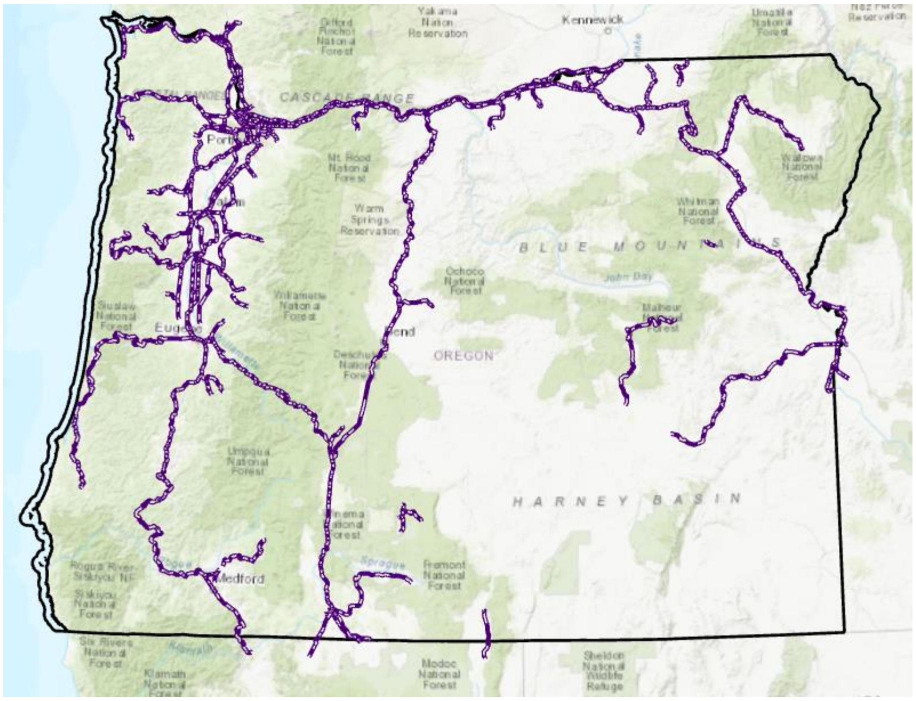

Figure 2 Railroad Distribution in Oregon

The railroad in Oregon is not widely distributed, and it is concentrated on the west side of the state. It has a total railroads length of 4895 miles, and approximately 80% of the rail was used by freight cargo. From 2011 to 2019, over 800 reported railroads casualties' incidents happened in Oregon state. Only 494 incidents data would be used in this analysis due to unknown location coordinates.

Methodology

The key points of this project were presenting incidents' characteristics, analyzing incidents' cause, and providing prevention recommendations. The analysis would mostly be done by using ArcGIS Pro. The first step was to obtain needed data from different sources, and input them into map layout. Approaching methods are listed below:

1. Data

   Data needed were obtained from three sources:

   - Federal Railroad Administration

     Data: Rail casualties incident data from 2011 to 2019

   - Oregon Spatial Data Library

     Data: Railroad, state boundary, state county, landslide susceptibility, tsunami

   - ArcGIS Hub

     Data: Railroad crossing

2. Incidents Characteristics

   Oregon state boundary, incidents data, and Oregon railroad would be used to visualize the incident distribution in Oregon. Then, an incident trend from 2011 to 2019 was plotted to present the variable of the incidents over time. By using the “Select By Attribute” tool, fatalities incident data were extracted from the overall incident data, and a new layer was made for comparison. Next, toolbox “Incident Analysis” was found online from the ESRI website and used to perform cluster analysis, calculate for incidents density and frequency, locate incidents hotspot areas, and present incidents percent change for year 2011 to 2015 and year 2016 to 2019.

3. Incidents Causes

   Causes of the incidents will be presented by a bar chart by setting the symbology of the incidents data to a unique value with the field of causes. Tools such as “Extract By Mask”, “Reclassify”, and “Raster To Polygon” were used to convert landslides data to the same feature (polygon) as the incidents data. Factors that might related to the incidents including, but not limited to, type of involved person, railroad crossings, landslides, and tsunami. “Select By Location” tool was then used to determine the relationship between these factors and the incident data.

4. Prevention Recommendations

Regarding the results from incidents distribution and data analysis, prevention recommendation for railroad users would be provided. Prevention related information would be obtained through Oregon highway-railroad crossing safety action plan and FRA’s current safety regulations and rulemaking proceedings.

Results

Incidents Characteristics

1. Incidents Distribution

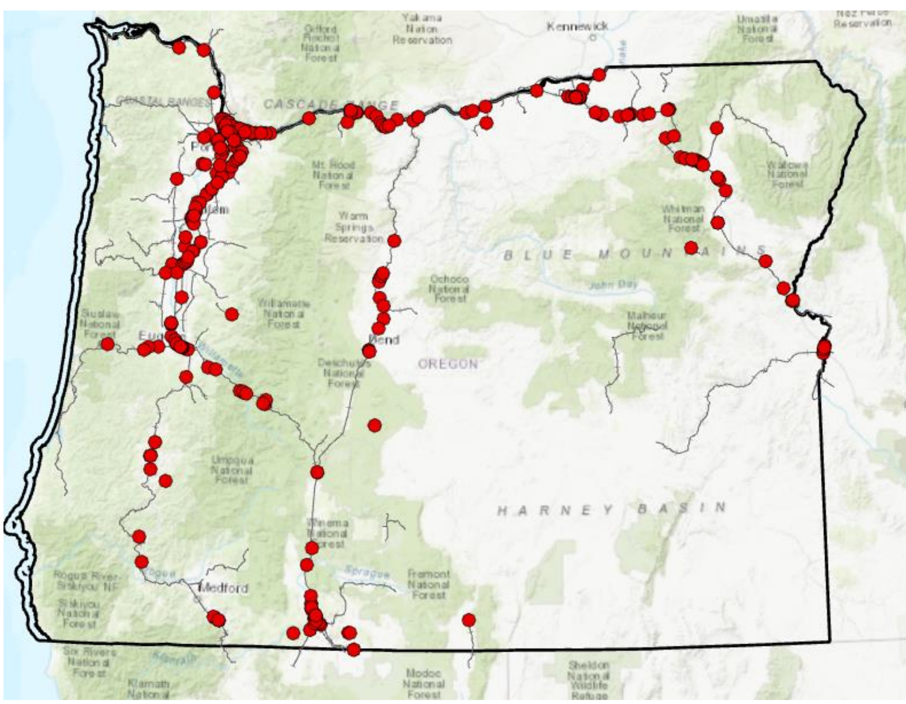

Figure 3 Incident Distribution

From 2011 to 2019, over 800 reported railroads casualties' incidents happened in Oregon state. However, only 494 incidents data would be used in this analysis due to unknown location coordinates. As shown in the figure, incidents were well spread through the railroad in Oregon, with more incidents concentrated in the northwest area compared to the other areas.

2. Incidents Trend

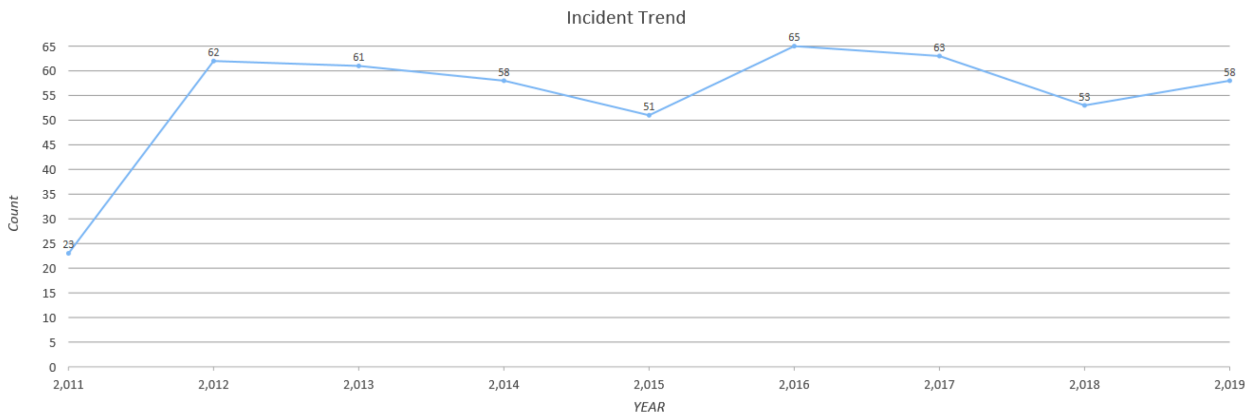

Figure 4 Incident Trend

Number of incidents in Oregon varied, that it went up and down, from 2011 to 2019. Incidents increased significantly from 2011 to 2012, and fell steadily from 2012 to 2015. It then rose and reached the peak in 2016 and there was a slight fall from 2016 to 2018. Incidents slightly went up again from 2018 to 2019.

