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Sea-Level Rise & Landslide Risk in Humboldt & Del Norte County Coastal Zones

Abstract

Sea-level rise and landslides pose particular risks to the California North Coast due to the region's distinctive tectonics and intensifying conditions related to anthropogenic climate change. Identifying areas of particular concern for intersecting natural hazards is the first step to taking appropriate actions against such risks. We hope these map layouts can give a display for the vulnerable areas throughout Humboldt and Del Norte Counties and for agencies to consider these coastal factors in any future renovations.

Introduction

Sea levels rising at increasing rates due to climate change and rising average global temperatures are a concern for all coastal communities, and the California North Coast (Fig. 1) is no exception. Since the North Coast already receives the most annual rainfall in the state, if climate change also results in more frequent and intense "extreme precipitation events" as suggested by several studies, flooding and landslide events in the region will also increase in frequency and intensity (Grantham 2018).

Figure 1. The California North Coast: Humboldt County (south) and Del Norte County (north) highlighted

Sea-level rise and landslide frequency are fundamentally interrelated issues on California's geologically active North Coast. The North Coast experiences sea-level rise at an annual rate of 40% on average, compared to "the global average rate of 6% per year," due to its unique regional tectonic instability (Grantham 2018).

Unstable geology contributes to frequent landslides inland, triggered especially by storm events (Grantham 2018). Erosion along coastlines is caused by a combination of sea-level rise and storm events, which consequently increases the risk of flooding lowlands which were previously protected by dunes, bluffs, and dikes (Grantham 2018). The intensifying effects of climate change on the natural hazards of landslides and sea-level rise definitely pose a threat to human settlement and infrastructure, but the specific timing and impacts are still uncertain.

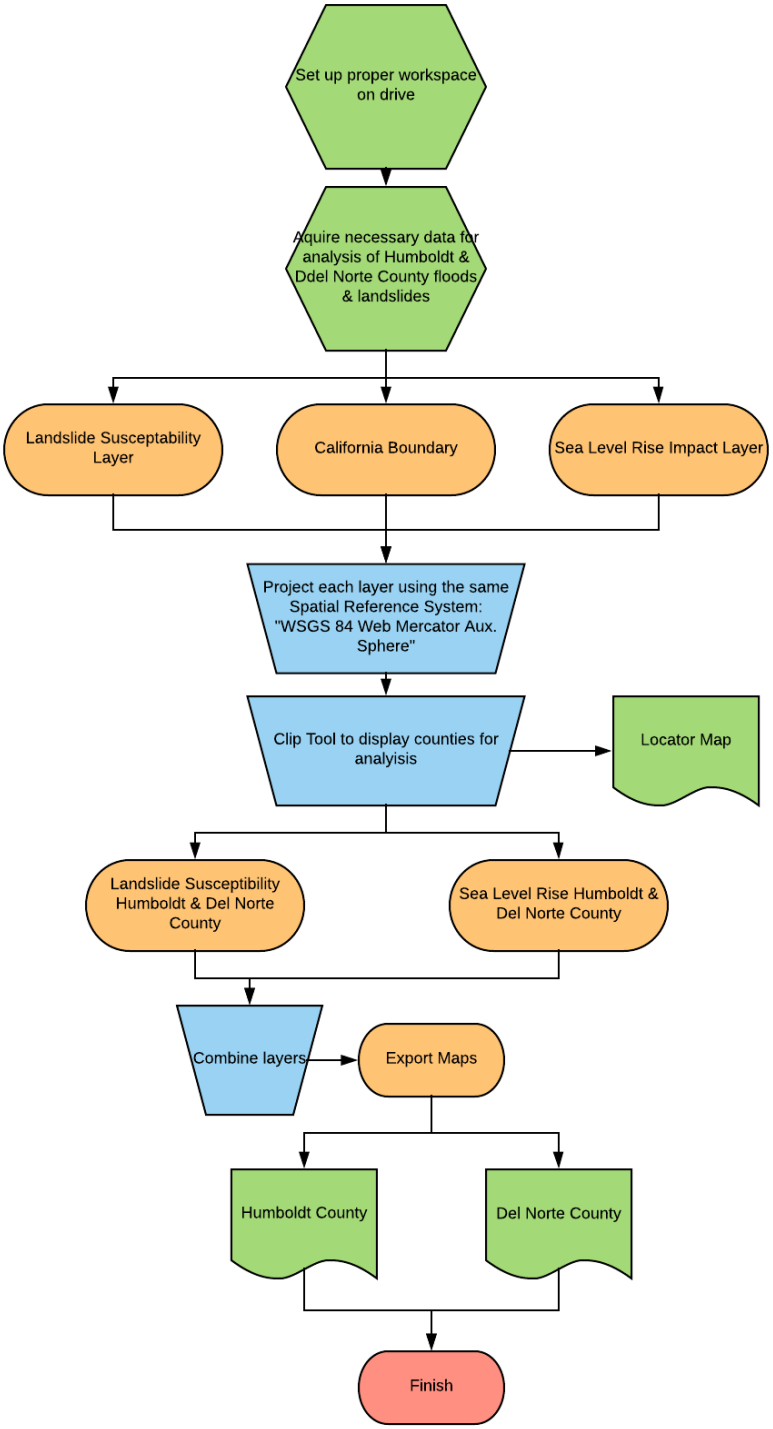
Numerous government agencies are evaluating and preparing for sea-level rise and landslide risk on the California Coast, and this project aims to contribute to this body of work. Our goal is to identify sites along the coast of Humboldt and Del Norte Counties where the intersection of sea-level rise potential and landslide risk suggests a particular hazard. The importance of this work cannot be understated; sea-level rise and landslide erosion threaten coastal communities, agricultural land, habitat, critical infrastructure, and transportation corridors (Grantham 2018).

