Assembly Area Selection and Critical Bridge Identification in Coos County, Oregon

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Chapter 1: Baseline Conditions

Recognizing hazards and understanding the spatial characteristics and demography are the first steps when considering assembly area placement and identification of critical bridges in a given area. This chapter will cover background information and provide an overview of the hazards present in Coos County to create a clear picture of the area. It will also identify the baseline metrics used to provide a numerical context to the spatial nature of this study.

Demography and Area Characteristics

Coos County is located on the southern Oregon Coast. In 2017, 63,888 people lived in the county, mostly along the coast in cities like Coos Bay, North Bend, and Bandon. Demographically, 85% of the county identifies as white, with the next largest demographic, Hispanic, contributing 6% of the population. 25% of the population is 65 years of age or older (Demographics, 2019).

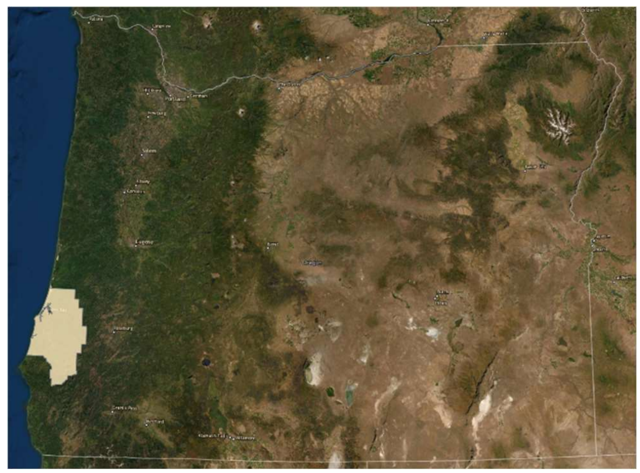

Figure 1: Coos County, Oregon

The economy of Coos Bay is supported by agriculture, forestry, fishing, entertainment, and recreation. Due to the county's location on the coast, an ever-growing tourism industry is becoming an important part of the local economy (Economy, 2019). Because of this, tourist population will be an important factor to consider moving forward in the analysis, especially with respect to messaging and signage.

Hazards and Sensitivity

Being located on the Oregon Coast, Coos County is subject to a number of hazards including coastal erosion, earthquake, flood, landslide, tsunami, and wildfire. This study will consider earthquake, liquefaction, tsunami, flood, and landslide. The spatial extent of these hazards in Coos County is shown in Figure 2. These hazards have the largest impact on bridge infrastructure and necessitate assembly areas for distribution of supplies, medical attention, and information. The earthquake, tsunami, landslide, and liquefaction hazard risk used in this analysis was created as part of Open-File Report O-13-06 by the Oregon Department of Geology and Mineral Industries (DOGAMI). The report models a magnitude (M) 9.0 Cascadia earthquake and its associated impacts. Flood risk is based on Oregon 100-year floodplains complied by the Oregon Department of Land Conservation and Development.

