Pedestrian evacuation modeling for tsunami hazards

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2004 Indian Ocean earthquake and tsunami

M9.1 earthquake, 226,898 estimated deaths

Recent Catastrophic Tsunamis in the Pacific Basin

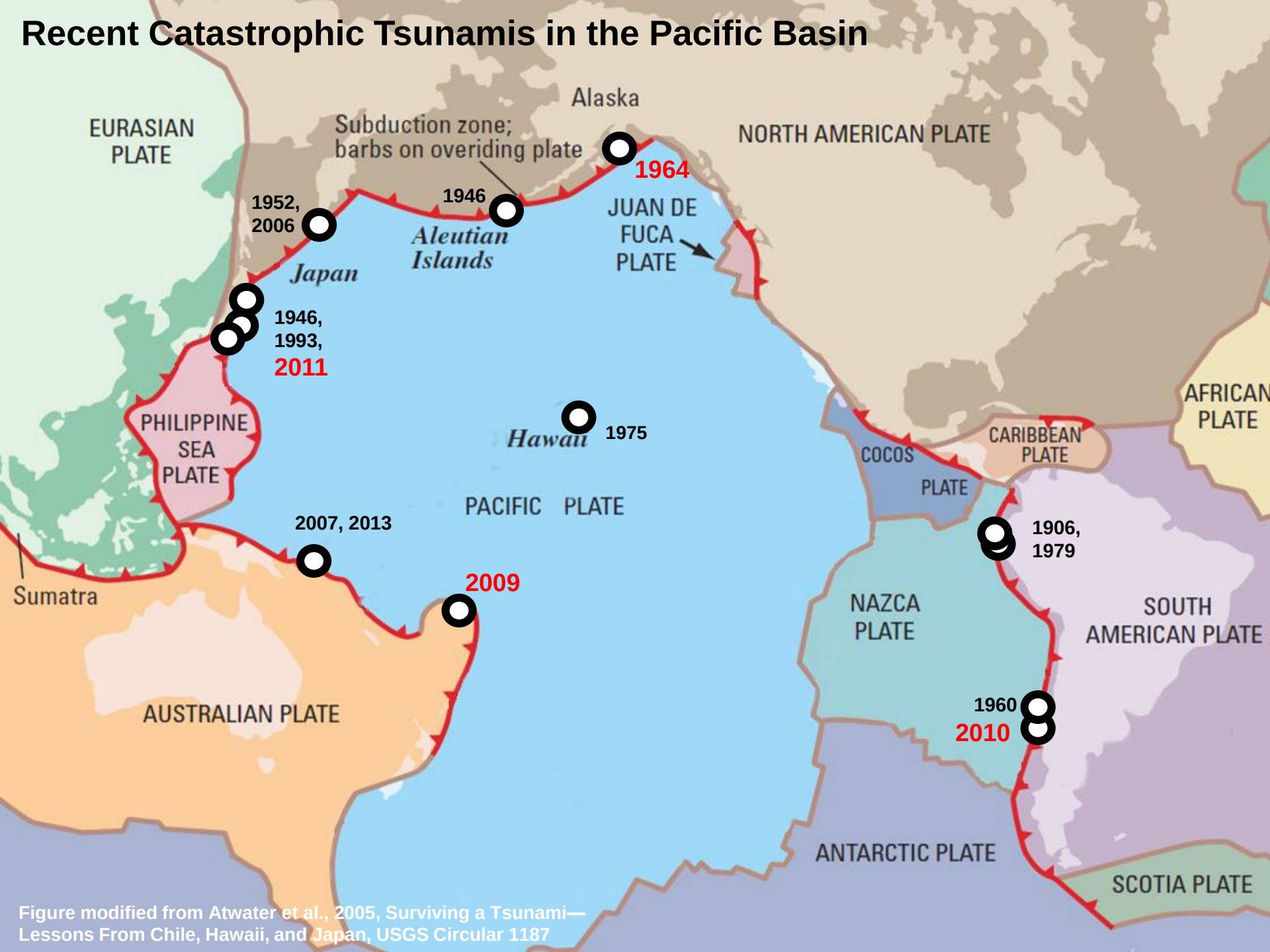


Figure modified from Atwater et al., 2005, Surviving a Tsunami—Lessons From Chile, Hawaii, and Japan, USGS Circular 1187

Exposure

How many and what kind of people are in hazard zones?

- Land cover
- Residents
- Employees
- Public venues
- Dependent-care facilities
- Community businesses
- Critical facilities

****Tsunami exposure reports available for Oregon, Washington, Hawaii, and California**

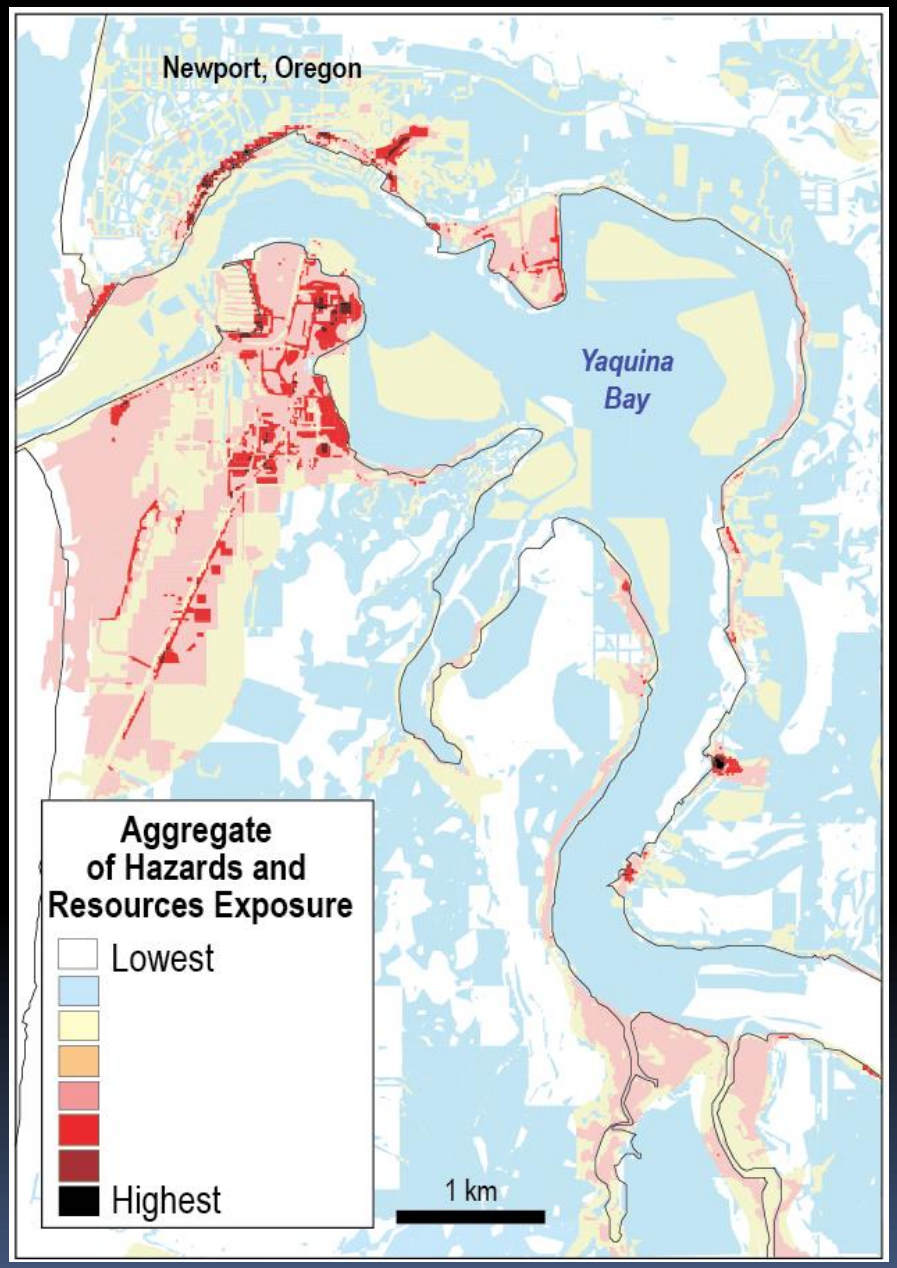


Figure adapted from Wood, N., and Good, J., 2004, Vulnerability of a port and harbor community to earthquake and tsunami hazards: the use of GIS in community hazard planning, *Coastal Management,* 32 (3), 243-269.