Identifying areas of concern is the first step to taking action on such intensifying but uncertain natural hazards because such data informs local "land use planning" and development of "adaptation strategies" (Grantham 2018). The California State Lands Commission emphasizes that "it is important to identify what properties, infrastructures, or services are at risk as soon as appropriate vulnerability data and maps are available" (Laird 2014).

Methods

We first gathered data: for United States sea-level rise from the NOAA Office for Coastal Management, for landslide susceptibility in the United States from the U.S. Geological Survey, and for California county and state boundaries from the U.S. Census Bureau. Then we exported the data for Humboldt and Del Norte County to a new shapefile to clip the rest of the data to this region. Next we projected each layer into the same spatial reference system: WGS 1984 Web Mercator. Then we clipped the sea level rise and landslide susceptibility layers to the geographic extent of Humboldt and Del Norte Counties. Overlaying the two layers highlighted coastal zones at particular risk of landslides and sea-level rise in Humboldt and Del Norte Counties.

Figure 2. Project Flow Chart



Results

Below is a series of maps that we created in order to show the landslide susceptibility as well as previous incidences of landslides. The maps also include data that displays zones susceptible to sea level rise at a 55” rise along with areas that would experience severe erosion along the coastline. Our maps display this data describe to the extent of Humboldt County as well as Del Norte County. With the data that we mapped we are looking to analyze the regions that would be most susceptible to flooding and erosion when there is a 55” sea level rise. The severity of landslide probability is marked by a color gradient. A darker blue is low incidents and a light blue is a high incidence. Also violet shows are with High Susceptibility with low incidents. The areas that would be affected by sea level rise are marked in pink. These areas reach from about northwest Ferndale to Northern Del Norte County. Areas more south have had low incidences but are very susceptible to a landslide. This area is also predicted to be greatly affected by rising sea levels. Areas more north are more at risk for landslides but are not as affected by ocean rise. We hope these results show the risk of landslide areas along the coast in relation to Sea Level Rise.

Figure 3. Below is a map of landslide susceptibility and incidence along with 55" sea level rise flood and erosion data. Also included is an inset map to take the place of a locator map showing where exactly Del Norte and Humboldt County are located in California.