3. Incidents Fatalities

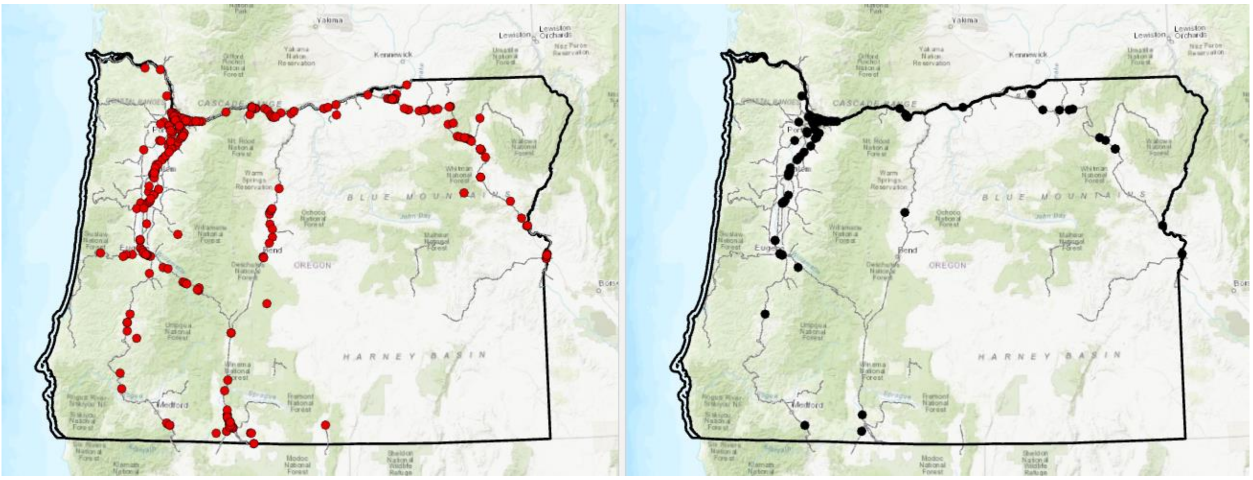

Figure 5 Comparison Between Overall Incidents and Fatalities

Fatalities incidents were extracted from the original incidents data to make a new layer. There was a total of 84 rail fatalities from 2011 to 2019, which equivalent to 17% of the overall incidents. As shown in figure 5, the fatality incidents were also concentrated in the northwest of the state.

4. Cluster Analysis

The result of cluster analysis pointed out the incidents' spatial clusters, and the clusters were labeled with contained number of incidents (ESRI, n.d.)

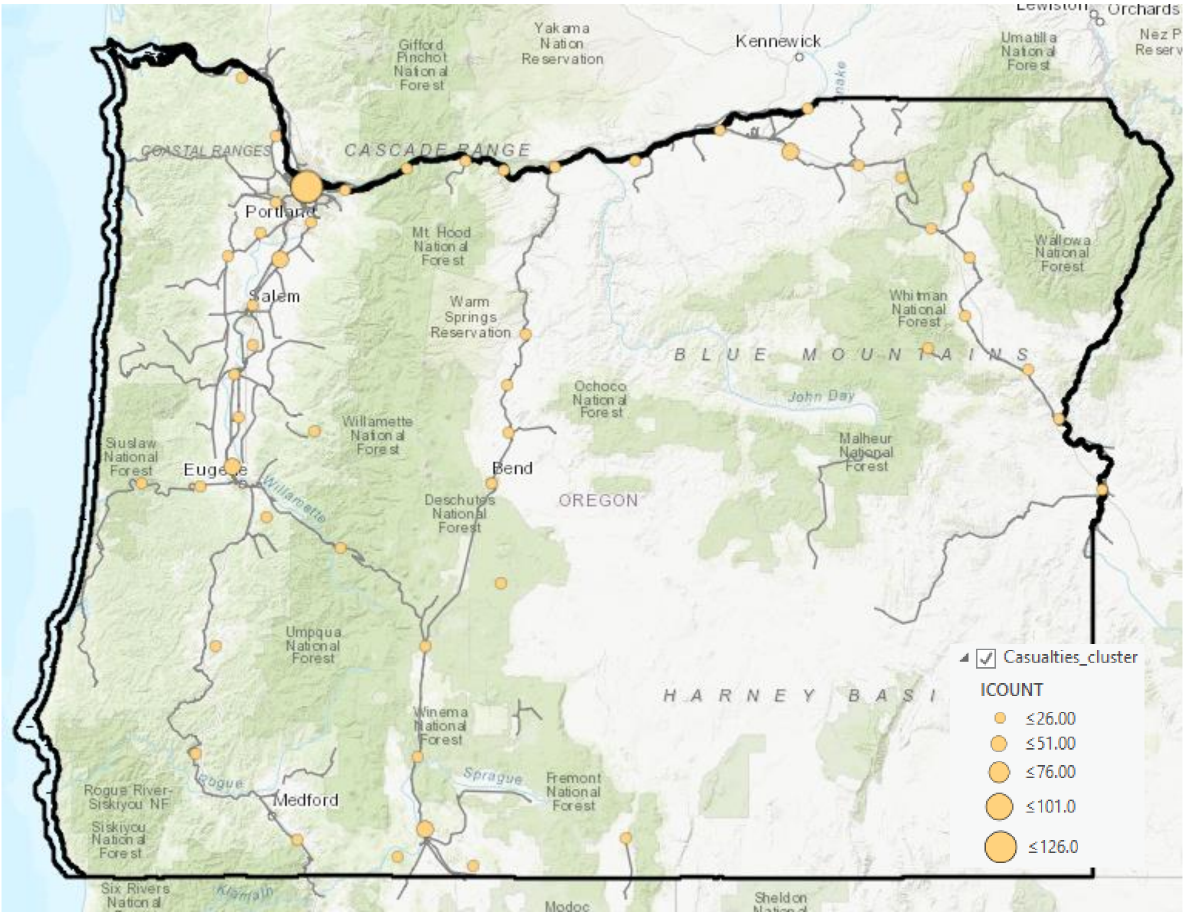

Figure 6 Incidents Clusters

As shown in the figure above, the largest cluster located in the northwest area, which supported the claim made in the incidents' distribution.

5. Incident Density

Incident density was found by using the "Calculate incident density" tool from the incident analysis toolbox. It indicates spatial clusters that are significant, with higher values as hot spots and lower values as cold spots (ESRI, n.d.).

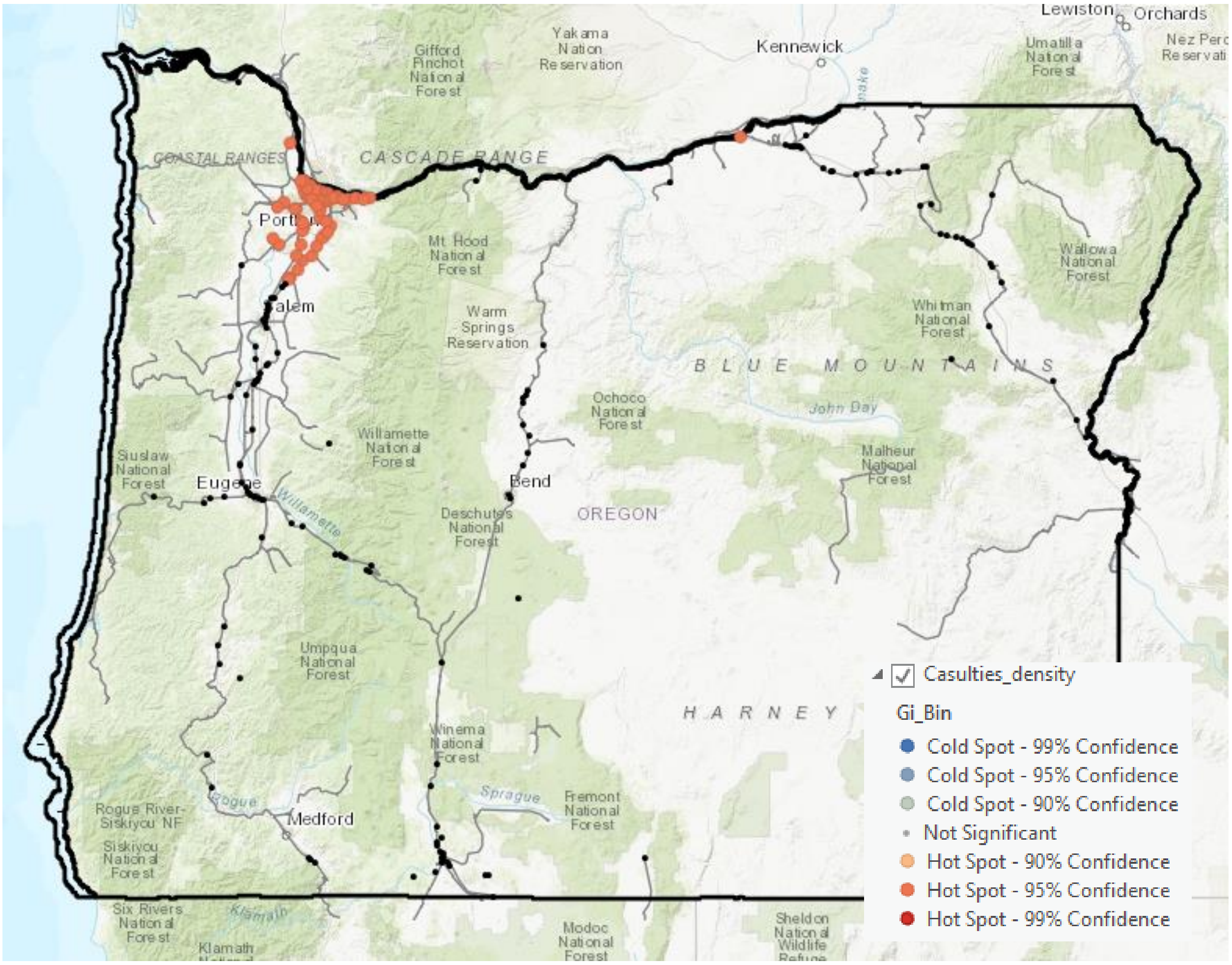

Figure 7 Incidents Density

The result from the analysis shown that the incidents density hot spots were mostly concentrated in the northwest area, with a point located in Gilliam county. Also, this analysis presented a similar outcome as the observation from overall incidents.