Sensitivity

What demographic characteristics influence resilience?

Age: median age, % < 5 yrs, % > 65 yrs, # of nursing home residents per capita, % 25 or older with < 12 yrs education

Employment: % civilian labor force participation, % civilian unemployment, % employed in industry, farming fishing, mining, and forestry, % employed in transportation, communication, and other public utilities, % employed in service

Gender: % of females, % households that are female headed and % female labor force participation

Housing: average # persons/household, % that are renter-occupied, % that are mobile homes, % in urban areas, % rural

Race and ethnicity: % Black or African American, % American Indian or Alaska Native, % Asian, % Hispanic or Latino, and % from international migration

Socioeconomic status: per capita income, % families earning > $100K, % persons living in poverty, % people receiving Social Security benefits, median home value, median rent

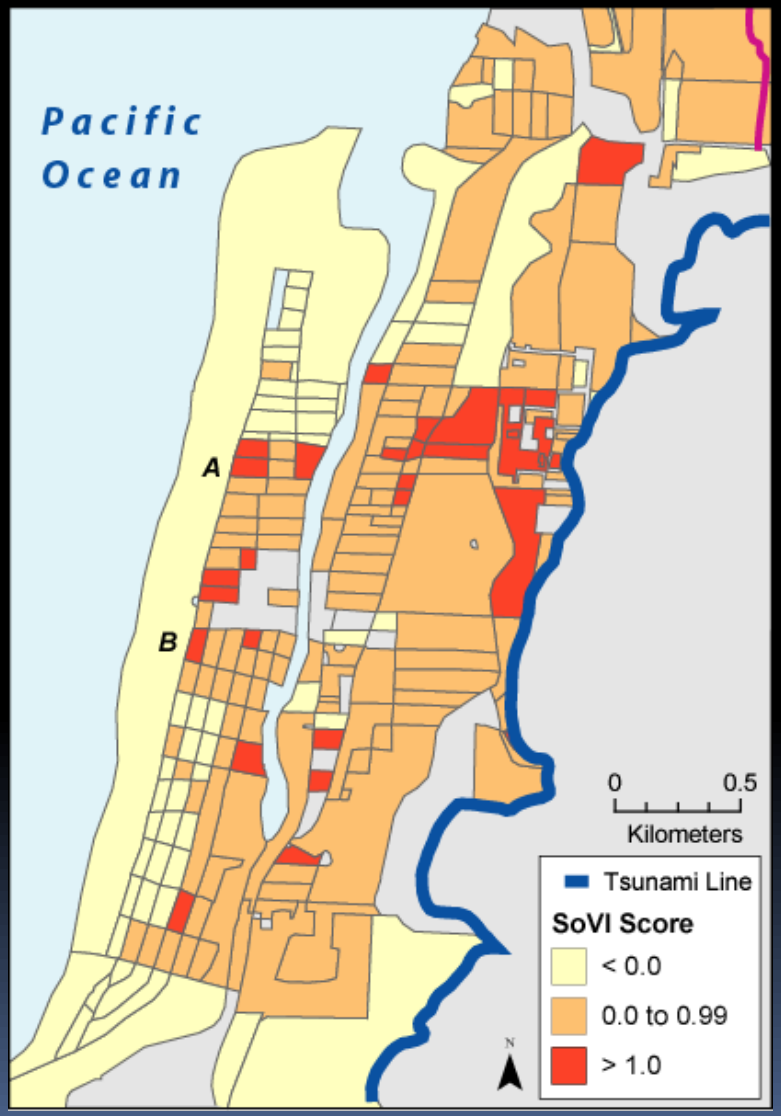
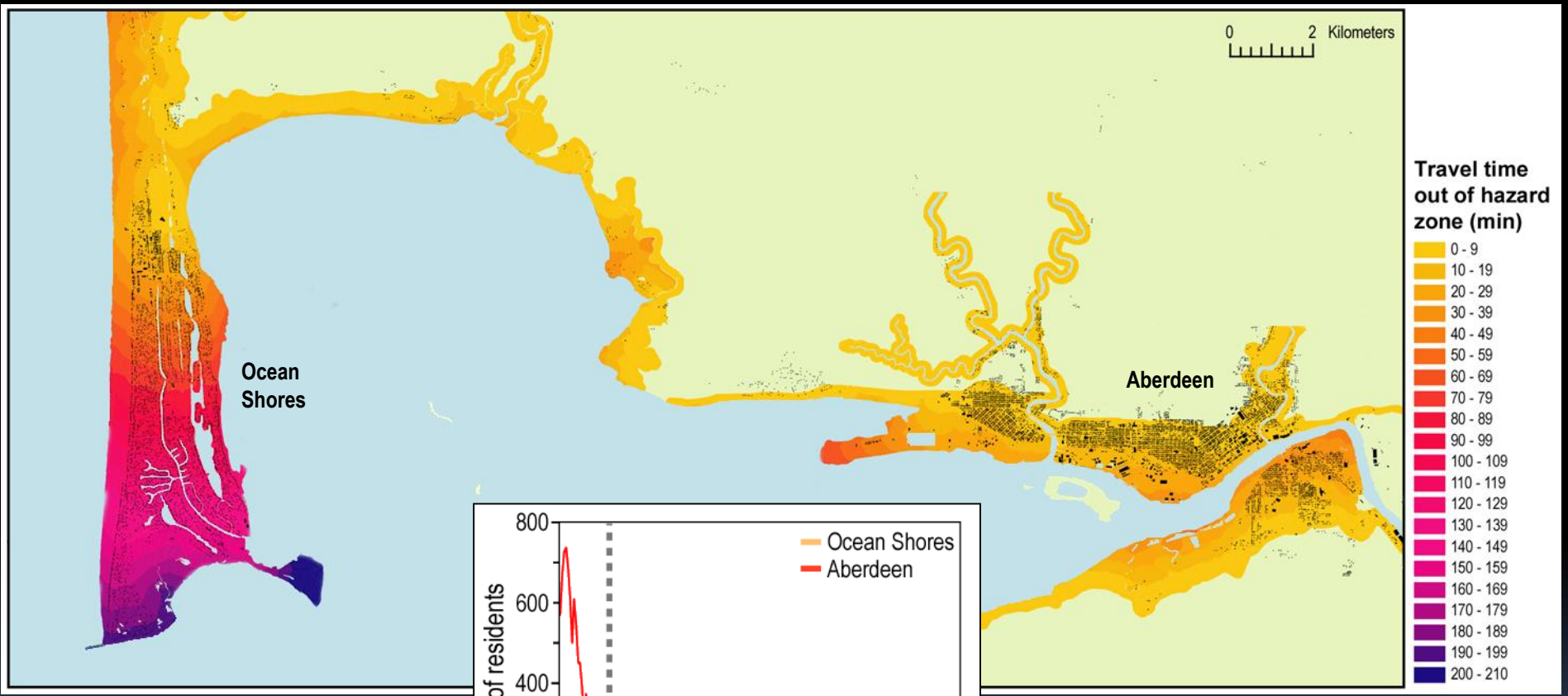
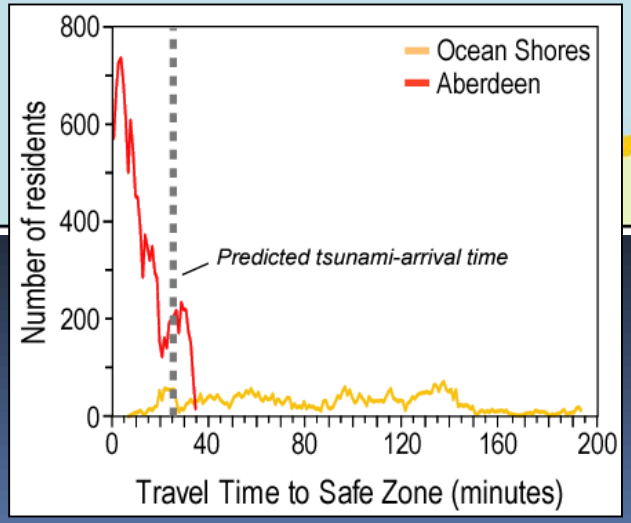