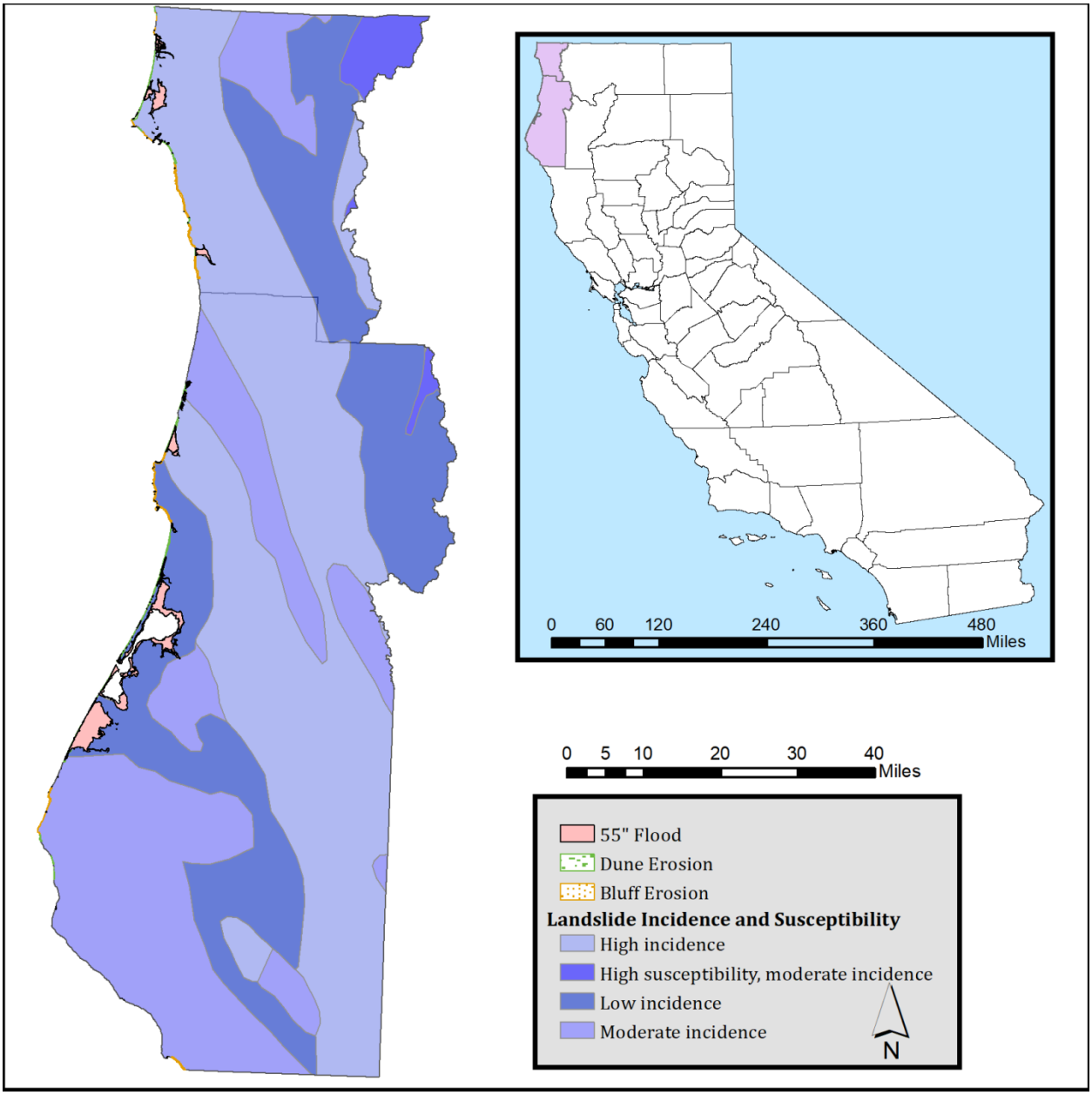


Figure 4. Below is a map of Crescent City and the regions surrounding, displaying the landslide susceptibility and incidence along with 55" sea level rise flood and erosion data of the area.