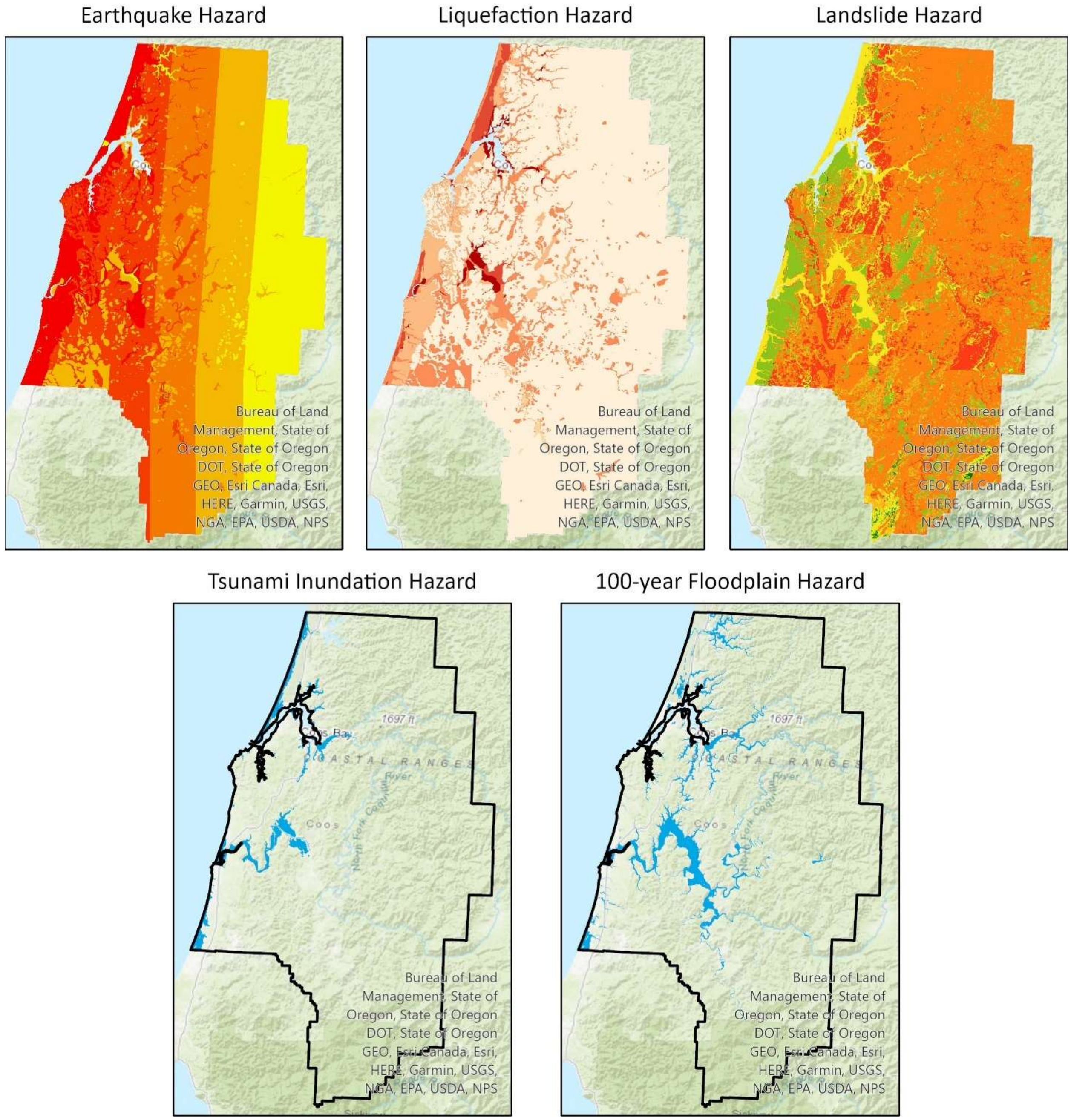

Figure 2: Maps showing the extent and severity of the hazards in Coos County

As shown in Figure 3, the majority of the population lives on the western edge of the county, along the coast. This exposes the local population to the complete array of major hazards in the county, whereas the smaller inland populations are threatened primarily by earthquakes, flooding, landslide, and liquefaction. The coastal population also includes the vast majority of the tourist population, meaning that these areas will need to be targeted with increased signage and messaging in order to inform non-permanent residents and tourist population of the hazards present in the area. Studies show that minority and 65+ populations are most at risk and least adaptable to hazards (Flanagan et al, 2011). While this study does not specifically address minority and 65+ populations, addressing their needs is nonetheless an important consideration. Figure 3 displays a high Social Vulnerability Index (SVI) map incorporating minority and 65+ status in order to create a comparison of population distribution. SVI was calculated using the methods outlined in A Social Vulnerability Index for Disaster Management by Flanagan et al.