Figure adapted from Wood, N., Burton, C., and Cutter, S., 2010, Community variations in social vulnerability to Cascadia-related tsunamis in the U.S. Pacific Northwest, *Natural Hazards*, 52(2), 369-389

Adaptive Capacity

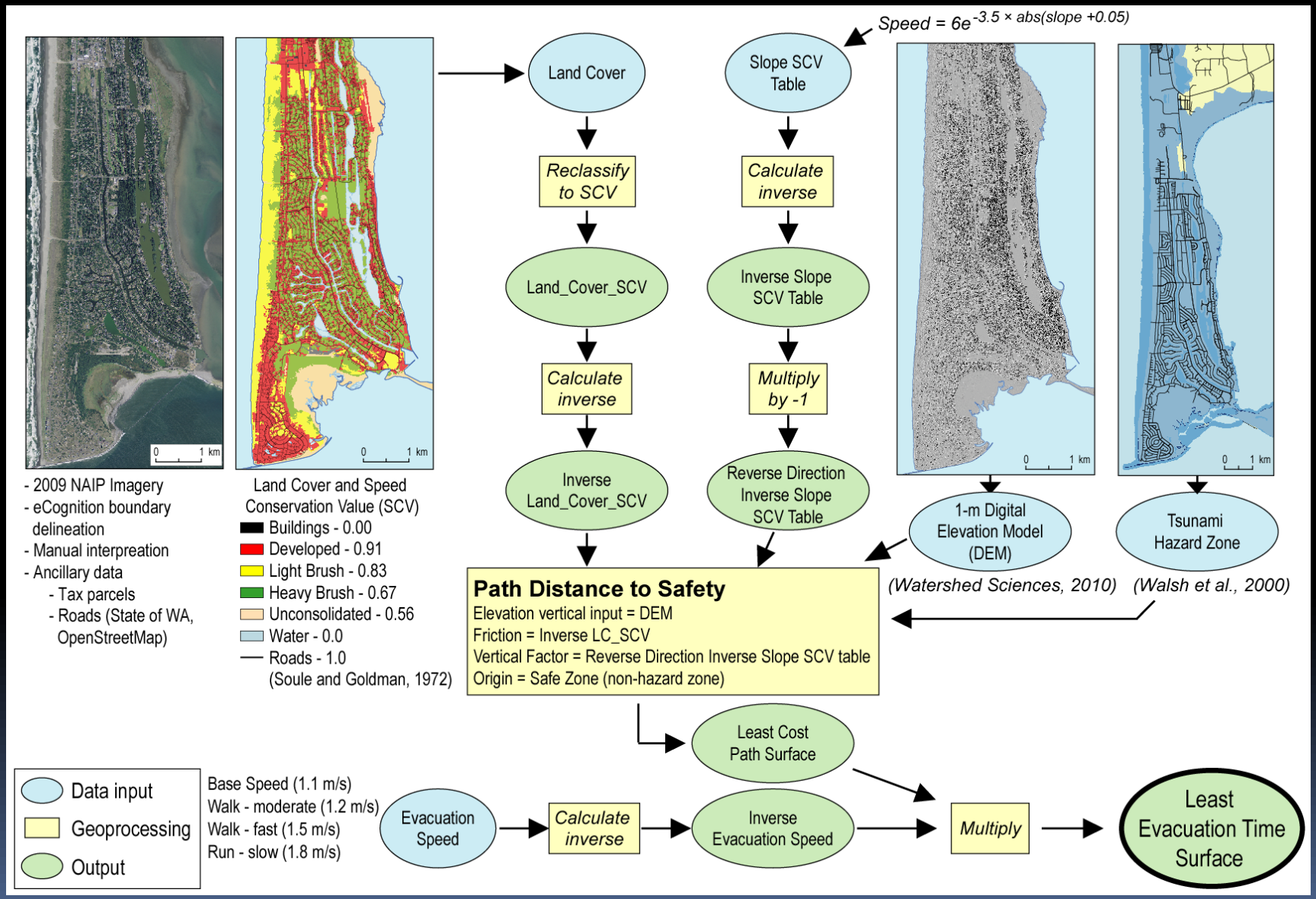
Can high ground be reached before wave arrival?





Figures adapted from Wood, N., and Schmidtlein, M., 2013, Community variations in population exposure to near-field tsunami hazards as a function of pedestrian travel time to safety, *Natural Hazards*, 65 (3): 1603-1628

Creating travel time maps



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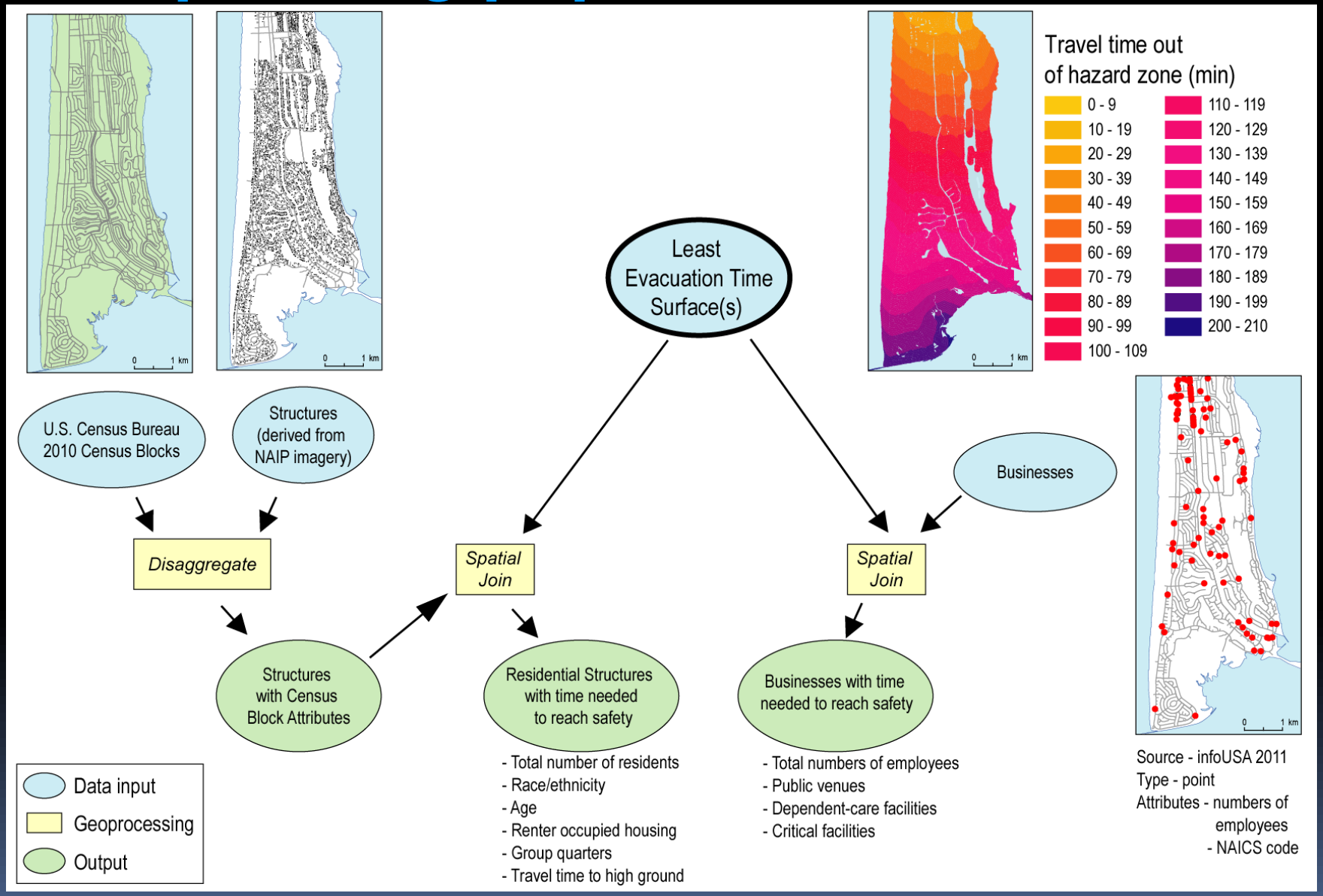
Incorporating population data