6. Incidents Frequency

The "Count Incidents By Lines of Communication (LOC)" tool conducted the incidents frequency near the railroad (ESRI, n.d.).

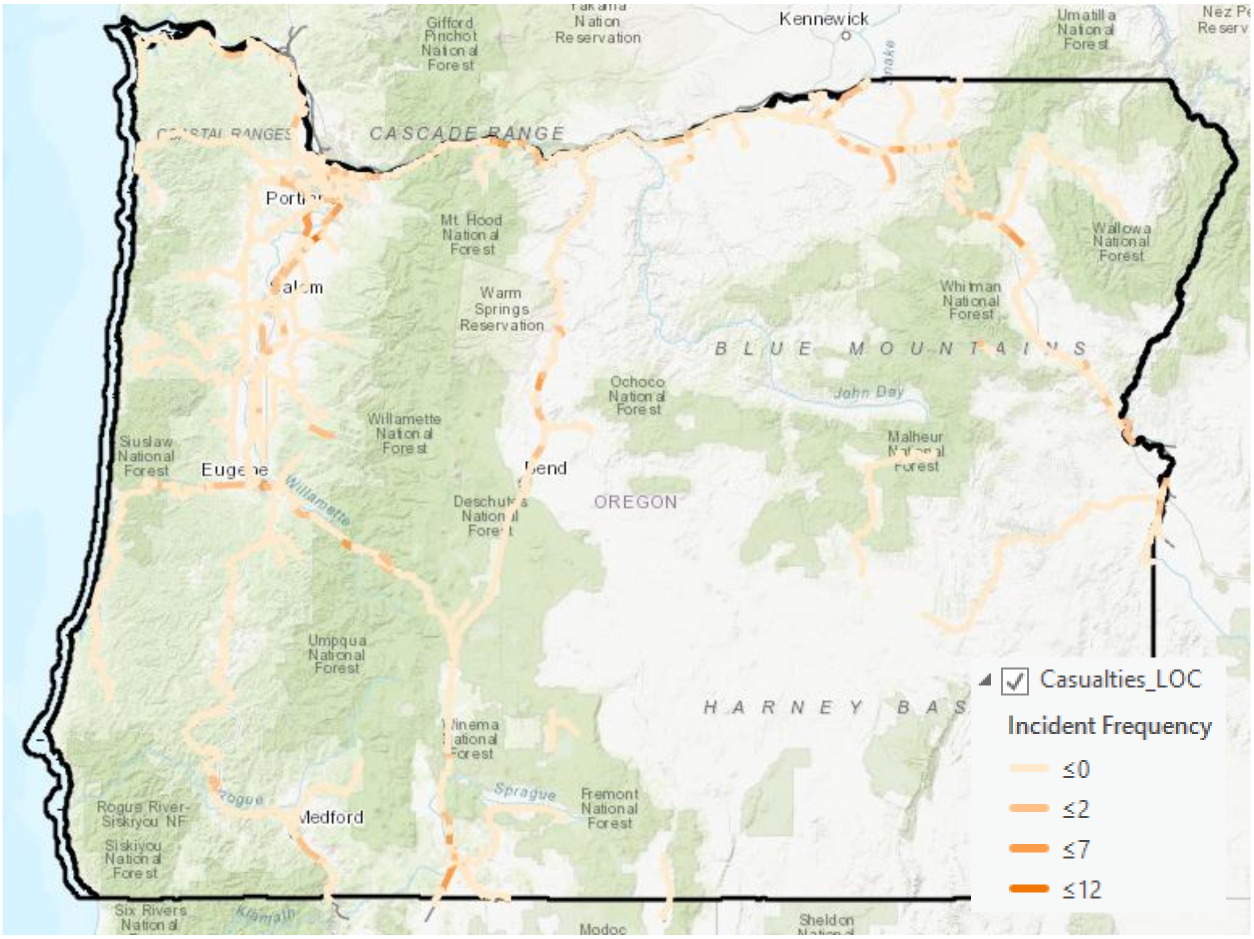

Figure 8 Incidents Frequency

Basically, this tool counted the number of incidents happened in a segment of railroad, and show the higher incident frequency with a darker color of polyline.

7. Incidents Hot Spot Areas

The Incident Hotspots tool allowed users to locate significant incidents' hot spots and cold spots using statistical methods (ESRI, n.d.).

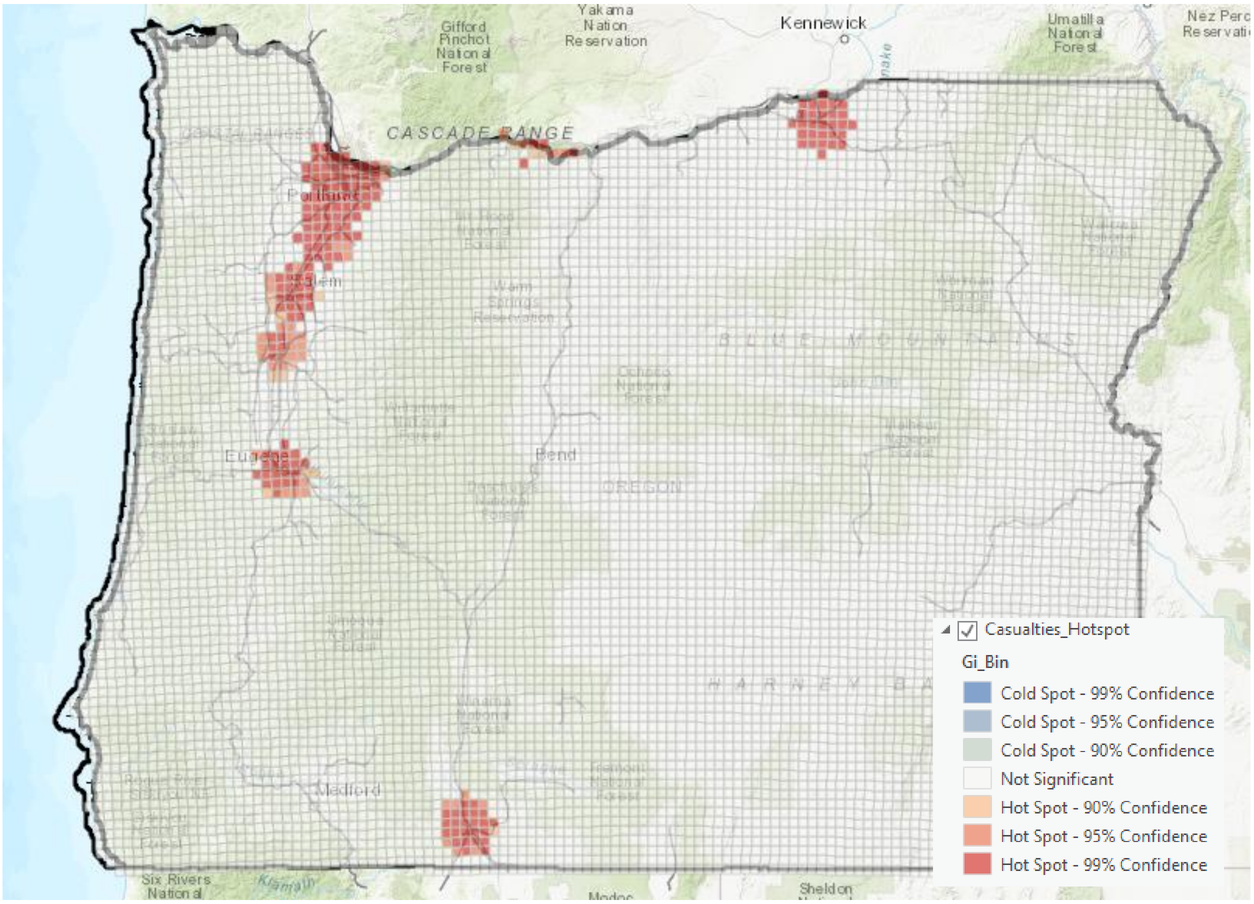

Figure 9 Incidents Hot Spots

From figure 9, it was not surprised to see hot spots located in the northwest region. However, this analysis appointed other hot spots locations such as Morrow county and Klamath county.

8. Incident Percent Change

This tool evaluates a trend that indicates the percent change of incidents in specified areas i.e. the counties in Oregon, between two period of times (ESRI, n.d.). For this project, evaluation was made between year 2011-2015 and 2016-2019.