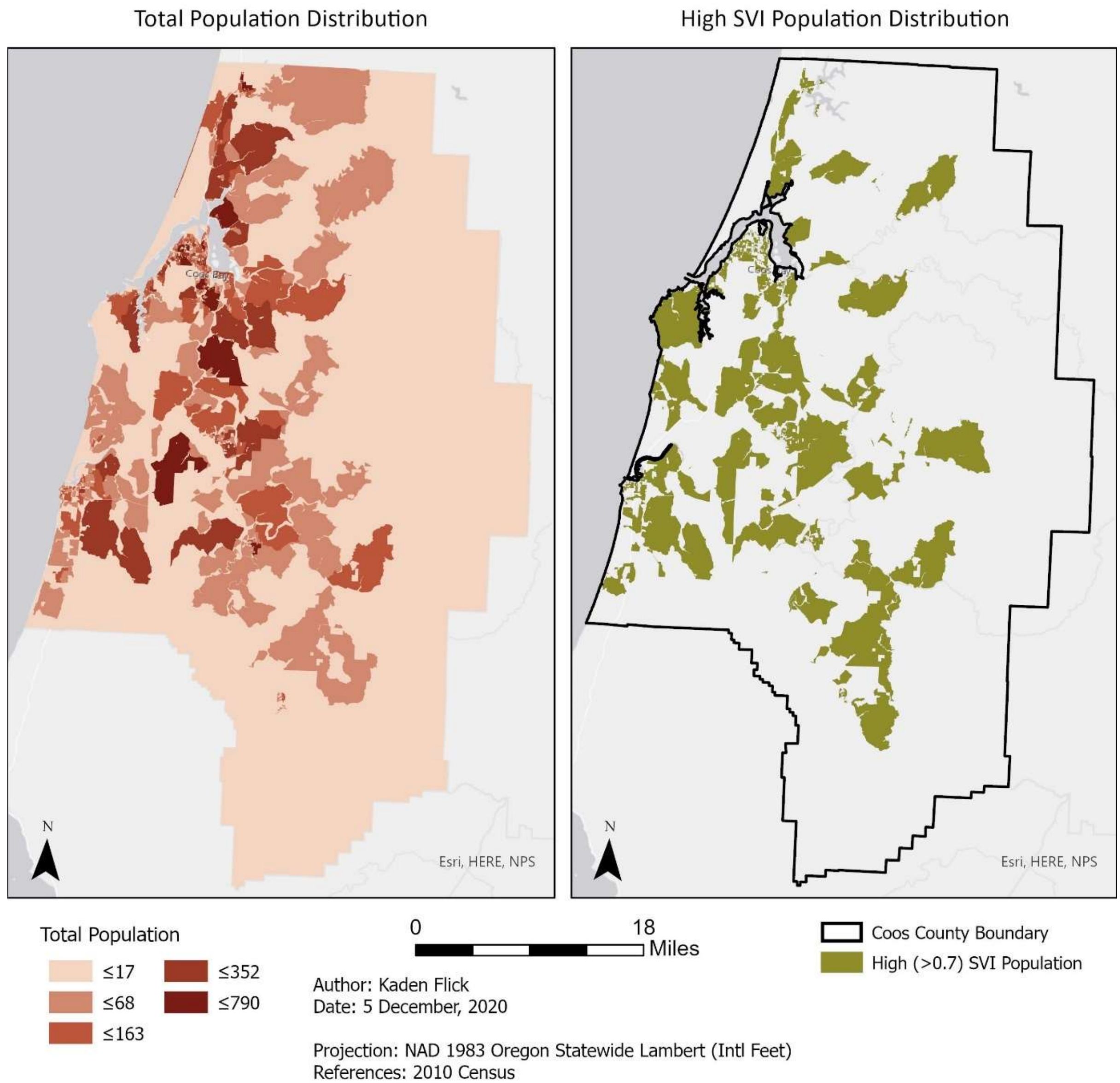

Figure 3: Block level maps of Total Population on the left and High SVI Population on the right

Adaptive Capacity and Baseline Metrics

Coos County has a high degree of adaptive capacity with respect to the hazards identified earlier in this study. Except for earthquake and liquefaction hazards, much of the population and infrastructure in Coos County is outside of significant hazard zones. Coos County also has a hazard mitigation plan (HMP) that identifies the hazards present in the county and outlines next steps for each participating city (Murphy et al., 2017). The document was published in 2017 and shows that various degrees of action have been taken around the county, but we were unable to find information pertaining to whether those steps were achieved, or a new plan drafted. Some critical bridges and assembly areas have also been identified as part of a DOMGI publication of tsunami evacuation maps for the Oregon Coast (Madin, 2013).

In order to numerically represent the spatial aspects of this analysis and address some shortcomings of the existing HMP, we propose three baseline metrics. They are:

- Number of parcels within 30-minute walking distance of an established assembly area.
- Estimated total population within 30-minute walking distance of an established assembly area.
- Number of critical bridges within earthquake, liquefaction, landslide, tsunami, and floodplain hazard areas.

Parcel level data is the smallest available form of applicable spatial boundaries and provides the highest degree of granularity for dividing populated space. As such, number of parcels was selected in order to most accurately measure the reach of establish assembly areas. However, parcel data does not include population data, which eliminates the human aspect of an assembly area's reach. To remedy this, total population was selected to represent the number of people within an assembly area's reach. The smallest scale population data publicly available is Census Block level data. While less precise, we can estimate the total population within an assembly area's reach. A 30-minute walking distance from an assembly area was chosen as a reasonable cutoff in order to define the reach of an assembly area.

The number of critical bridges within various hazard zones was chosen as the third metric in order to represent the total number of critical bridges threatened by a specific hazard. This metric allows us to track what hazards we are addressing based on how each metric changes when a bridge is retrofitted versus when it has not been retrofitted. The table below shows the baseline data for each of the three proposed metrics.

Figure 4: Baseline for the three proposed metrics

Threatended Critical Bridges		Assmebly Area Population	Assembly Area Parcels
Hazard	Count		
Earthquake	112	39,277	20,502
Landslide	14		
Liquefaction	17		
Floodplain	55		
Tsunami	26		

Summary

In this chapter, we provided background information for Coos County including demography, significant hazards, and sensitivity to those hazards. We identified the adaptive capacity of Coos County to respond to the identified hazards and developed baseline metrics for quantifying some shortcomings moving forward in the study. Coos County is well situated to respond to many of the most severe hazards that it faces. It has a comprehensive HMP and appears to be implementing some of the steps outlined in it. There are some areas that can be improved, however. Accounting for these shortcomings is what this study aims to achieve.

Coos County has already identified the most significant hazards for the whole of the county (Murphy et al., 2017) and has identified the critical bridges and designated some assembly areas in the western portion of the county threatened by local tsunami inundation from a M 9.0 Cascadia earthquake or by inundation from a distant tsunami (Madin, 2013). However, it has not designated assembly areas or identified critical bridges for some of the smaller population centers in the interior of the county, specifically around the cities of Powers, Myrtle Point, or Coquille. This analysis will locate the most critical bridges around those areas and identify additional potential assembly areas in each of those cities using similar criteria. This analysis will also recommend additional measures that could be taken to improve the function of both new and existing assembly areas.

Chapter 2: Goals and Methods

Before proceeding with any analysis, it is important to lay out the goals for the project, as well as define the methods used to attain those goals. In this chapter, we define the goals that guide this study, and provide the conceptual models used to reach each goal and policy objective. Included is a narrative of the conceptual models, as well as a discussion about the sources and limitations of the data.

Goals:

Goal 1 – Identify additional assembly areas in the major population centers of the county not covered in previous analyses that service the most amount of people within a 30-minute walking distance of the assembly area.

Goal 2 – Identify additional critical bridges in areas of the county not covered by previous analyses that are under threat of the major hazards in the county.

Policy Objectives:

Policy Objective 1 – Generate recommendations for signage and infrastructure at each assembly area throughout the county in order the make an assembly area easier to locate and more effective as a distribution center for supplies, medical help, and information.

Policy Objective 2 – Recommend replacement or seismic retrofit of critical bridges in the county in order to open each bridge for evacuation and emergency personnel in the event of a disaster that cripples an area's ability to respond.