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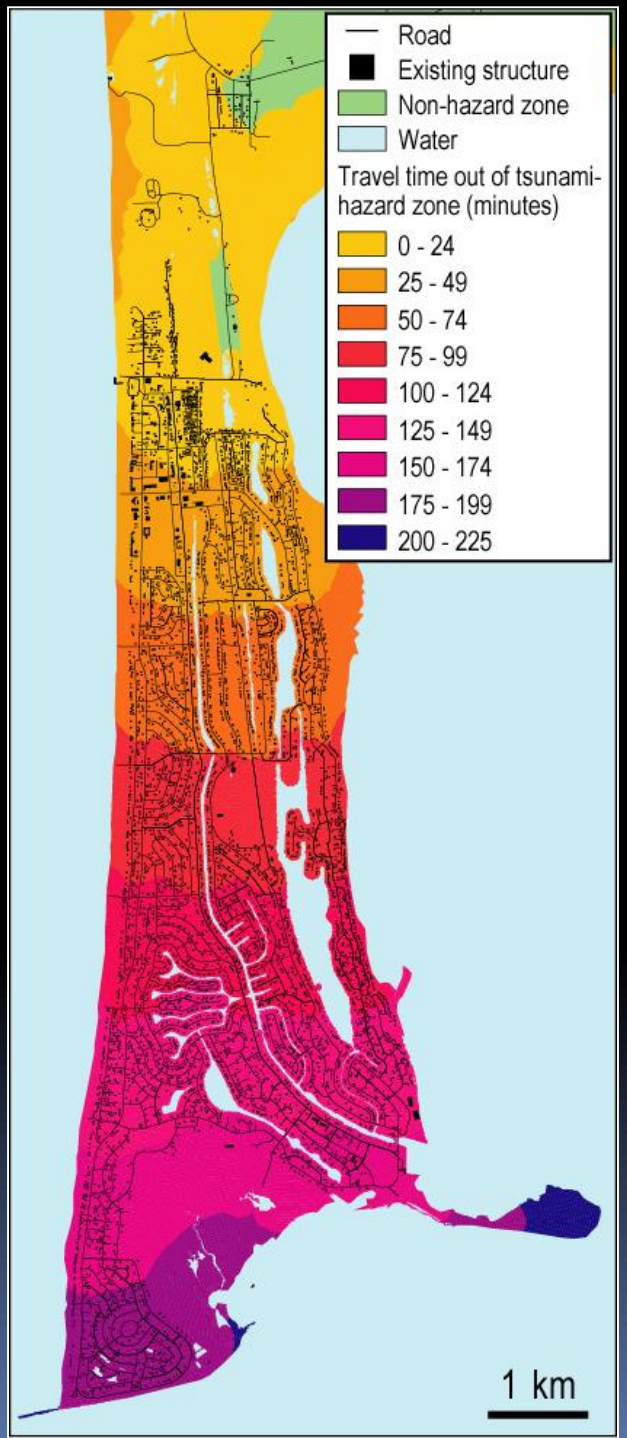