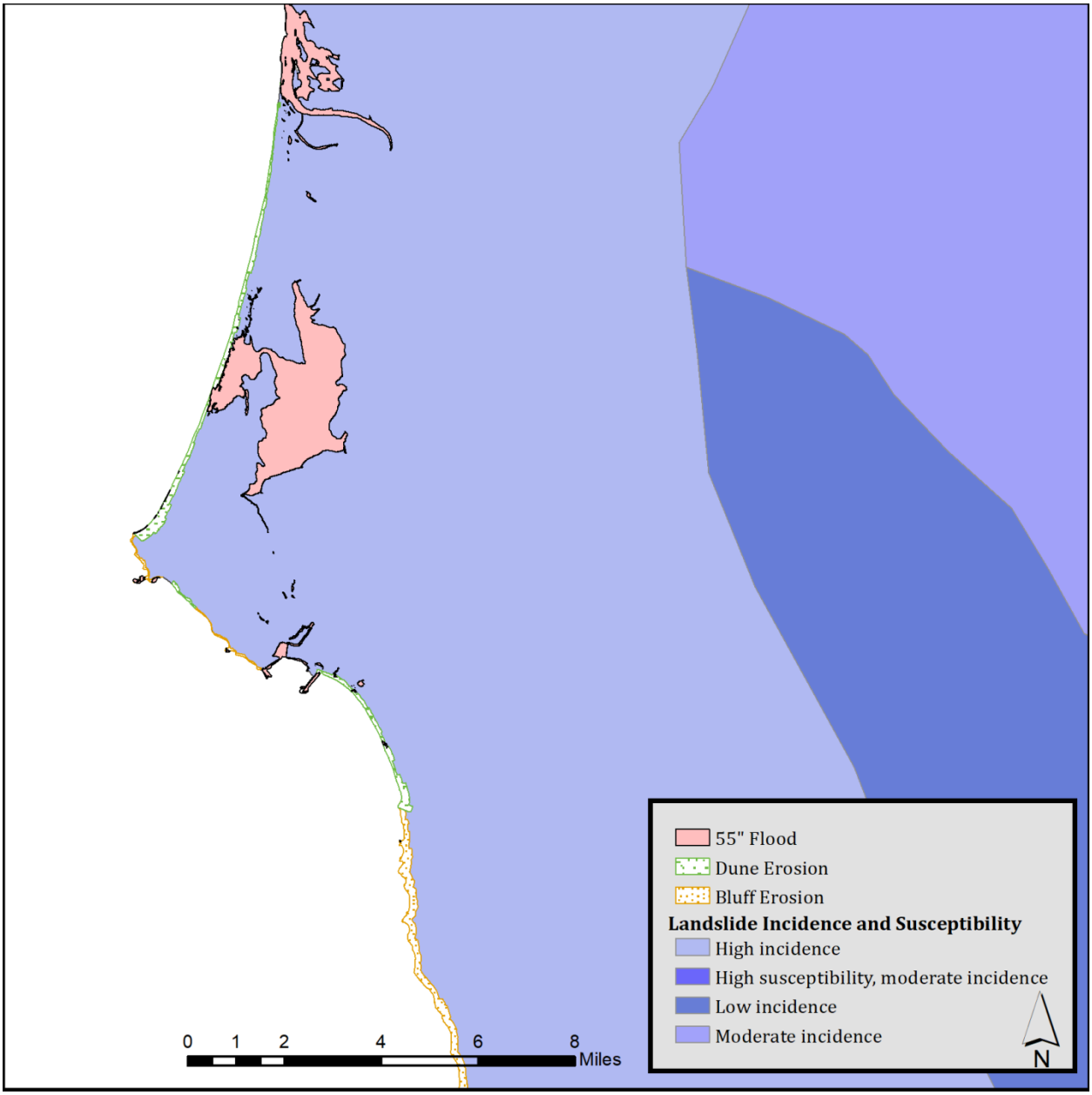
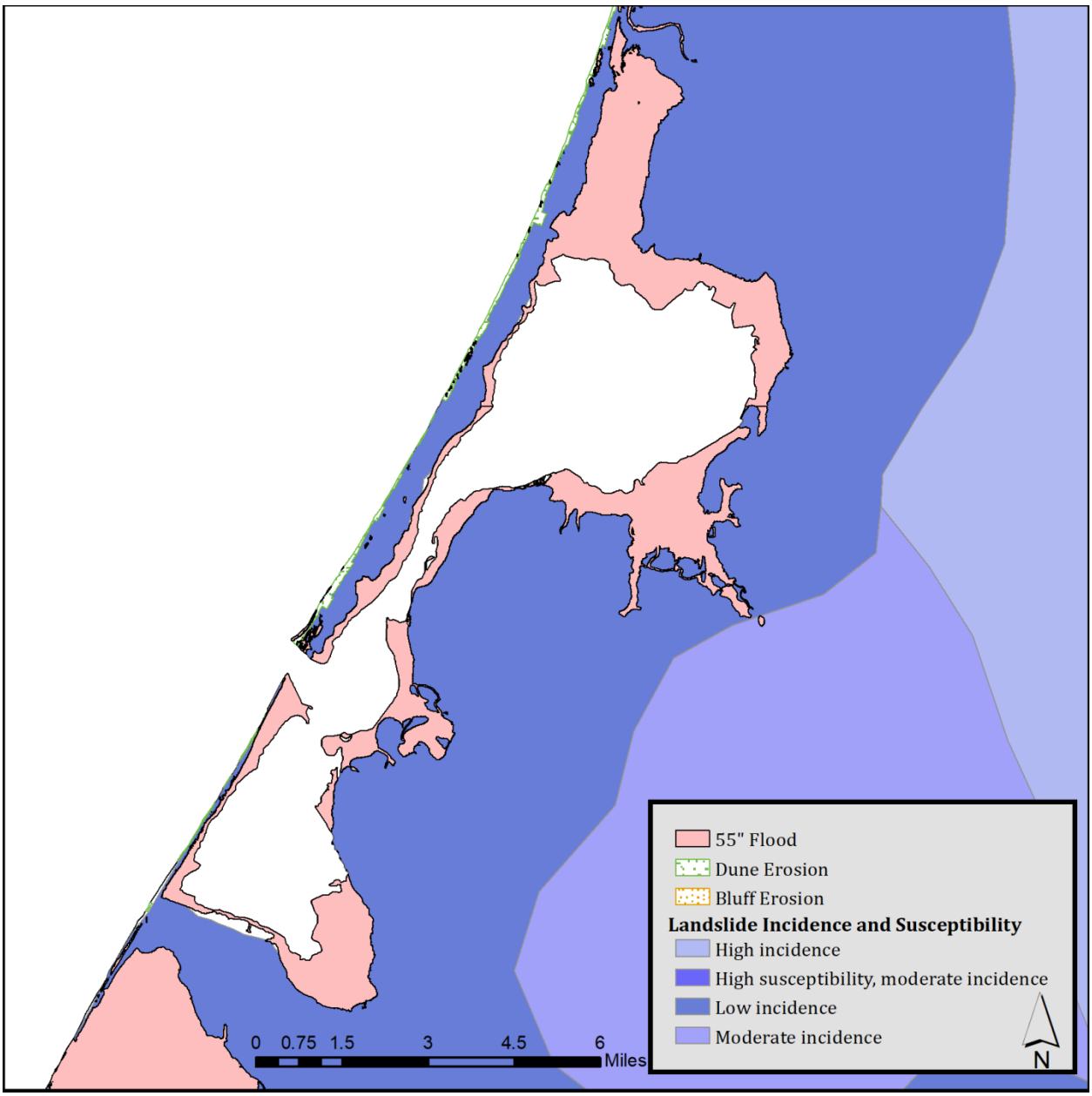