These goals and policy objectives will both guide our research and help create communities and a county that are more prepared for and resilient to the hazards that they face. Identifying additional assembly areas will provide locations for a greater number of county residents to get supplies, medical help, and information in the aftermath of a disaster. Identifying critical bridges will help evacuees and emergency personnel to plan safe and effective routes in and out of the county, allowing for increased mobility and awareness of potential hazards and blockages on the roads.

Methods for Goal 1 and Policy Objective 1:

The first step in identifying appropriate parcels for additional assembly areas in the larger population centers in the middle of the county was to create spatial layers that represented the extent and severity of the hazards present in the area. To do this, we used data from the DOGAMI Open File Report O-13-6 that includes Oregon statewide data on earthquake, liquefaction, and landslide risk for a M 9.0 Cascadia event. We used M 9.0 Cascadia event tsunami inundation data also complied by DOGAMI for tsunami inundation risk. Finally, we used

100-year floodplain data compiled by the Oregon Department of Land Conservation and Development to represent our landslide risk. While this study has not independently confirmed this data, we will rely upon the knowledge and expertise of those at the State who created and compiled this data. The Coos County Boundary layer is selected from the Oregon Counties – 2000 layer complied by the Oregon State University Rural Studies Program.

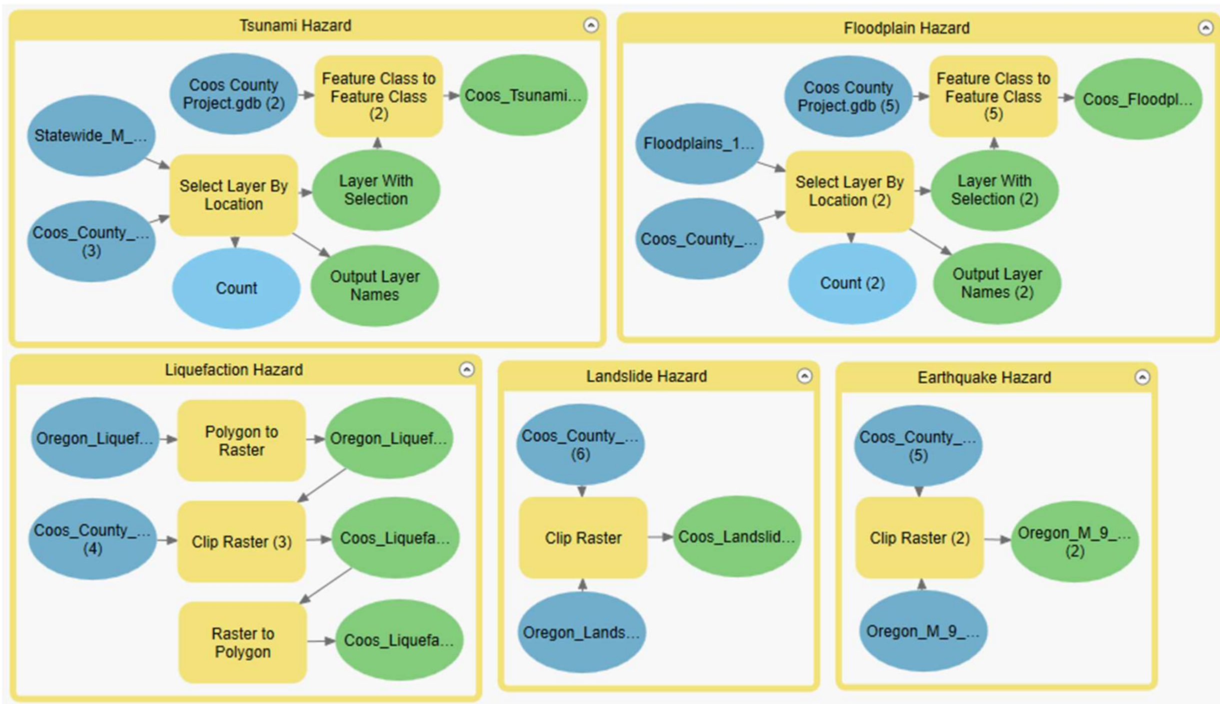

Figure 5: Conceptual Model for identifying hazards in Goal 1

The above conceptual model is an outline of how the extents and severity of hazards in the county were identified. Each group is a hazard, and the ovals and rectangles represent data and geoprocessing tools, respectively. The following segments are a narrative version of the above model to provide clarity.

Tsunami and Floodplain Hazards – Starting with statewide polygons and a Coos County Boundary layer, the Select Layer by Location operation was used to select only those polygons within the extent of the Coos County Boundary layer. The resulting polygons were then exported to a new feature class, creating a new polygon layer to represent those hazards within the county boundary.

Liquefaction Hazard – Starting with statewide polygons, the Polygon to Raster tool was used to create a statewide raster layer. The resulting raster was then clipped to the extent of the Coos County Boundary Layer using the Clip Raster tool and converted back to a polygon using the Raster to Polygon tool, creating a new polygon layer representing the liquefaction hazard for the county.

Landslide and Earthquake Hazards – Starting with statewide raster layers, each raster was clipped to the extent of the Coos County Boundary Layer, creating new raster layers that represent the landslide and earthquake hazards for the county.