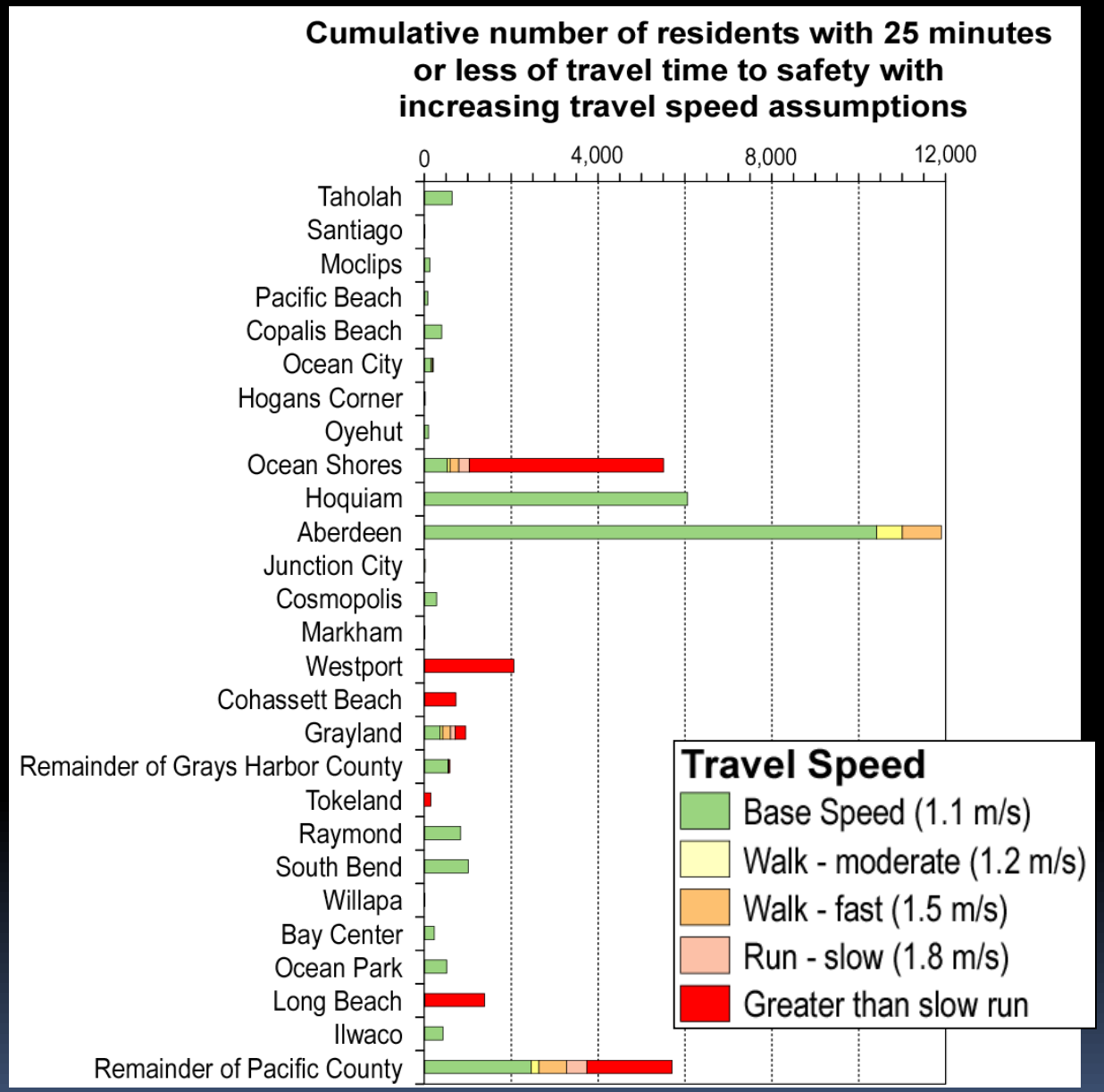

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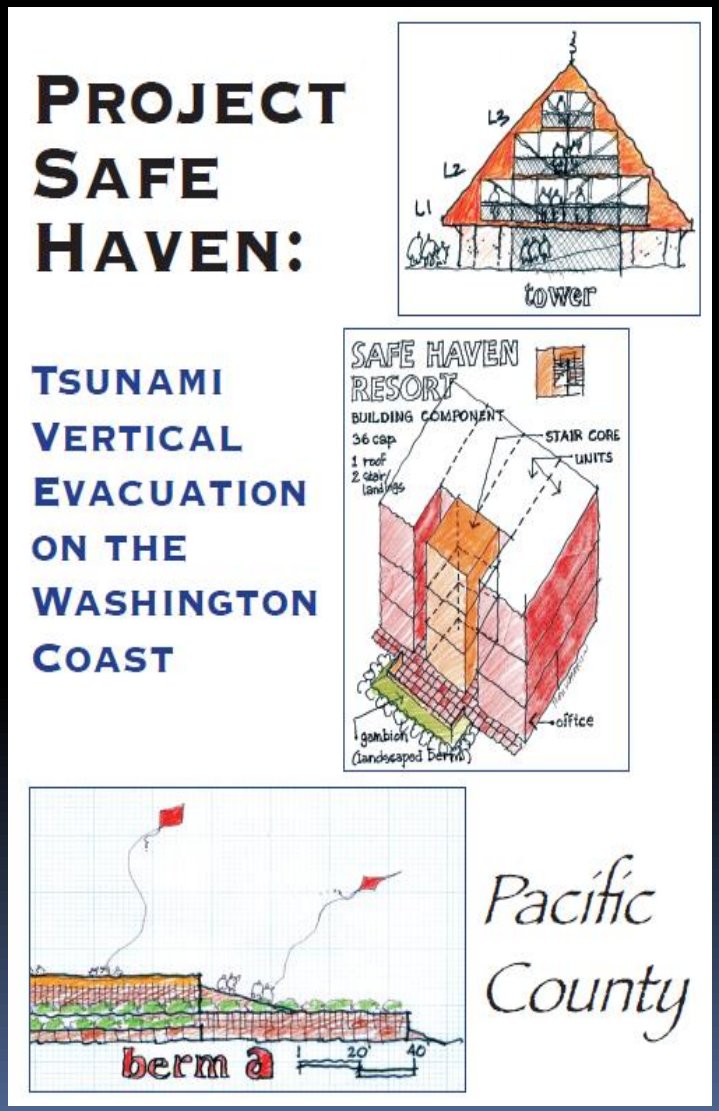
Risk reduction

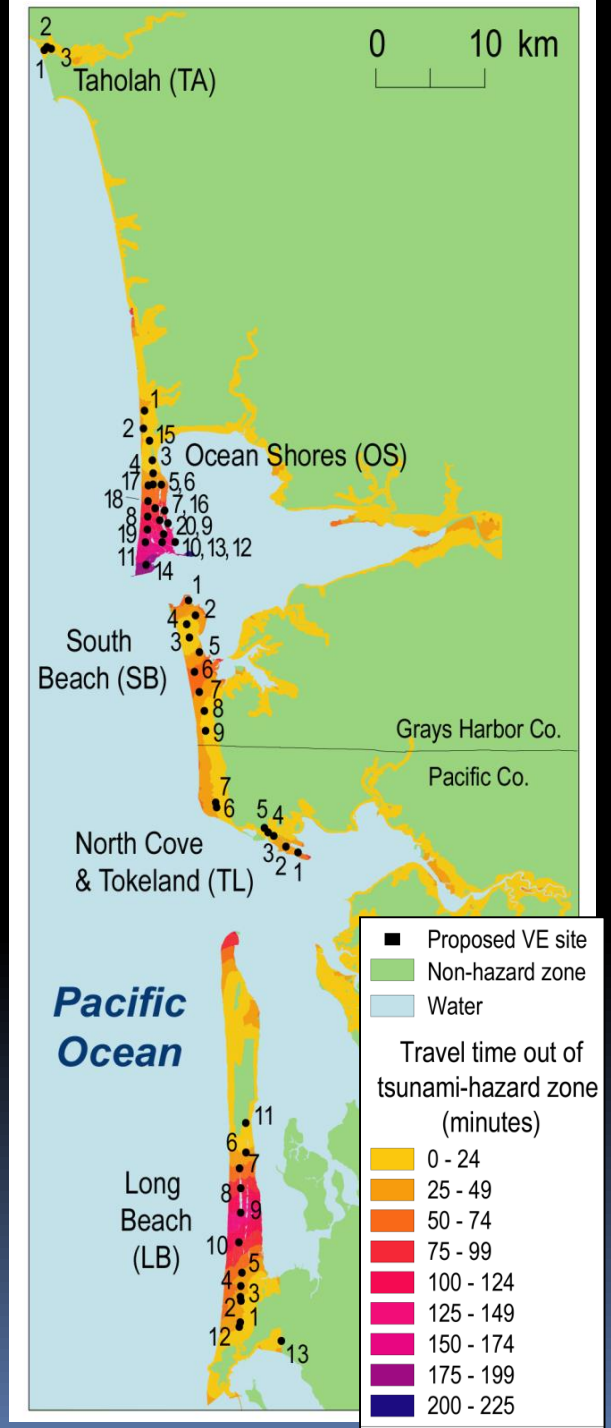
Where could vertical-evacuation refuges be built?



Information about Project Safe Haven

https://catalyst.uw.edu/workspace/wiserjc/19587/116498

http://www.facebook.com/ProjectSafeHaven



Risk reduction

How would each refuge change the evacuation landscape?