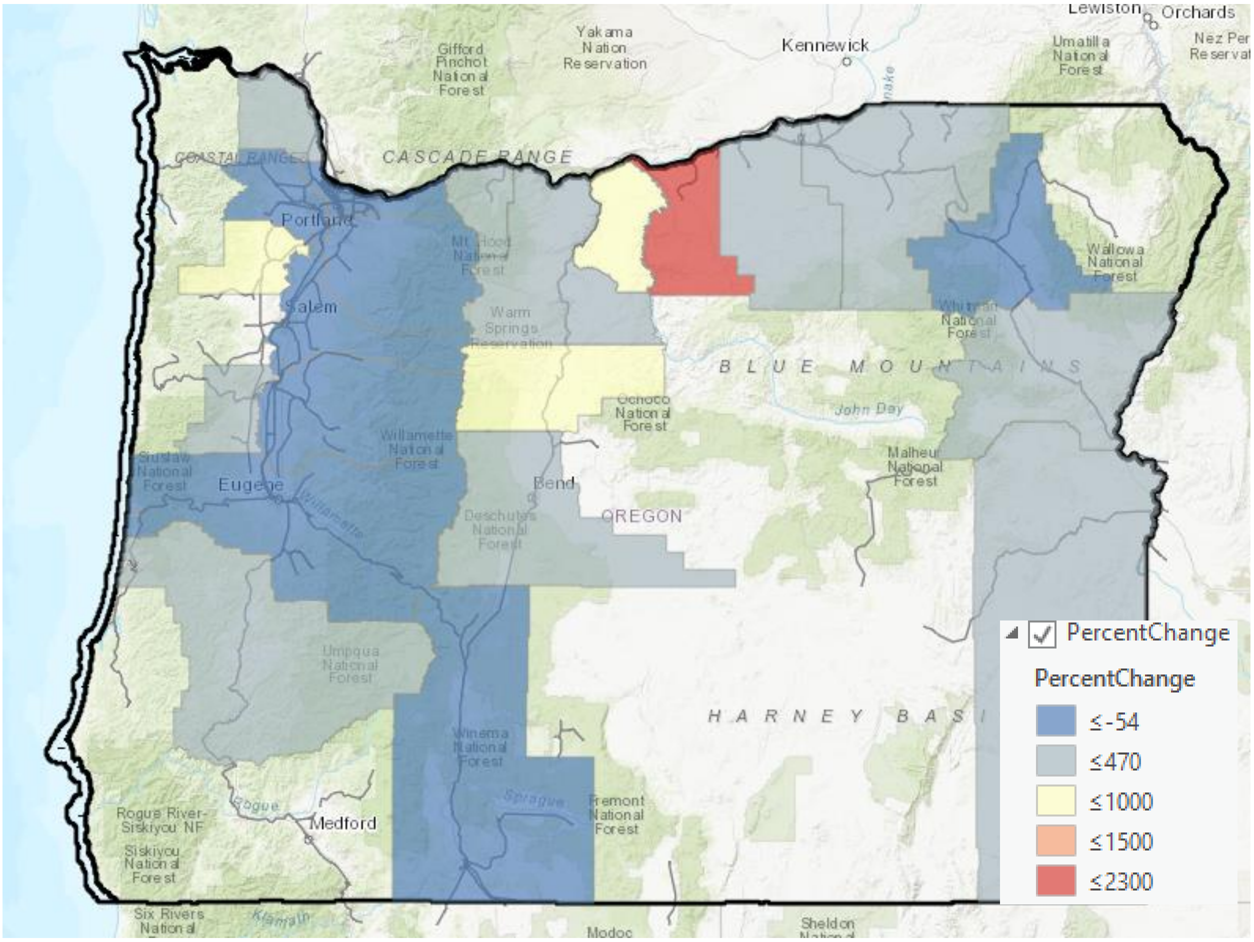

Figure 10 Incident Percent Change between 2011-2015 and 2016-2019

Above figure shown that the result was not accurate to represent the trend of the incidents. However, Gilliam county, that had stood out from incidents density analysis, should be considered as potential risk area.

To conclude the part of incidents characteristics, northwest region in Oregon should be considered as high-risk area, where potential risk areas will include Morrow county, Gilliam county and Klamath county. These places should increase awareness of rail incidents to develop prevention methods and improve safety.

Incidents Causes

Overall Causes

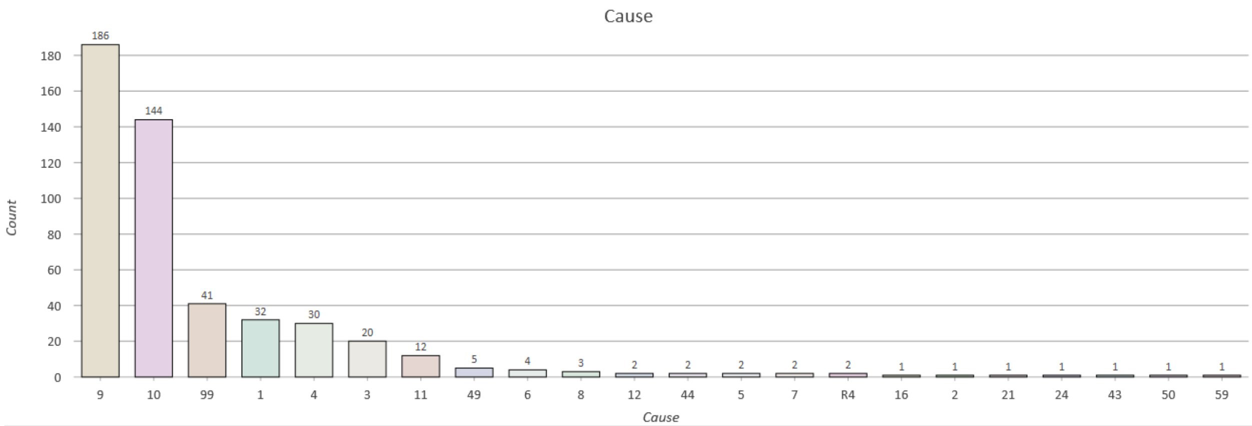

Figure 11 Overall Incidents Causes

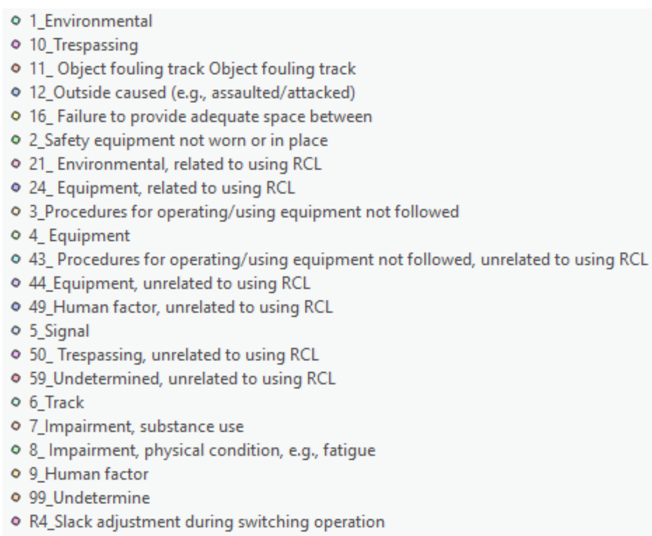

Figure 12 Overall Incident Causes Legend

Causes of the incidents are presented by the bar chart shown in figure 11 with the codes that corresponded to the explanation in figure 12. The top 5 causes of the incidents excluding undetermined data were:

1) Human Factor
2) Trespassing (e.g. intended suicide)
3) Environmental
4) Equipment (e.g. broken joint bar)
5) Procedures for using equipment not followed

The top three of the causes were used to analyze and determine their association with the incidents:

1. Human Factor

   Involved person type information was included in the incidents data, and the bar chart below presented the type of people that involved in the incidents. The information will be useful to develop prevention recommendations.

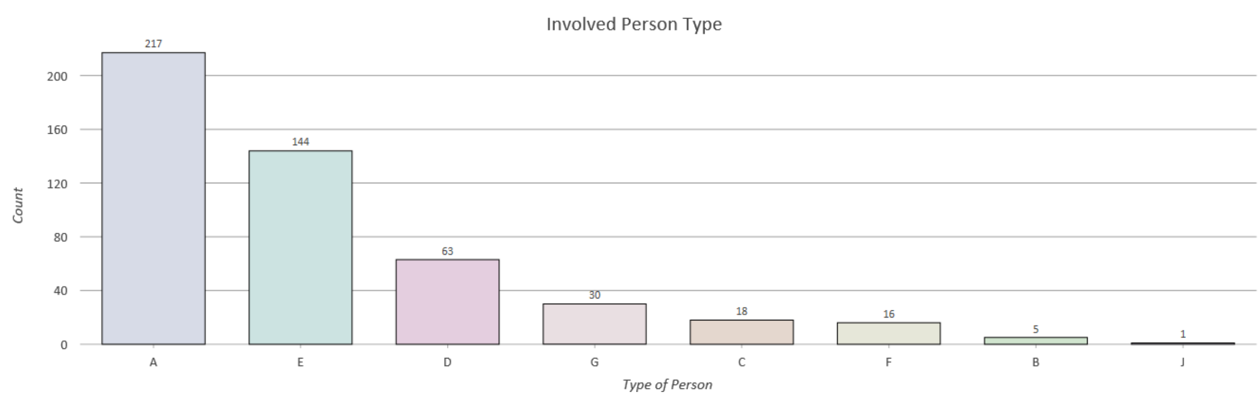

Figure 13 Involved Person Type

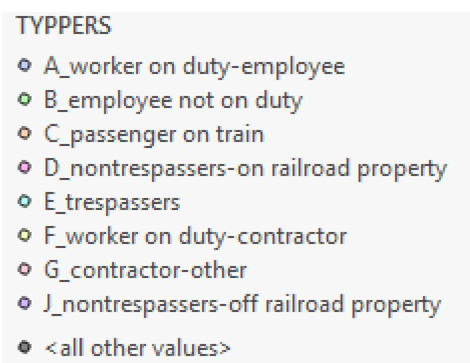

Figure 14 Involved Person Type Legend

From figure 13, the top three type of person will be:

1) Worker on duty- employee
2) Trespassers
3) Non-trespassers- on rail property

2. Trespassing

   Trespassing related incidents has come up in both overall causes and involved person type. Railroad crossing layer was used to investigate how was incidents related to trespassing in railroad crossings.