The second step in identifying appropriate parcels is to identify the parcels themselves. With the previous conceptual model, we identified the extent and severity of the hazards within the county in order to select on those parcels outside of the more hazardous areas. In the following model, we used this data in addition to parcel data and 2018 urban growth boundaries compiled by the Oregon Department of Land Conservation and Development. The earthquake data was excluded from the analysis because the overwhelming majority of the county is under severe threat of earthquake damage. Assembly area selection prioritized well known areas with open spaces, regardless of the structure on the parcel. Church and school parcels were selected in order to be consistent with the parcels selected in the DOGAMI tsunami inundation evacuation study.

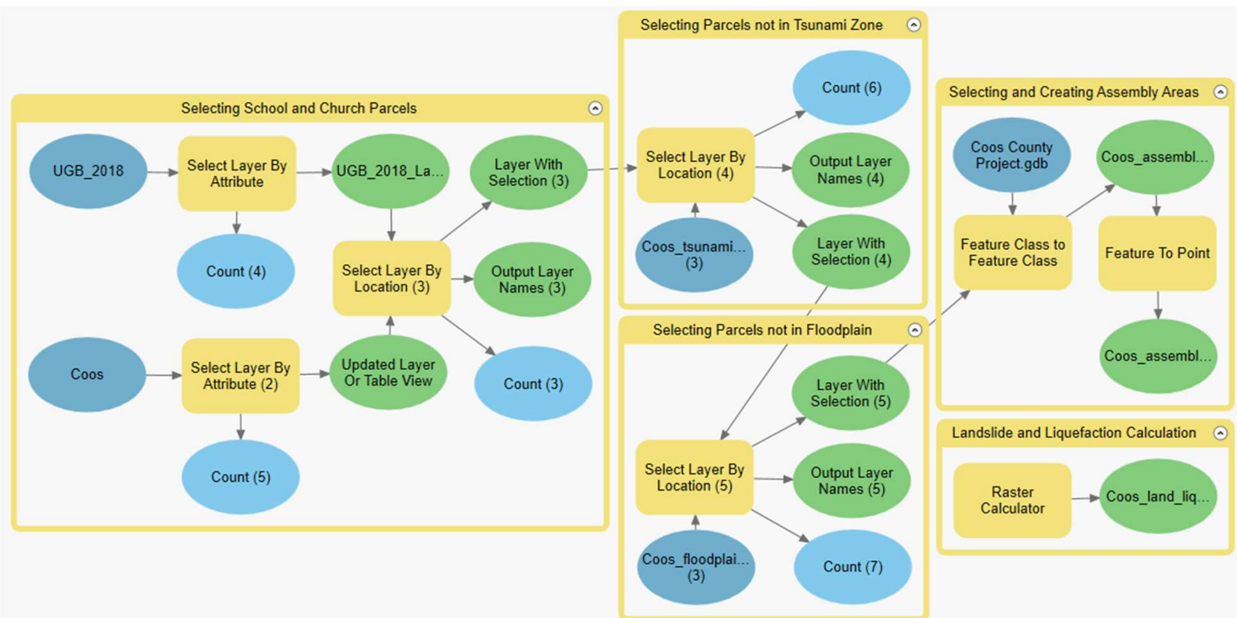

Figure 6: Conceptual Model for identifying parcels in Goal 1

The above conceptual model is an outline of the methods used to identify potential parcels that could be used as assembly areas. In the model, each group represents a step in the selection process, and each oval and rectangle represent data and geoprocessing tools, respectively. The following segments are a narrative version of the above model to provide clarity.

Selecting School and Church Parcels – Urban growth boundaries for Coquille, Myrtle Point, and Powers were selected from the urban growth boundary layer using the Select Layer By Attribute tool. School and religious parcels were selected from the Coos County Parcels layer also using the Select Layer By Attribute tool. School and religious parcels were selected from within the urban growth boundaries previously identified using the Select Layer by Location Tool.

Selecting Parcels not in Floodplain or Tsunami Zones – An inverted Select Layer By Location tool was used to select only those parcels identified previously that were not in a tsunami zone. The same tool was then used to narrow the selected parcels even further by identifying only those parcels not in a floodplain.

Landslide and Liquefaction Calculation – The landslide and liquefaction rasters were added together in order to create a single raster that displayed both hazards together and to make the selection process more streamline. This was done by multiplying the landslide raster by 10 and adding the liquefaction raster. This created a single raster that with a 2 to 3-digit value code. The first digit (or two digits in the case of class 10 areas) represented the landslide risk, and the last digit represented the liquefaction risk.

Selecting and Creating Assembly Areas – The parcels outside of hazard areas selected earlier were turned into their own feature layer by using the Feature Class To Feature Class tool. The handful of parcels was then overlaid on top of the combined landslide-liquefaction layer created earlier in order to gauge the suitability of each area. Using only those parcels that were in areas with the lowest risk of landslide and liquefaction, two parcels each were hand selected as assembly areas in both Powers and Myrtle Point. Three parcels were selected in Coquille to account for its larger population. The selected parcels were then turned into points that represent their locations using the Feature To Point tool.

Methods for Goal 2 and Policy Objective 2:

In order to find additional critical bridges in the county, we used critical bridge data compiled by DOGAMI as part of their M 9.0 Cascadia tsunami inundation evacuation plan. In order to find additional critical bridges in the county, we used 2020 bridge data compiled by the Oregon Department of Transportation. We overlayed current critical bridges data on top of the 2020 bridge data we obtained and compared the two in order to locate bridges that would be critical to connecting the larger communities in the county. While we did not independently confirm the accuracy of the data, we will rely upon the expertise and experience of those at the State who compiled this data.