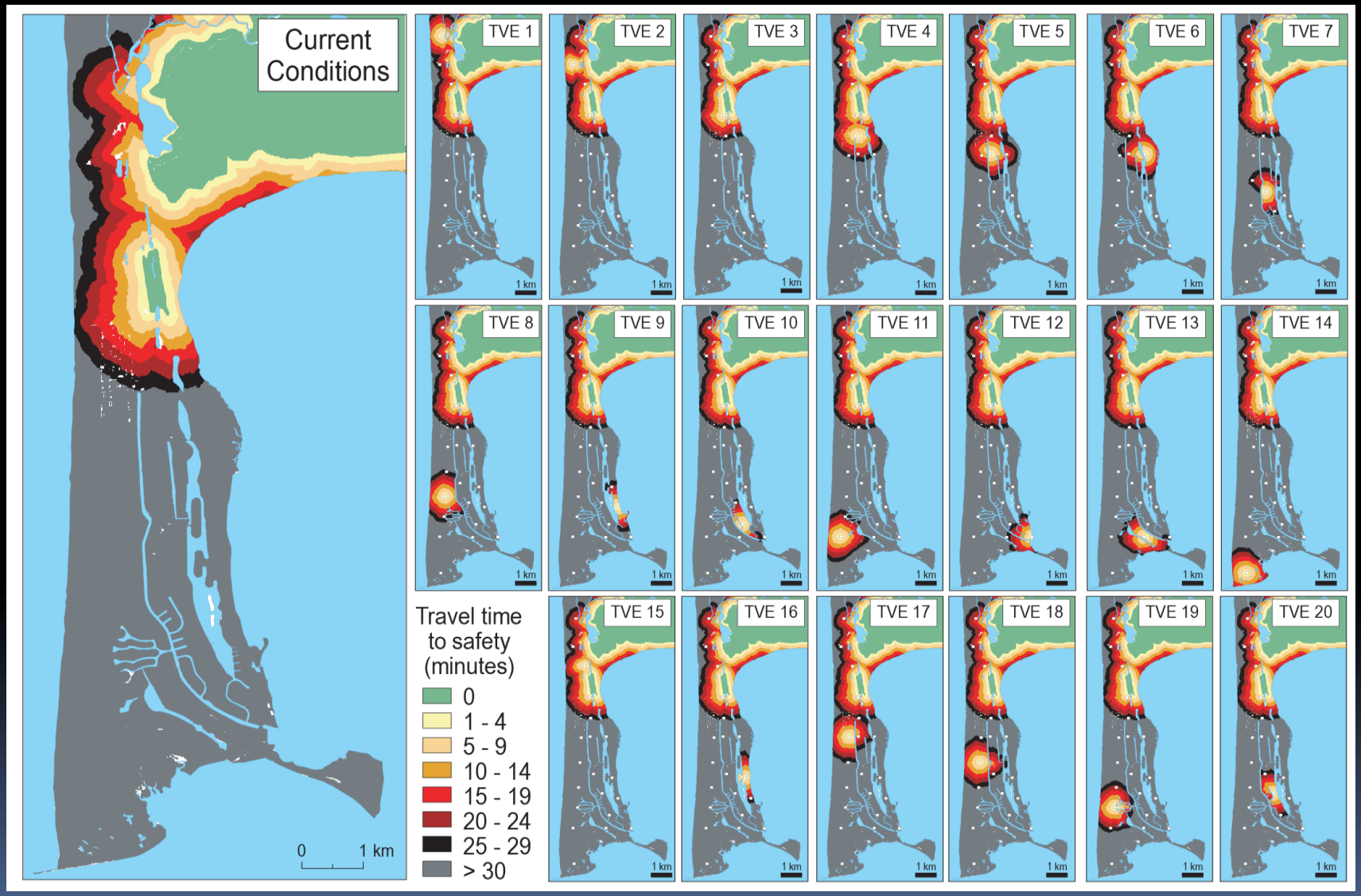
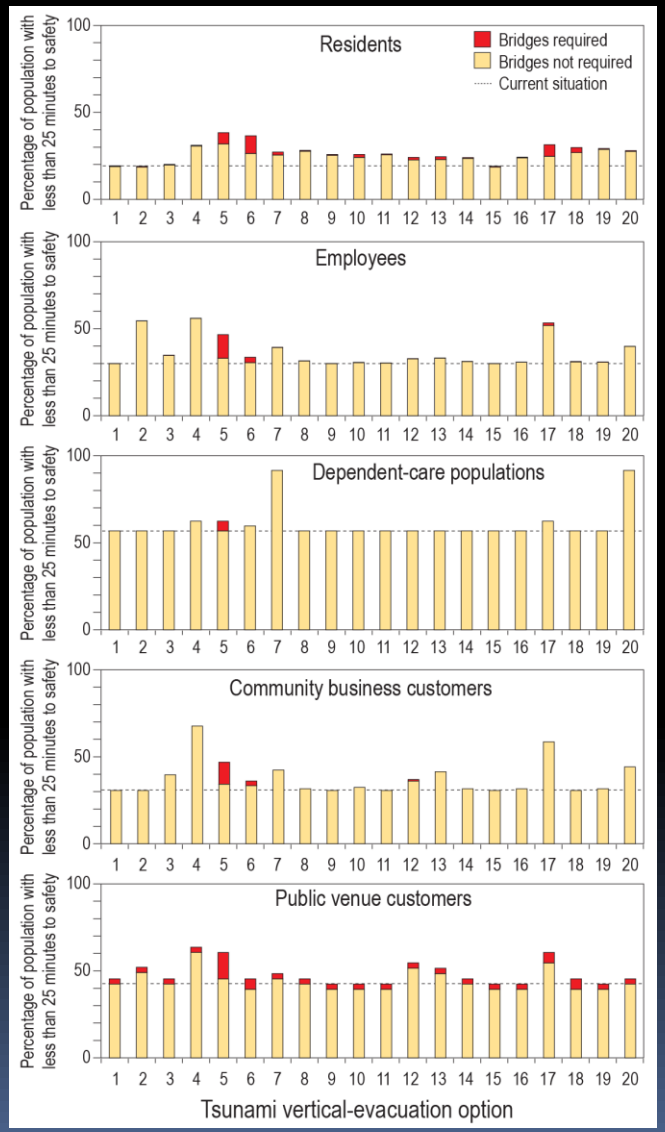
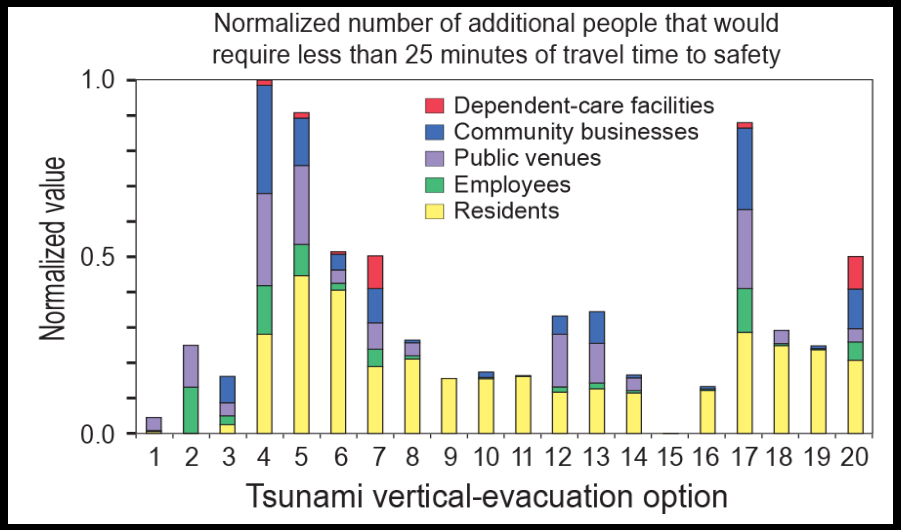