Figure 5. Below is a map of Humboldt Bay, showing the landslide susceptibility and incidence along with 55" sea level rise flood and erosion data.



Conclusion

Living in areas with high amounts of rainfall like Northern California, landslides are a common factor involved with the areas' geography and is necessary to assess when determining any future county projects such as building new infrastructure or creating new roads to reduce traffic on main highways. The factor of rising sea levels influencing coastal landslides is an idea that is frequently overlooked and may cause hazard in areas where the idea is not considered. In this project we collected and displayed the risk of landslides along the coastline of Humboldt and Del Norte county and hope to showcase these regions of susceptibility for future county plannings.

Understanding the threats of sea level rise and landslide susceptibility will potentially give advantage in creating and managing future civilized sites and help the public to be knowledgeable about the common threats of living near the California coastline. The maps created display these areas of coastal inundation and landslide susceptibility being color-coated with a gradient in relation to the rise of sea level at 1.4 meters (55 inches) and the areas susceptible for landslides that may be influenced by a rise in the coastline. Main highways among Humboldt and Del Norte County such as the 101 are constantly threatened towards landslides from local storm events that cause coastal erosion and potential rising sea levels. If a roadway is damaged by a natural landslide, the area would presumably display economic damage in losing the connection or route to communities that people commute to for work or their families. We hope these map layouts help in consideration of these coastal factors for any future renovations to these regions that exist to favor the work and analyzation of projects by the California Department of Transportation in noticing the relative vulnerability of areas throughout the popular highway and others.

Acknowledgments/References

Anderson, Jeffrey K. “Sea-Level Rise in the Humboldt Bay Region.” *Sea Level Rise Initiative*, Northern Hydrology & Engineering, March 2018. Web. Accessed via <http://gsp.humboldt.edu/Websites/SLR/reports/HumBaySeaLevelRise_Update1_Mar2018.pdf>

California Governor’s Office of Emergency Services. “Californica Cascadia Subduction Zone Earthquake and Tsunami Response Plan.” *Federal Emergency Management Agency Region IX*, U.S. Department of Homeland Security, Sept 2013. Web. Accessed via <https://www.caloes.ca.gov/PlanningPreparednessSite/Documents/CascadiaCatastrophicEQConops(Public)_2013.pdf>.