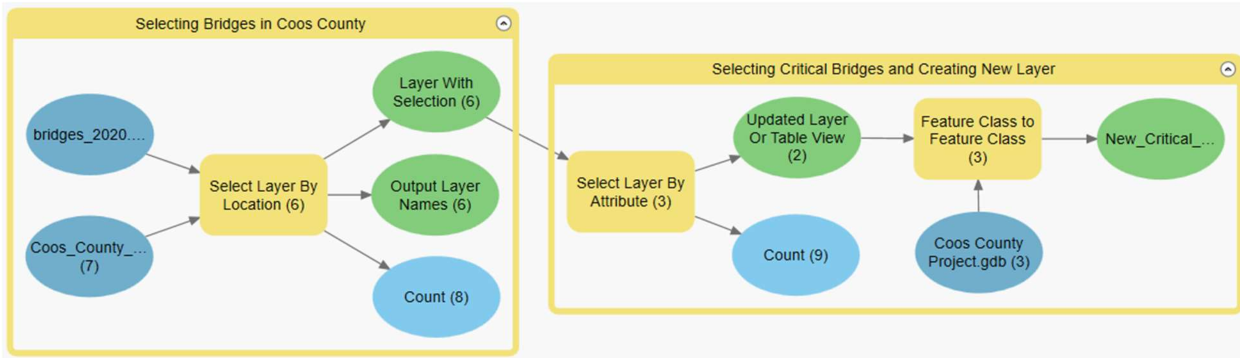

Figure 7: Conceptual Model for Goal 2

The above conceptual model details the methods used to identify additional critical bridges. In the model, each group represents a step in identifying additional critical bridges. As the with the previous models, ovals represent data layers and rectangles represent geoprocessing tools. The following is a narrative version of the above model to provide clarity.

Selecting Bridges in Coos County – The Select Layer By Location tool was used to find bridges within the Coos County Boundary.

Selecting Critical Bridges and Creating New Layer – New critical bridges were hand selected in order to connect the smaller inland communities. Prior identification covered all of the coastal bridges and a large proportion of the inland bridges, so we selected bridges that would connect the cities of Powers and Myrtle Point to the areas already covered. These bridges were all along a single highway connecting the communities.

Chapter 3: Results

This chapter discusses the results of the analysis and presents a map of existing assembly areas, new assembly areas, previously identified critical bridges, and newly identified critical bridges. It will also detail two new metrics to measure the cost and benefit of each policy objective, including a narrative to provide context for the new metrics. The maps below show the locations of critical bridges and assembly areas in the county, both new and existing.