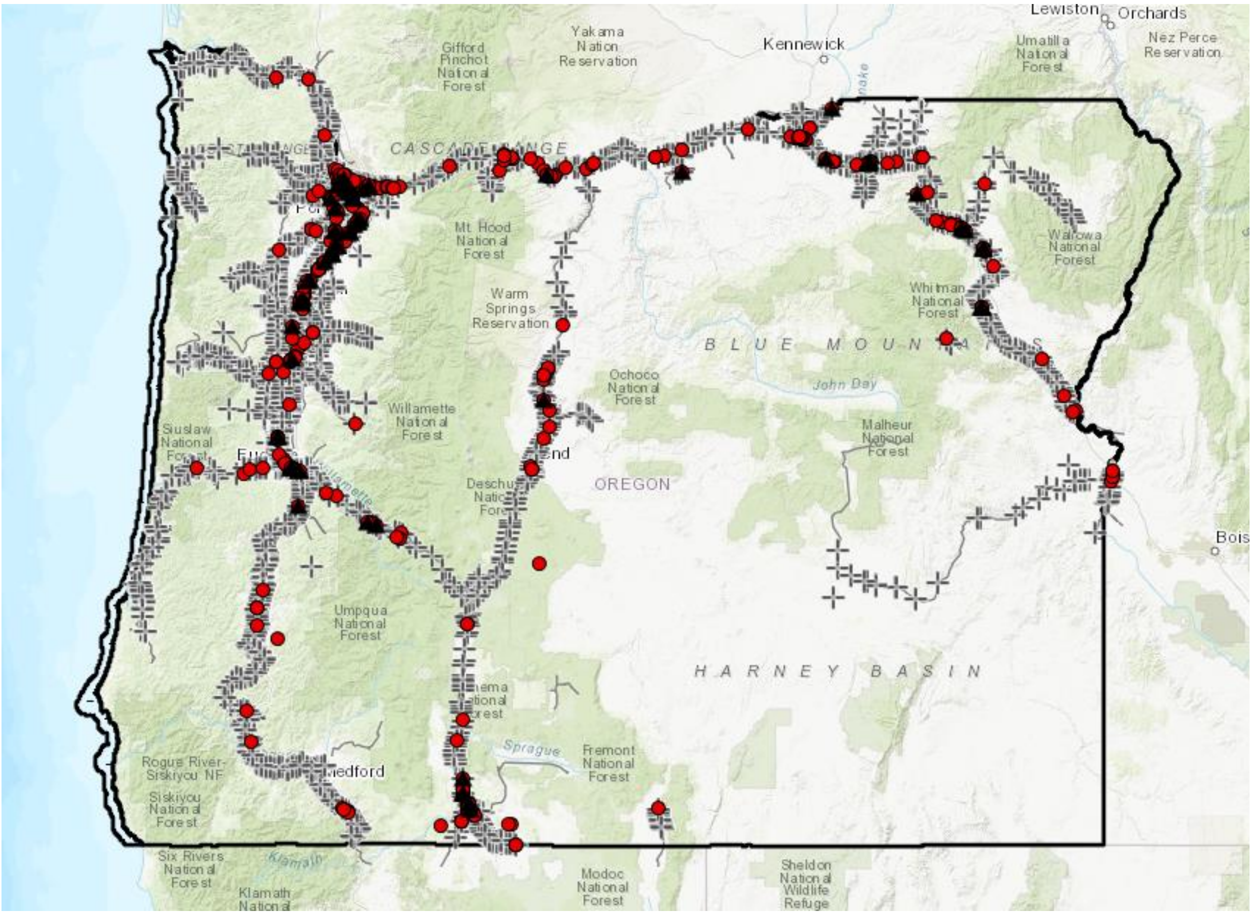

Figure 15 Incidents and Railroad Crossing

Figure 13 shows the relationship between incidents and railroad crossing, with cross symbol as railroad crossing; red circle as overall incidents; black triangle as intersect point. There was a total of 96 intersect data, which equivalent to 19% of overall incidents, and it is considered as high in this analysis.

3. Environment

Regarding the environmental hazard that might affect the incidents, landslide and tsunami were used to present their relationship with overall incidents:

1) Landslide

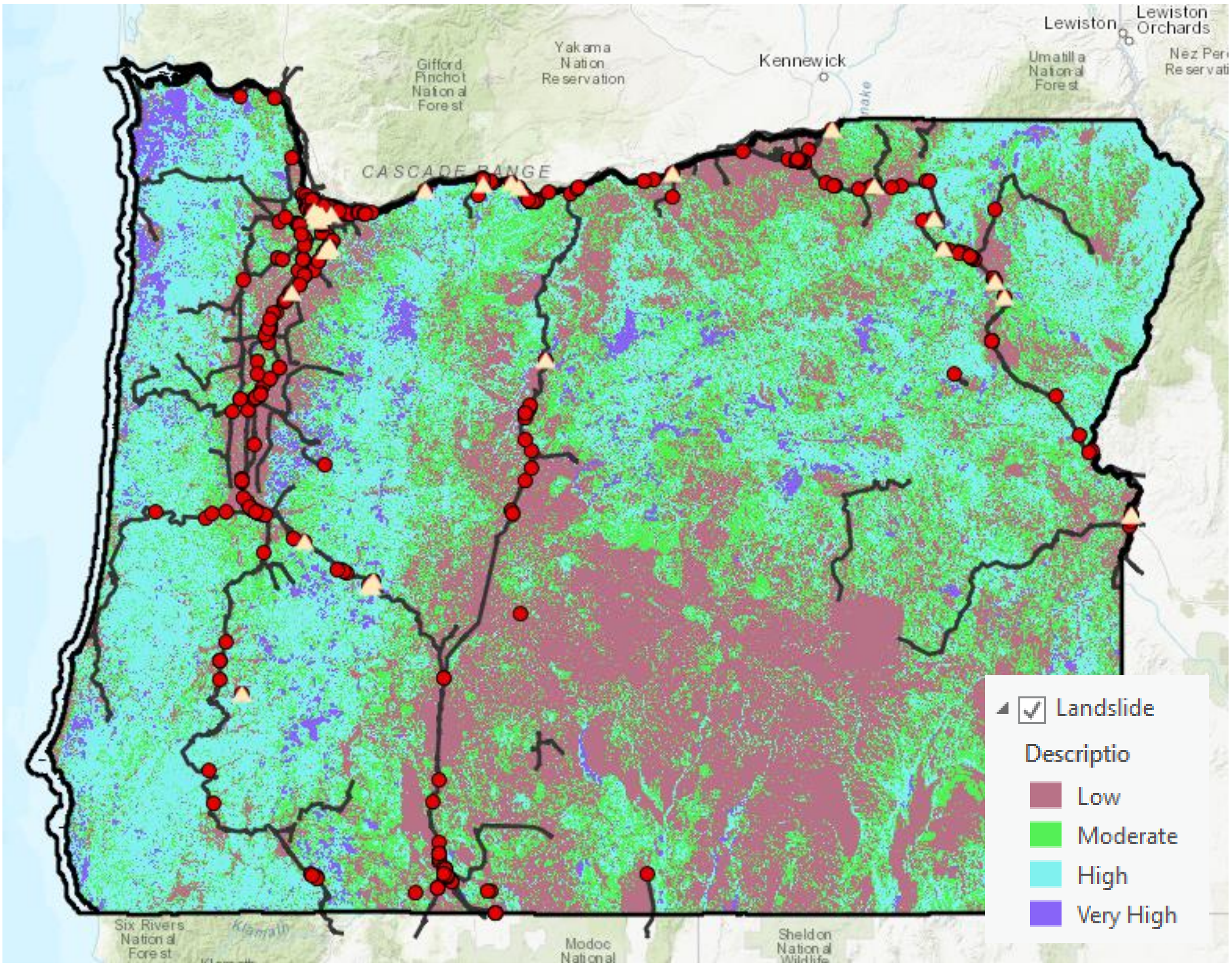

Figure 16 Incidents and Landslide

The total area in Oregon that contained high or very high landslide susceptibility is 33574 square miles. Result shown in figure 16 calculated 38 (yellow triangle) incidents cases, equivalent to 7%, that will be related to landslide.