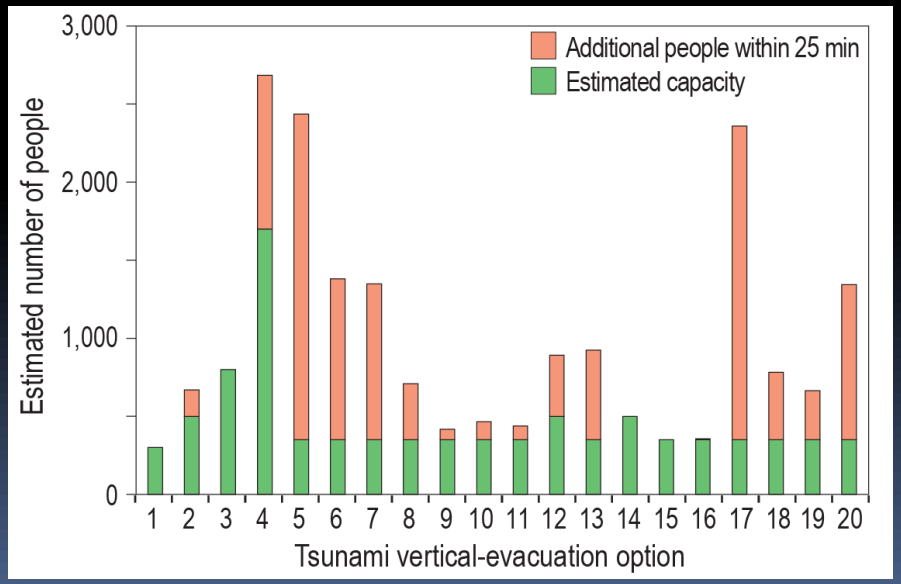
Figure adapted from Wood, N., Jones, J., Schelling, J., and Schmidtlein, M., 2014, Tsunami vertical-evacuation planning in the U.S. Pacific Northwest as a geospatial, multi-criteria decision problem, *International Journal of Disaster Risk Reduction*, 9, 68-83.

Risk reduction

Comparing potential benefits at each vertical-evacuation refuge







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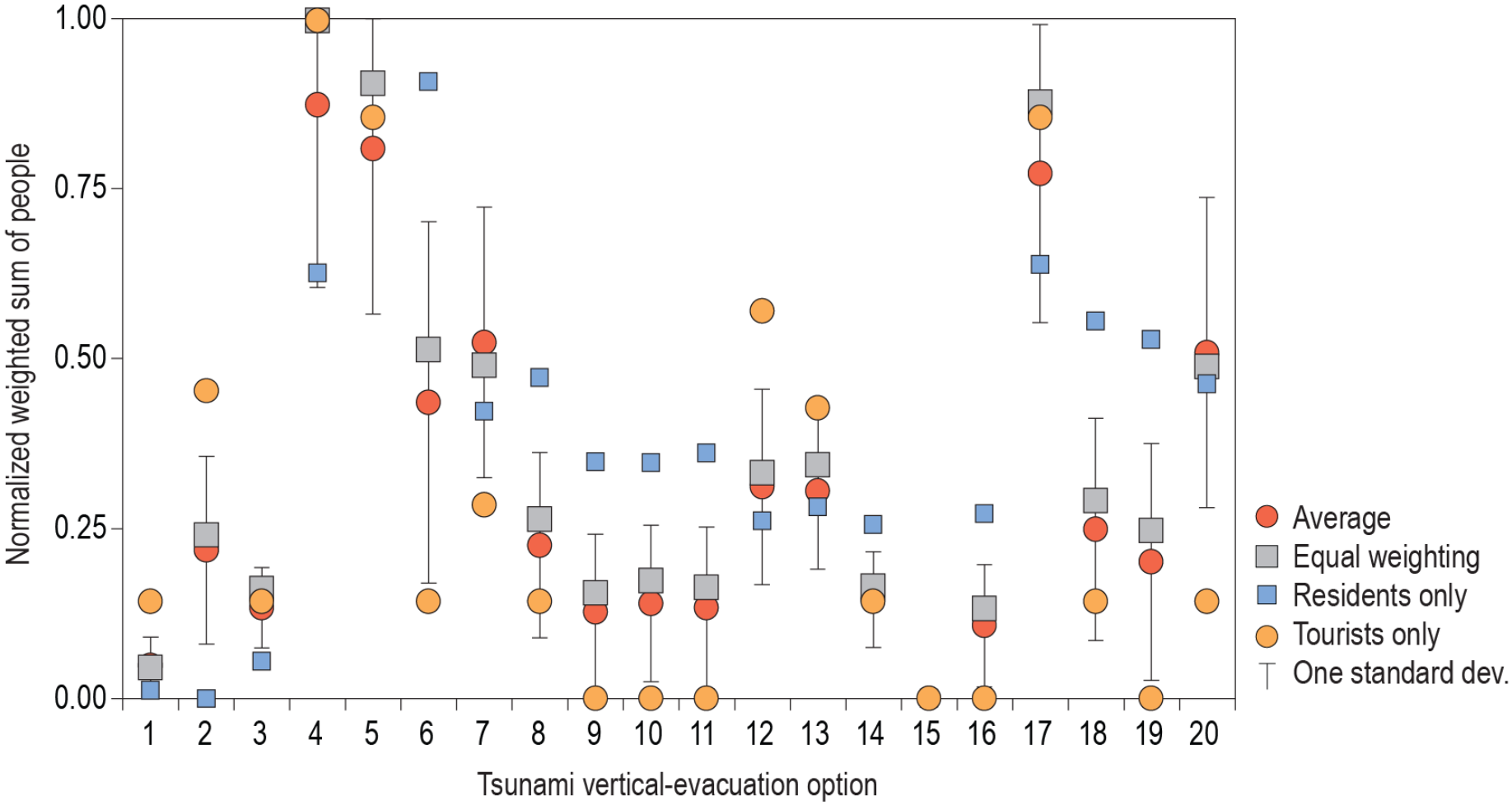
Risk reduction