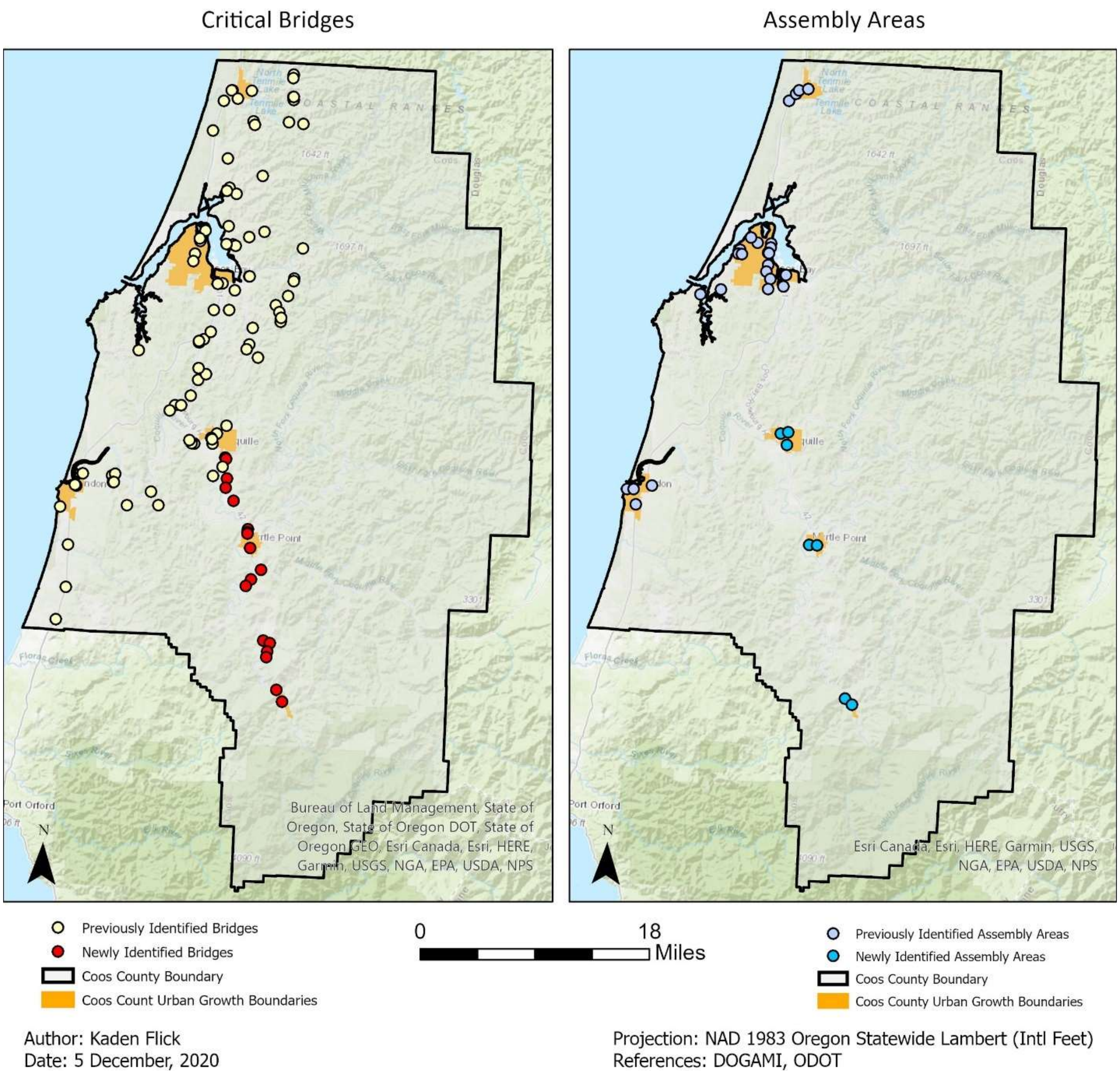

Figure 8: Maps of existing and previously identified assembly areas and critical bridges

Policy Objective 1

Figure 9: Table showing the results of Policy Objective 1, including cost and benefits

	Threatended Critical Bridges Hazard	Count	Assmebly Area Population	Assembly Area Parcels	Cost	Benefit
Baseline	Earthquake	112	39,277	20,502	$0	--
	Landslide	14				
	Liquefaction	17				
	Floodplain	55				
	Tsunami	26				
Assembly Area Increase	Earthquake	112	47,764	24,649	$112,000	Increased ability of population to gather and receive supplies, information, and medical help.
	Landslide	14				
	Liquefaction	17				
	Floodplain	55				
	Tsunami	26				

The above table shows the change in the two metrics measuring the impact of the additional assembly areas in the county. Our analysis shows a parcel coverage gain of 4,147 parcels and an estimated coverage area population increase of 8,487 people. The two additional metrics for this policy objective measure the cost and benefit of adding wind and water-tight containers filled with supplies to each of the new and existing assembly areas in order to make them more effective centers to distribute supplies, information, and medical help to those in need in the event of a disaster. In their analysis, DOGAMI notes that assembly areas are not meant to serve as distribution centers for disaster supplies long term. As such, the contents of the containers are meant only to house short-term necessities such as shelter, basic medical supplies, and a short-term supply of food and water for the impacted population.

Estimated cost was determined based on the average cost of a used water and wind-tight 20-foot shipping container from a container wholesaler, priced at $1,500, and a budget of $2,000 for the contents of each container, including food, water, shelter, and medical supplies. Prices were calculated based on consumer rates, so the cost of outfitting all 32 assembly areas could reasonably be expected to go down based on the bulk-buying of supplies and county purchasing power and ability to negotiate. Benefits were determined by evaluating the value of having acted. While it is difficult to place a dollar value on the benefits of the proposed policy objective, the non-monetary benefits are numerous, including an increased ability for a community to be self-sufficient for longer, allowing additional time for first responders and emergency personnel to respond to the most severely damaged areas first, without also having to worry about those less impacted by a disaster for a longer period of time.

Supply caches might not be necessary for coastal communities that are in closer proximity to more robust emergency services. However, inland communities would be harder to reach in the event of a disaster and would be required to be self-sufficient for longer periods of time. If supply caches were not established in coastal communities, estimated cost could be reduced significantly. This analysis estimates cost for creating supply caches throughout the county in order to provide the most flexibility.

Policy Objective 2

Figure 10: Table showing the results of Policy Objective 2, including cost and benefits

	Threatended Critical Bridges Hazard	Count	Assmebly Area Population	Assembly Area Parcels	Cost	Benefit
Baseline	Earthquake	112	39,277	20,502	$0	--
	Landslide	14				
	Liquefaction	17				
	Floodplain	55				
	Tsunami	26				
Fixed Bridges	Earthquake	0	39,277	20,502	$26,000,000	Increased ability for population to evacute and increase access for emmergency personnel.
	Landslide	14				
	Liquefaction	0				
	Floodplain	55				
	Tsunami	26				

The above table shows the change in the metrics measuring the impact of replacing or retrofitting critical bridges in the county. Our analysis shows that retrofitting or replacing all of the critical bridges in the county will result in a reduction of 112 bridges threatened by earthquake and a reduction of 17 bridges threatened by liquefaction. We do not see a change in the number of critical bridges threatened by the remaining hazards because the bridge replacement or retrofit methods used in this study are not designed to address those hazards. In the case of tsunami inundation or flood damage, bridges could be evaluated on a case-by-case basis to determine road surface height above ground and whether or not a road surface would be covered by water and debris in the event of a disaster. That analysis is outside the scope of the study. Evaluating the landslide hazard for each bridge is also outside the scope of this study and would require a case-by-case study of each bridge's type and surrounding slope characteristics. While seismic retrofits might reduce landslide hazard in some cases, in others it might not.