2) Tsunami

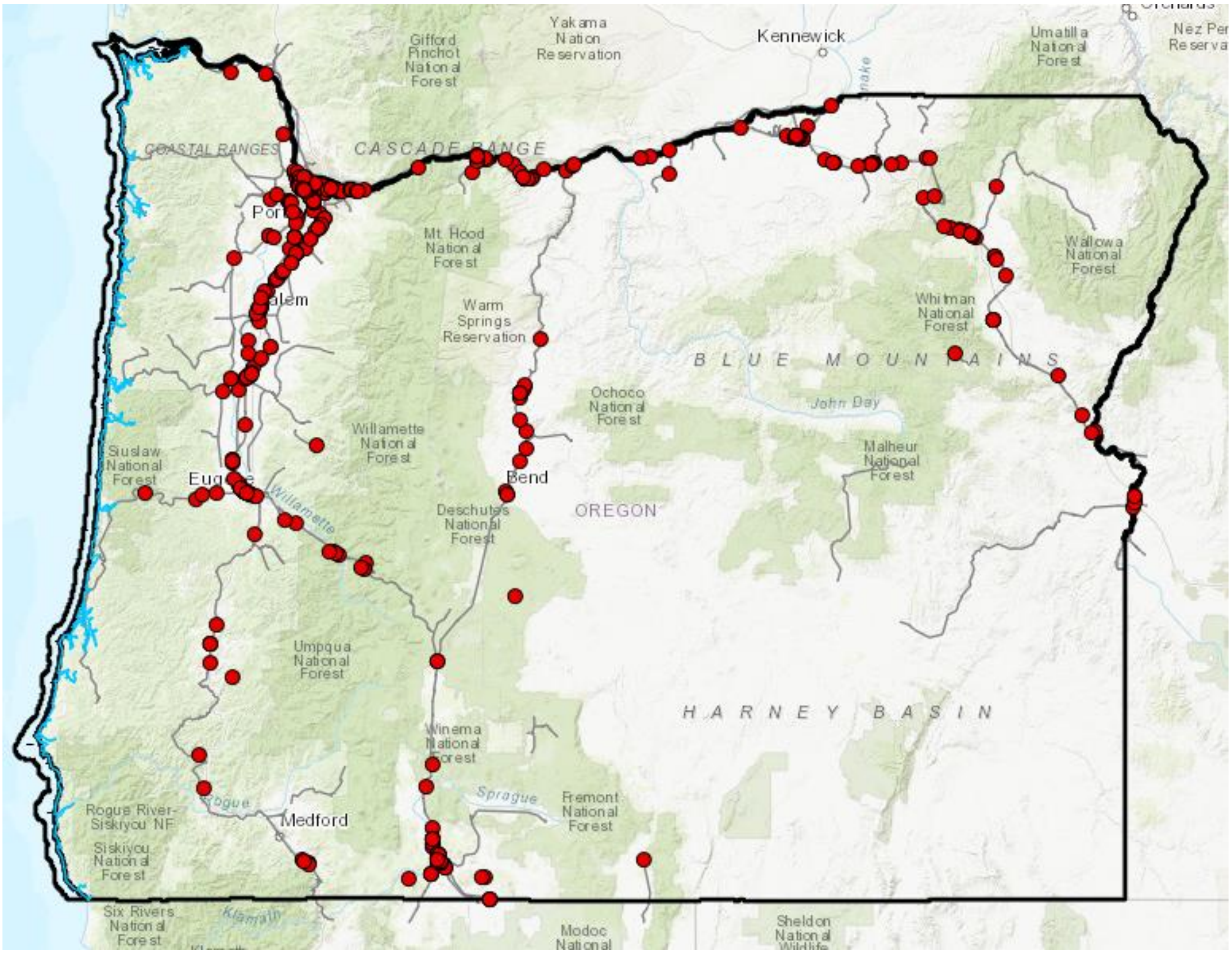

Figure 17 Incidents and Tsunami

As shown in the figure, tsunami is not related to the incidents as the railroad is far away from the coast. However, it might still affect some of the tracks that are closer to the coast.

A flowchart will be shown below to visualize the process of the analysis:

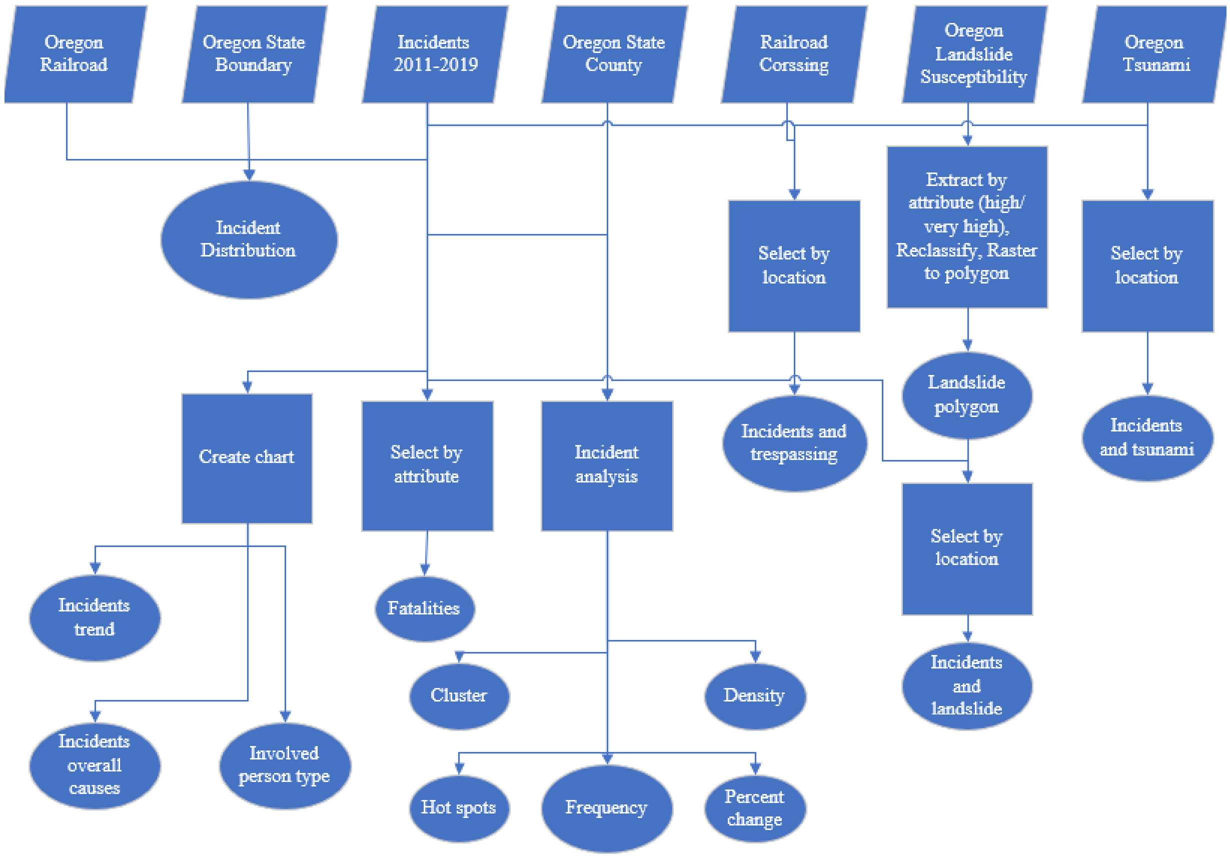

Figure 18 Work Flow

Based on incidents causes analysis, prevention recommendation was conducted and listed on section below.

Prevention Recommendations

Prevention recommendations will be made based on 3 categories: technology, legislation, and education.

- Technology

  Innovative technology such as automated and connected and autonomous vehicles technology has high opportunity to decrease transportation accidents and improve safety issues. This technology should be applied in developing railroad system with radar detection and track intrusion detection, which could potentially decrease crossing or trespassing incidents. In addition, efficient engineering designs should also be constructed. This is because traffic control information including warning devices, signages, and pavement markings are important keys to increase safety issues (Oregon Department of Transportation, 2019).

- Legislation

  Local area government should develop specific safety plan and safety guidance for railroad users, and strengthen law enforcement to avoid disobediences. Also, government should support technology development by providing funding. In addition, regularly equipment inspections should be conducted to prevent potential equipment failure that might cause rail derailment (Boardman, 2006).

- Education

  It is important for railroad related companies to provide proper technical and safety training to their employees to make sure employees follow correct working procedures. Also, increasing awareness of safety plans and guidance to all railroad users is another way to improve safety issues. In addition, driver education is an area to be focused on, that this will decrease risky drivers' behavior and therefore improve safety (Oregon Department of Transportation, 2019). Last but not least, encourage people to seek help through different platforms e.g. media to help prevent intended suicide.

Conclusion

In the United States, rail networks are an essential transportation mode for both passengers and freights. However, it brought negative impacts once it occurs. This project performed a railway safety analysis in Oregon by using incidents data from 2011 to 2019. Incidents characteristics including incidents distribution, trend, fatalities rate, cluster, density, frequency, hot spots, percent change between 2011-2015 and 2016-2019 were presented and results could be found in results section above. In addition, overall causes bar chart was plotted and the top three causes containing human factor, trespassing, and environment were used to determine their relationship with incidents. Lastly, prevention recommendations were provided based on the analysis results.