Cascadia Region Earthquake Workgroup. “Cascadia Subduction Interface.” *Cascadia Region Earthquake Workgroup*, n.d. Web. Accessed via <https://crew.org/earthquake-information/cascadia-subduction-interface/>.

Center for Biological Diversity. “Deadly Waters: How Rising Seas Threaten 233 Endangered Species.” *Center for Biological Diversity*, Dec 2013. Web. Accessed via <https://www.biologicaldiversity.org/campaigns/sea-level_rise/pdfs/Sea_Level_Rise_Report_2013_web.pdf>.

Humboldt County. “GIS Data Download.” *Humboldt County Planning & Building*, County of Humboldt, n.d. Web. Accessed via <https://humboldtgov.org/276/GIS-Data-Download>.

Grantham, Theodore, et al. “North Coast Region Report.” *California’s Fourth Climate Change Assessment,* 2018. Web. Accessed via <http://www.climateassessment.ca.gov/regions/docs/20180827-NorthCoast.pdf>.

Laird, Aldaron. “California Collaborative on Coastal Resiliency: Humboldt County Pilot.” *Humboldt Bay Sea Level Rise Adaptation Planning Project,* State of California Ocean Protection Council, 2010-2014. Web. Accessed via <http://humboldtbay.org/sites/humboldtbay2.org/files/HBSLRAP%2011172014.pdf>.

Lazkani, Mustafa. “Map of the Cascadia Subduction Zone.” *FEMA*, Department of Homeland Security, 2 Feb 2016. Web. Accessed via <https://www.fema.gov/media-library/assets/images/115834>.

Leonard, Lucinda J., et al. “Coseismic Subsidence in the 1700 Great Cascadia Earthquake: Coastal Estimates Versus Elastic Dislocation Models.” *GSA Bulletin* 166:5-6(655-670), Geoscience World, 1 May 2004. Web. Accessed via <https://pubs.geoscienceworld.org/gsa/gsabulletin/article-abstract/116/5-6/655/2085/coseismic-subsidence-in-the-1700-great-cascadia?redirectedFrom=fulltext>.

NOAA Office for Coastal Management. “Sea Level Rise Data: Current Mean Higher High Water Inundation Extent.” *National Oceanic and Atmospheric Administration*, Department of Commerce, 2016. Web. Accessed via <https://coast.noaa.gov/slrdata/>.

Pacific Northwest Seismic Network. “Cascadia Subduction Zone.” *Pacific Northwest Seismic Network*, Universities of Washington & Oregon and U.S. Geological Survey, n.d. Web. Accessed via <https://pnsn.org/outreach/earthquakesources/csz>.

Pacific Northwest Seismic Network. “Plate Tectonics.” *Pacific Northwest Seismic Network*, Universities of Washington & Oregon and U.S. Geological Survey, n.d. Web. Accessed via <https://pnsn.org/outreach/about-earthquakes/plate-tectonics>.

Schmalzle, Gina. “Why the Cascadia Subduction Zone is Creepy.” *Gina Schmalzle,* Pelican Development Blog, 1 May 2014. Web. Accessed via <http://geodesygina.com/Cascadia.html>.

U.S. Census Bureau. “CA County Boundaries.” *California Open Data Portal*, State of California, 7 Nov 2017. Web. Accessed via <https://data.ca.gov/dataset/ca-geographic-boundaries/resource/091ff50d-bb24-4537-a974-2ce89c6e8663>.

U.S. Census Bureau. “CA Geographic Boundaries.” *California Open Data Portal,* State of California, 2 Feb 2017. Web. Accessed via <https://data.ca.gov/dataset/ca-geographic-boundaries>.

U.S. Geological Survey. “Digital Compilation of Landslide Overview Map of the Coterminous United States.” *Data.gov*, Department of the Interior, 4 Feb 2015. Web. Accessed via <https://catalog.data.gov/dataset/digital-compilation-of-landslide-overview-map-of-the-conterminous-united-states>.

U.S. Geological Survey. “Landslide Susceptibility.” *Open Data Catalog,* Esri, Department of the Interior, 15 Nov 2011. Web. Accessed via <http://open-fedmaps.opendata.arcgis.com/datasets/b3fa4e3c494040b491485dbb7d038c8a_0>.