Refuge-siting implications of prioritizing one group over others



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Risk reduction

Post-disaster analysis of evacuation landscapes

Comparison of reported deaths with evacuation hotspots

Changes in population vulnerability due to post-disaster recovery decisions

Seward, Alaska

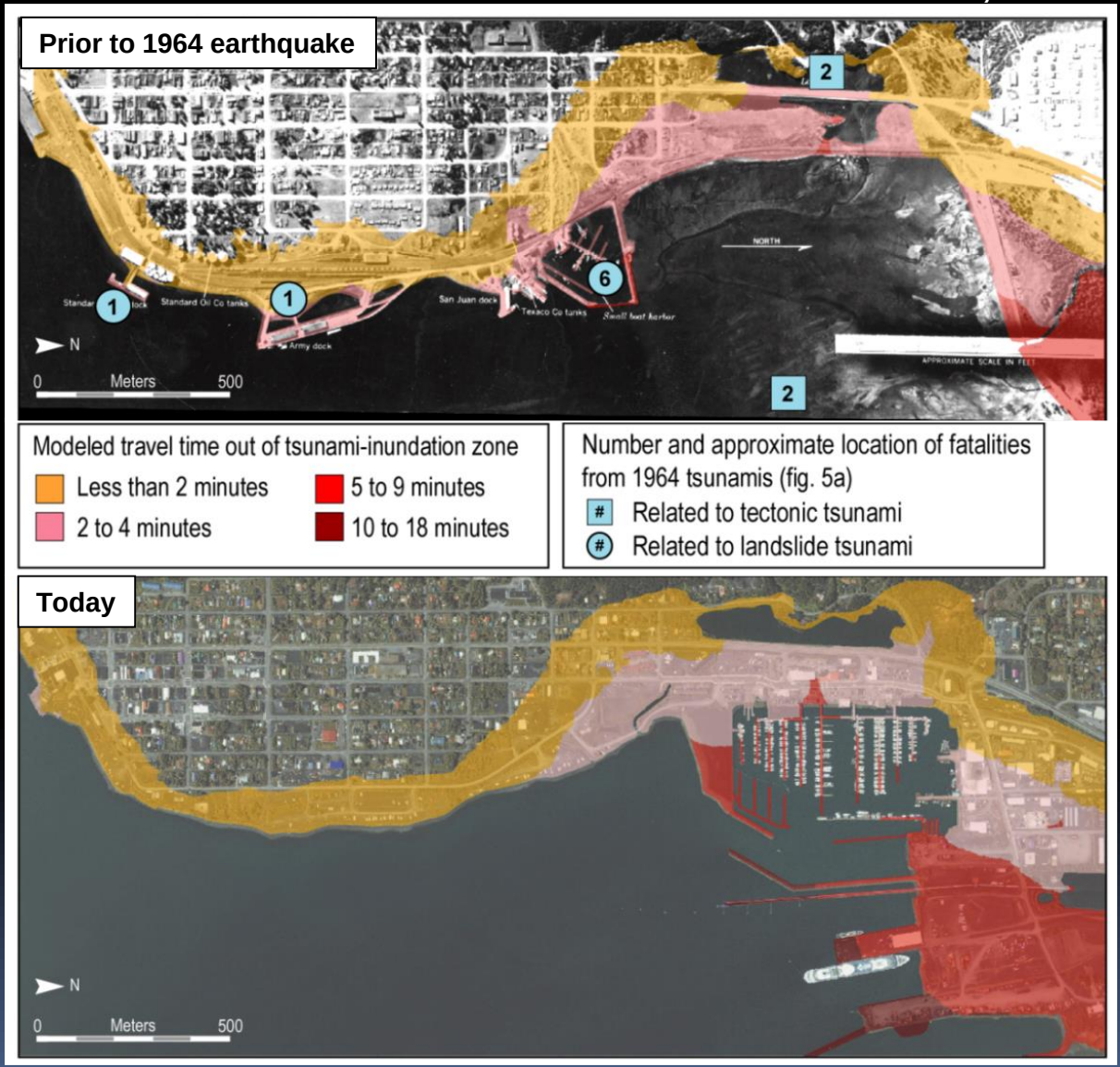
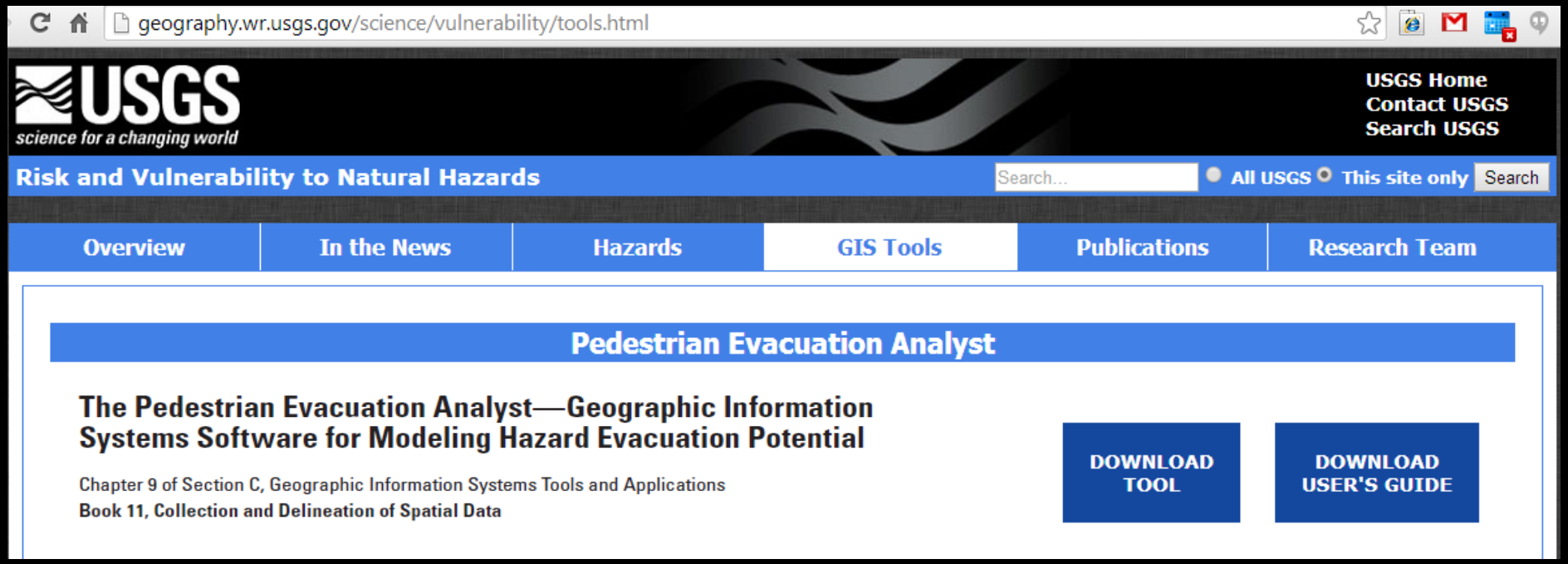
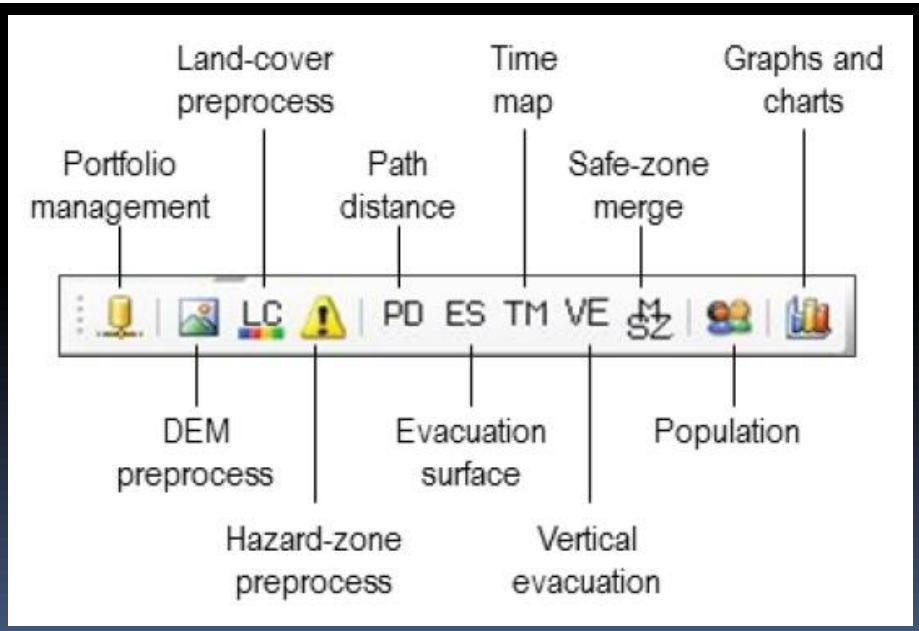


Figure adapted from Wood, N., Schmidtlein, M., and Peters, J., 2014, Changes in population evacuation potential for tsunami hazards in Seward, Alaska, since the 1964 Good Friday earthquake, *Natural Hazards*, 70:1031-1053





Pedestrian Evacuation Analyst Workflow

1	Create a portfolio for the study area	
2	Preprocess input data	Digital elevation model Land use/land cover Hazard zone Safe zone
3	Create evacuation surfaces and maps	Calculate path distance Create evacuation surface Determine maximum time value Create time map
4	Model potential vertical-evacuation sites	Process vertical evacuation sites Merge safe zones
5	Incorporate population data	
6	Develop charts and graphs	

Figures adapted from Jones et al., 2014, The Pedestrian Evacuation Analyst—Geographic Information Systems Software for Modeling Hazard Evacuation Potential, USGS Techniques and Methods, book 11, chapter C9, 25 p.

Summary

- GIS has been instrumental in understanding variations in exposure, sensitivity, and adaptive capacity to tsunami hazards
- Different vulnerabilities require different risk reduction efforts (education, evacuation training, and/or vertical refuges?)
- No one refuge can save everyone so difficult policy questions
- Continuing work – optimization, pathways, landscape preferences

For more information

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http://geography.wr.usgs.gov/science/vulnerability