References

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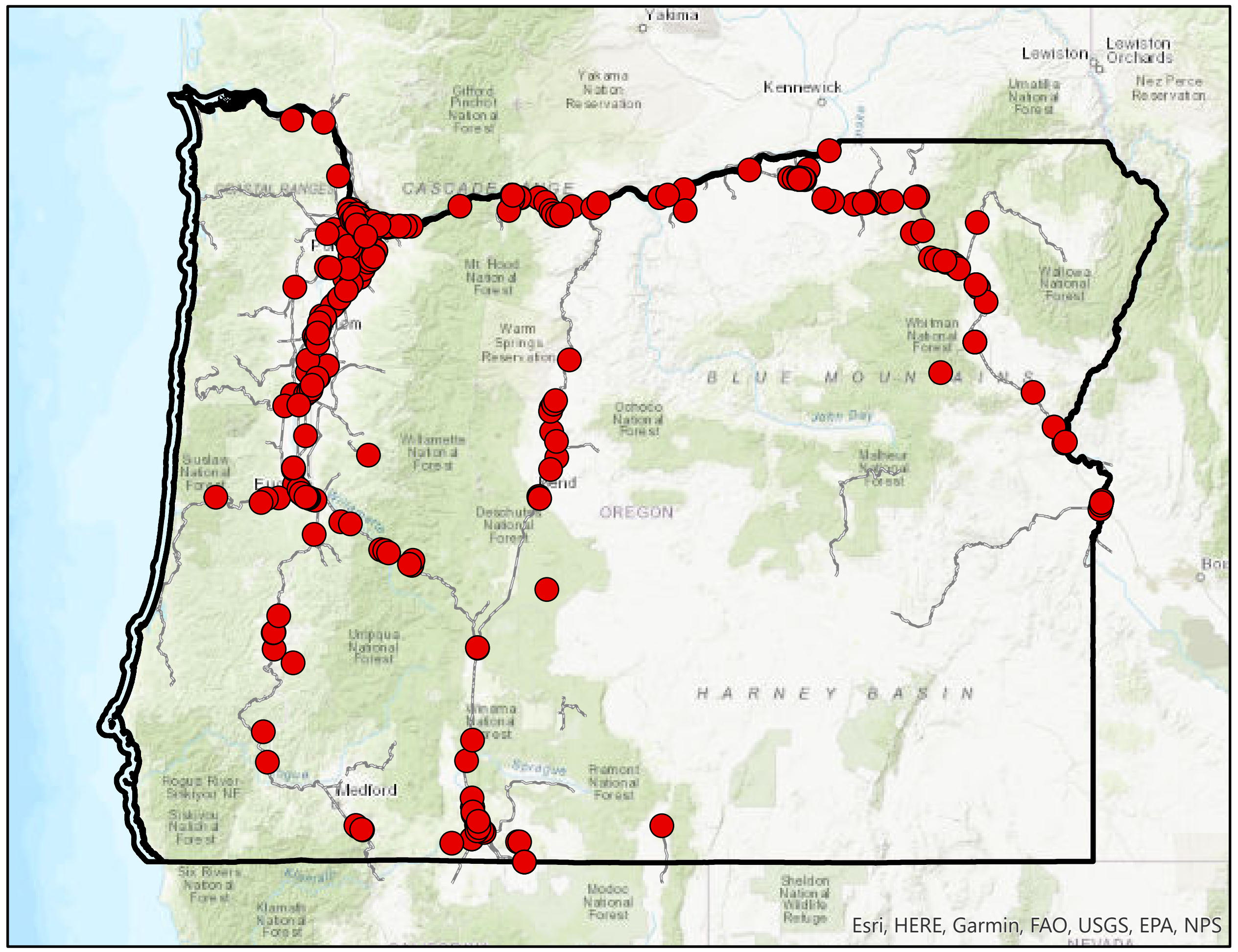
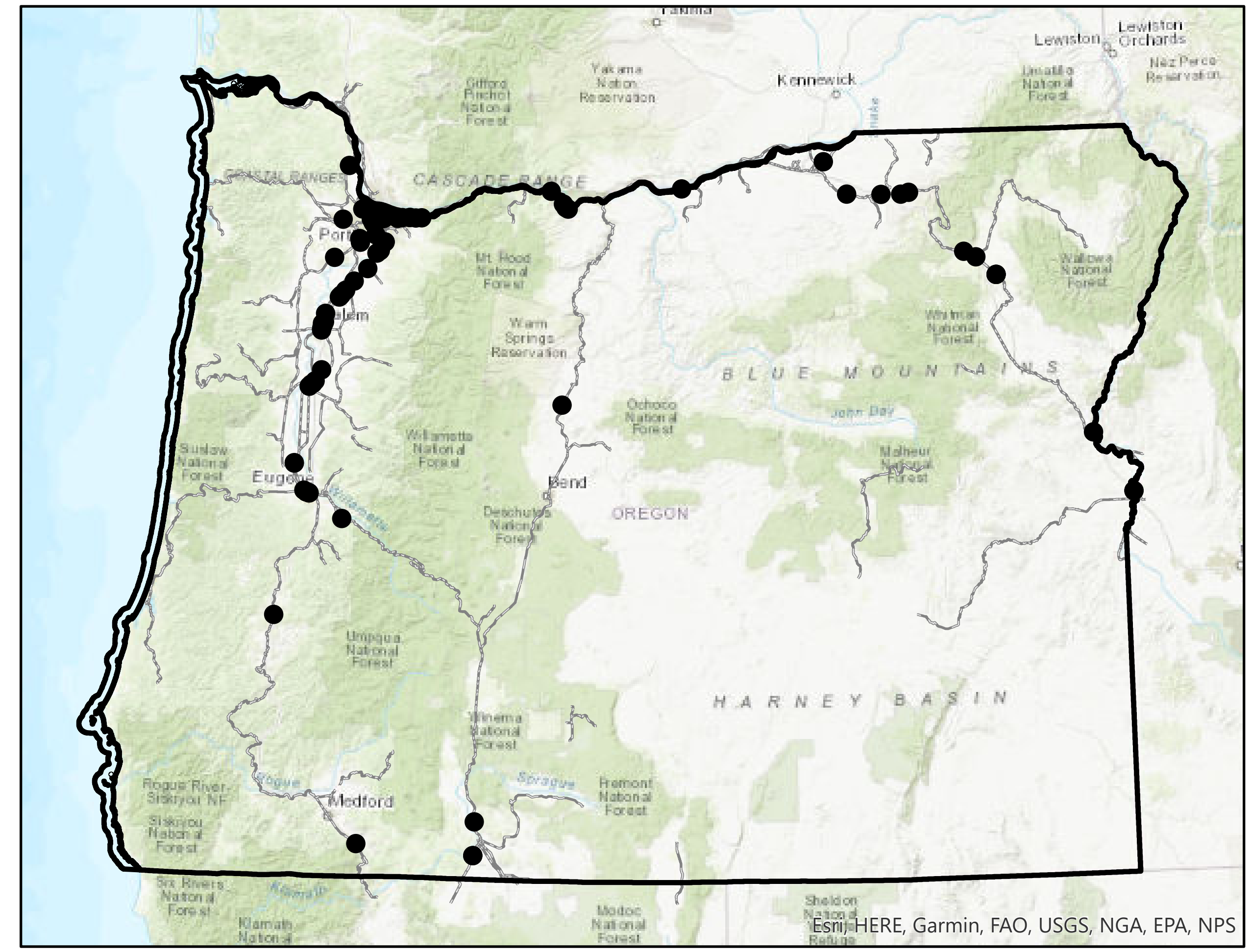
Incidents Distribution and Fatalities

Name of Map: Incidents Distribution



Casualties_snap
or_state_boundary
railroads

Name of Map: Incidents Fatalities



Fatalities
or_state_boundary
railroads

Description:
From 2011 to 2019, over 800 reported railroads casualties' incidents happened in Oregon state. However, only 494 incidents data would be used in this analysis due to unknown location coordinates. As shown in the map, incidents were well spread through the railroad in Oregon, with more incidents concentrated in the northwest area compared to the other areas.

Description:
Fatalities incidents were extracted from the original incidents data to make a new layer. There was a total of 84 rail fatalities from 2011 to 2019, which equivalent to 17% of the overall incidents. As shown in the map, similar to incidents distribution, the fatality incidents were also concentrated in the northwest of the state.