Cost was estimated based on an Oregon Department of Transportation (ODOT) statewide seismic retrofit benefit report. The total square-footage of deck height was calculated for both new and existing critical bridges in the county. Using the equations developed in the ODOT report, we calculated an estimated total cost for both replacement and retrofit of the critical bridges. The number reported in the table above is the estimated cost of retrofitting the critical bridges in the county. The cost of completely replacing all the bridges was in the hundreds of millions of dollars. Getting the true cost for replacing or retrofitting the bridges would take a far more detailed analysis than was within the scope of this project. Benefits were determined by considering the benefits of increased access to and from an area in the event of a disaster. While it is again difficult to estimate a dollar value of replacing critical bridges, the non-monetary benefits are significant, allowing both evacuees and emergency personnel to have significantly increased access to areas impacted by a disaster than they would otherwise. This would significantly increase the time to rebuild and reduce the cost of transportation without having to rely on expensive transportation methods like helicopters or airplanes.

Chapter 4: Recommendations

This chapter will provide recommendations for community and county decision makers. It will also provide a list of potential indicators that could be used to measure progress towards achieving the goals and policy objectives developed in this analysis, as well as a summary that bookends the project, discussing the key findings and next steps for the communities in this report.

Baseline Metrics Summary

Figure 11: Table showing all results from policy objectives, including cost and benefit metrics

	Threatended Critical Bridges		Assmebly Area Population	Assembly Area Parcels	Cost	Benefit
	Hazard	Count				
Baseline	Earthquake	112	39,277	20,502	$0	--
	Landslide	14				
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	Floodplain	55				
	Tsunami	26				
Assembly Area Increase	Earthquake	112	47,764	24,649	$112,000	Increased ability of population to gather and receive supplies, information, and medical help.
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Fixed Bridges	Earthquake	0	39,277	20,502	$26,000,000	Increased ability for population to evacute and increase access for emmergency personnel.
	Landslide	14				
	Liquefaction	0				
	Floodplain	55				
	Tsunami	26				

The above table is a summary of Figures 8 and 9. It shows baseline metrics for each of the three-original metrics, as well as cost and benefit metrics for each of the policy objectives. The table compares the number of critical bridges in each of the five hazard zones with and without seismic retrofits and includes the estimated cost and potential benefits of each approach. The table does the same for additional assembly areas inland, comparing parcel and estimated population service between the original locations and the proposed additional locations. For additional parcels, the cost metric estimates the cost of adding shipping containers full of supplies to each assembly area in the county. The benefit metric aims to define some of the benefits of adding additional assembly areas and equipping them with supplies.

Recommendations

We have developed several recommendations for how Coos County could increase the preparedness and accessibility of the county in the event of a disaster. Our recommendations align closely with the stated policy objectives used in this project and take into account the budget realities of many communities.

In order to reach the maximum amount of people in the county in the event of a disaster, we propose creating seven new assembly areas in the interior of the county; two each in Myrtle

Point and Powers, and three in Coquille to address its larger population. Additionally, we recommend the installation of shipping containers at each of the assembly areas in the county, both existing and proposed, in order to cache supplies to provide immediate medical support, food, water, and shelter. These assembly areas would also be sources of information to the residents of these communities. While we selected locations for additional assembly areas in this study, the final locations of assembly areas in the county should be left up to community members in order determine the most effective and well-known locations in individual communities.

Alternatively, supply caches could be installed only in the interior communities that are further away and harder to get to than the coastal communities. This would still provide support for the inland communities that might be isolated for a longer period of time in the event of a disaster but could potentially limit the preparedness of residents in coastal communities that might not have prepared individually. However, it would be a cheaper alternative. In order to access these containers in the event of a disaster, we propose distributing keys to community leaders, increasing the number of people who have access to the caches in order to guarantee community access to the supplies.

To increase road access to evacuees and emergency personnel throughout the county, we recommend the seismic retrofit of the critical bridges identified in this study. Ensuring that these bridges are passable in the event of a large-scale disaster would allow short routes for evacuees and faster response times from emergency personnel. Recognizing that budgets might not allow the large scale retrofit of all bridges in the county, we also recommend additional analysis to determine the bridges that would have the most impact on community access if they were retrofitted or replaced. Regardless, additional bridges would speed recovery times and allow for less expensive methods of transportation to be used to transport people and supplies across the county in the event of a disaster.

Progress Indicators

In order to track progress on the above recommendations, we have developed a series of indicators. These indicators can be used by the county in order to quantify progress, or the lack thereof, towards achieving these goals. They are:

- The number of additional assembly areas officially created and communicated to the residents of the communities they are located in. This could be measured by polling the members of a community to see whether or not they know where their closest assembly area is.
- The number caches installed at assembly areas throughout the county. This number could be compared to the number of assembly areas selected to receive supply caches to determine progress.

- The number of critical bridges retrofitted in the county. Similar to the above indicator, this could be measured by comparing the number of retrofitted bridges to the number of bridges selected for retrofit.

Conclusion

This report examined the adaptive capacity of Coos County and identified areas two areas that could be improved. Our analysis showed that many residents in the county did not have a designated assembly area near them and that a large number of vulnerable critical bridges prevented access to large portion of the county should they become impassable or destroyed. We recommended that Coos County create additional assembly areas in the interior communities of the county, and that all assembly areas in the county receive supply caches in the form of wind and water-tight shipping containers. We also recommended that Coos County replace or retrofit critical bridges in the county in order to expand access to the county in the event of a disaster. Next steps following this report should include additional analysis to identify the critical bridges in the county that would have the most impact if replaced or retrofitted, community meetings to determine locations of new assembly areas, and the selection of assembly areas to receive supply caches.

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