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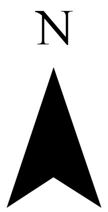
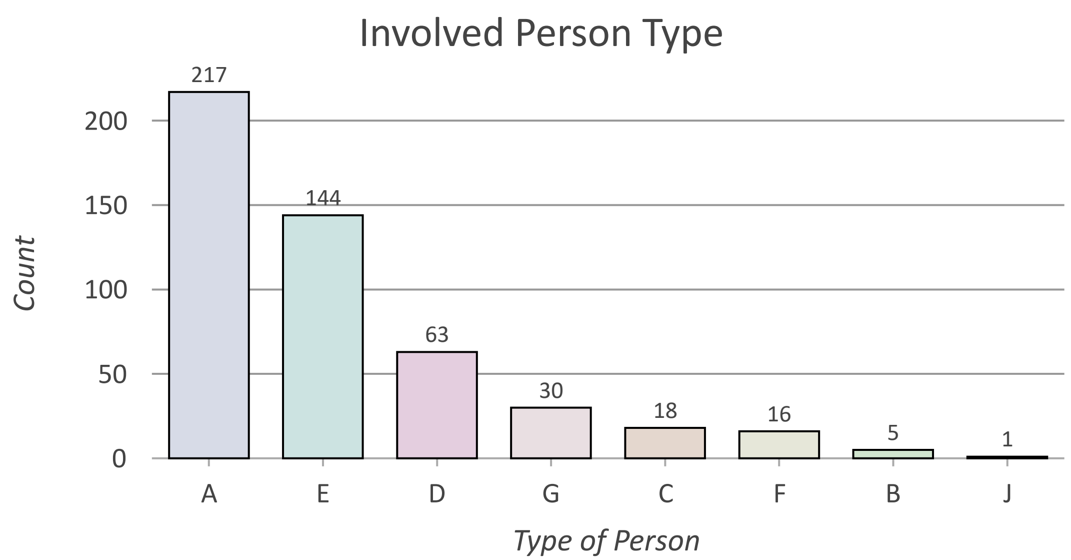
Spatial Reference
Name: NAD 1983 Oregon Statewide Lambert Feet Intl
PCS: NAD 1983 Oregon Statewide Lambert Feet Intl
GCS: GCS North American 1983
Datum: North American 1983
Projection: Lambert Conformal Conic

0 50 100 200 Miles

Map Units: Foot



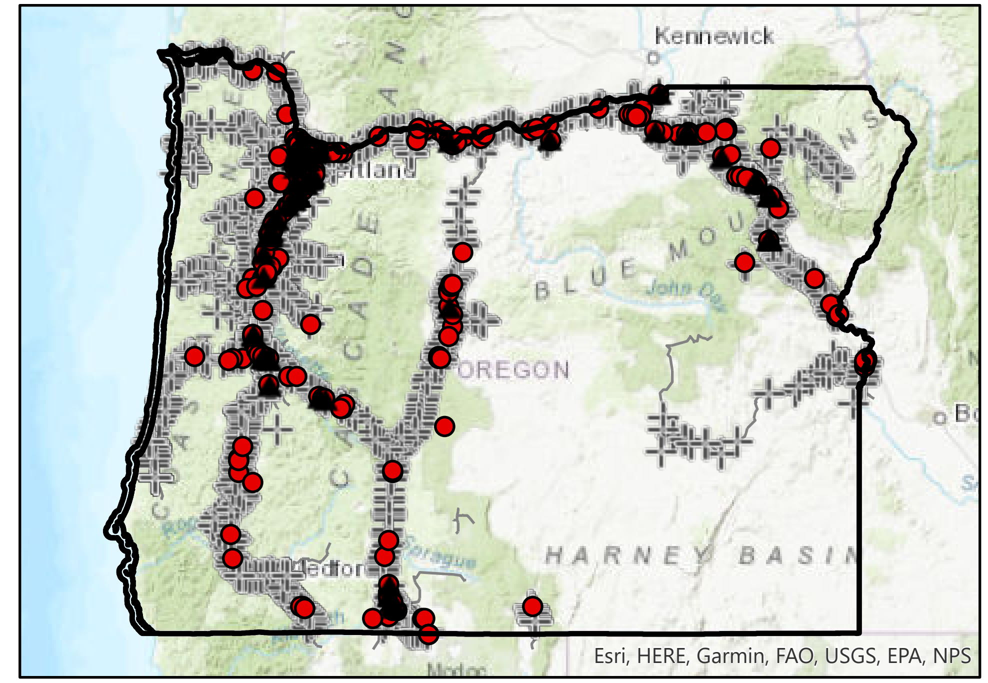
Relationship Between Incidents and Potential Causes



Casualties_type_Person
TYPPERS
A_worker on duty-employee
B_employee not on duty
C_passenger on train
D_nontrespassers-on railroad property
E_trespassers
F_worker on duty-contractor
G_contractor-other
J_nontrespassers-off railroad property
<all other values>

Description:
Involved person type information was included in the incidents data, and the bar chart presented the type of people that involved in the incidents.
The top three type of person will be:
1) Worker on duty- employee
2) Trespassers
3) Non-trespassers- on rail property

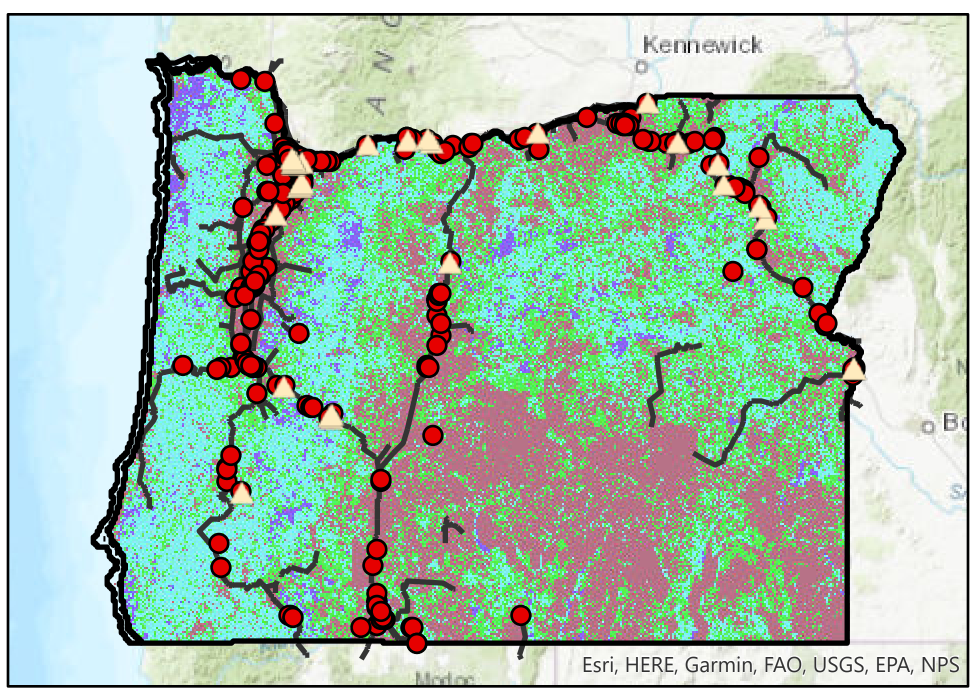
Name of Map: Incidents and Trespassing (Railroad crossing)



or_state_boundary
Casualties_snap
railroads
RC_Casualties
Railroad_Crossing

Description:
This map presented the relationship between incidents and railroad crossing. There was a total of 96 intersect data, which equivalent to 19% of overall incidents, and it is considered as high in this analysis.

Name of Map: Incidents and Landslide

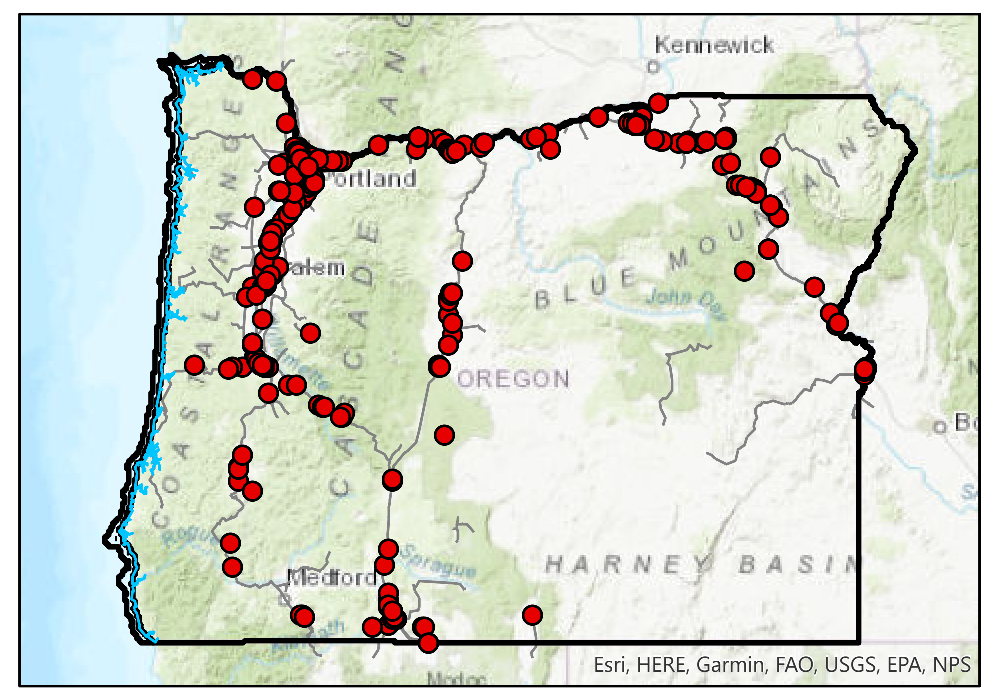


LandS_Casualties
Casualties_snap
or_state_boundary
railroads

Oregon_LS_Susceptibility.tif
Descriptio
Low
Moderate
High
Very High

Description:
The total area in Oregon that contained high or very high landslide susceptibility is 33574 square miles. Result shown in figure 16 calculated 38 incidents cases, equivalent to 7%, that will be related to landslide.

Name of Map: Incidents and Tsunami



Tsunami line
or_state_boundary
Casualties_snap
railroads

Description:
As shown in the map, tsunami is not related to the incidents as the railroad is far away from the coast. However, it might still affect some of the tracks that are closer to the coast.

Map Units: Foot

Spatial Reference
Name: NAD 1983 Oregon Statewide Lambert Feet Intl
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