Building Resilience to Oregon's Next Great Cascadia Subduction Earthquake

- Why is Cascadia our biggest threat?
- How do Cascadia earthquakes compare to the 2011 Tohoku earthquake?
- What controls earthquake vulnerability and risk?
- How vulnerable is Oregon?
- What are the likely consequences of a Cascadia earthquake in Oregon?
- How do we decrease our vulnerability and increase our resilience?

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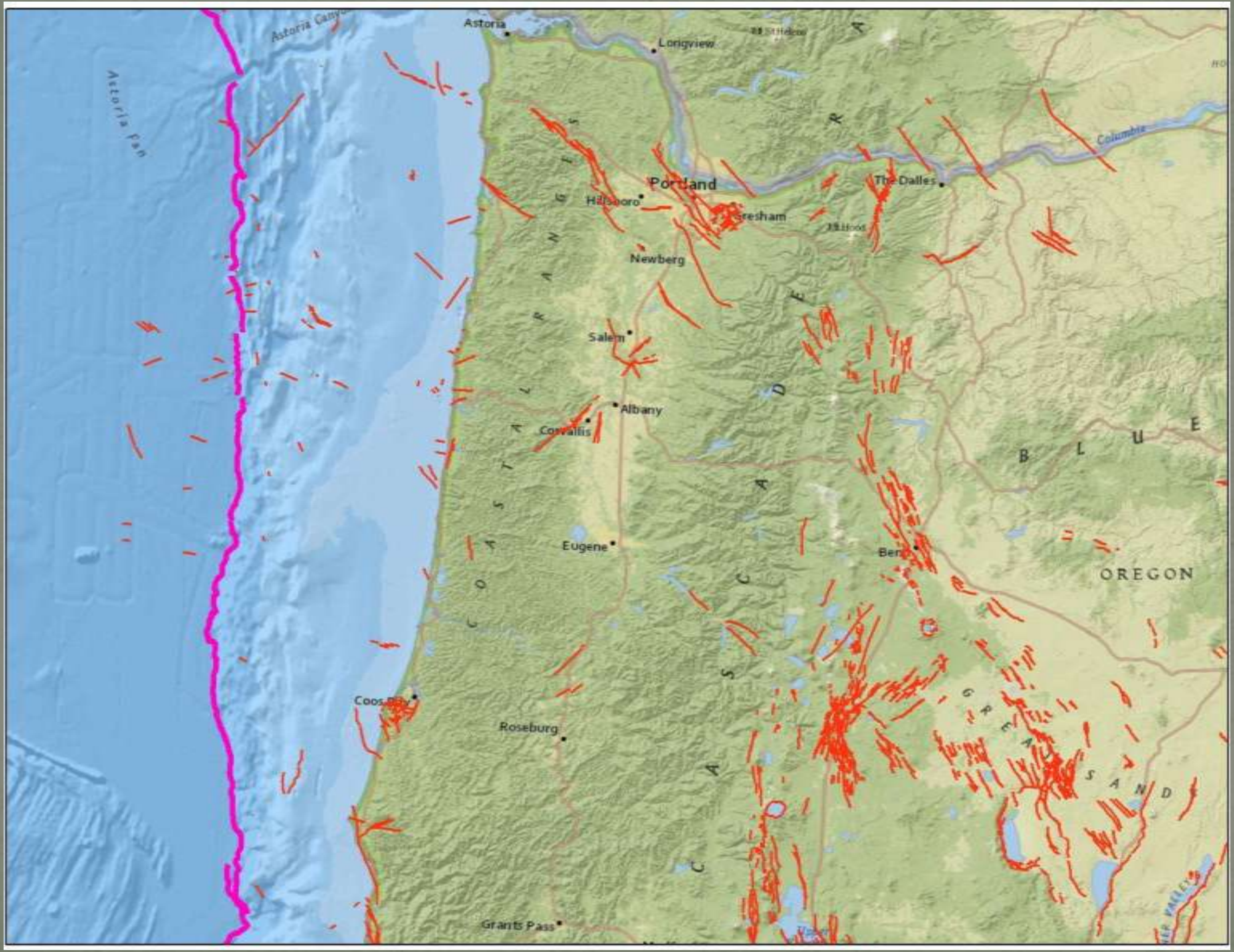
Although there are many faults that threaten Oregon with future earthquakes, The Cascadia Subduction zone is by far the greatest threat to the State



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Great earthquakes on subduction zones like the 2011 Tohoku, Japan earthquake are unusually destructive

Image: Reuters

Almost 16,000 dead and almost 4,000 missing
Almost 6,000 injuries
300,000 homes destroyed
600,000 homes damaged
But…
92% of deaths were due to tsunami (drowning) and about 676,000 of the damaged buildings were in the tsunami inundation zone.

As great as the damage was, well designed structures meant that the impact was largely due to the tsunami. <u>Decades of good seismic design and construction made a huge difference</u>.

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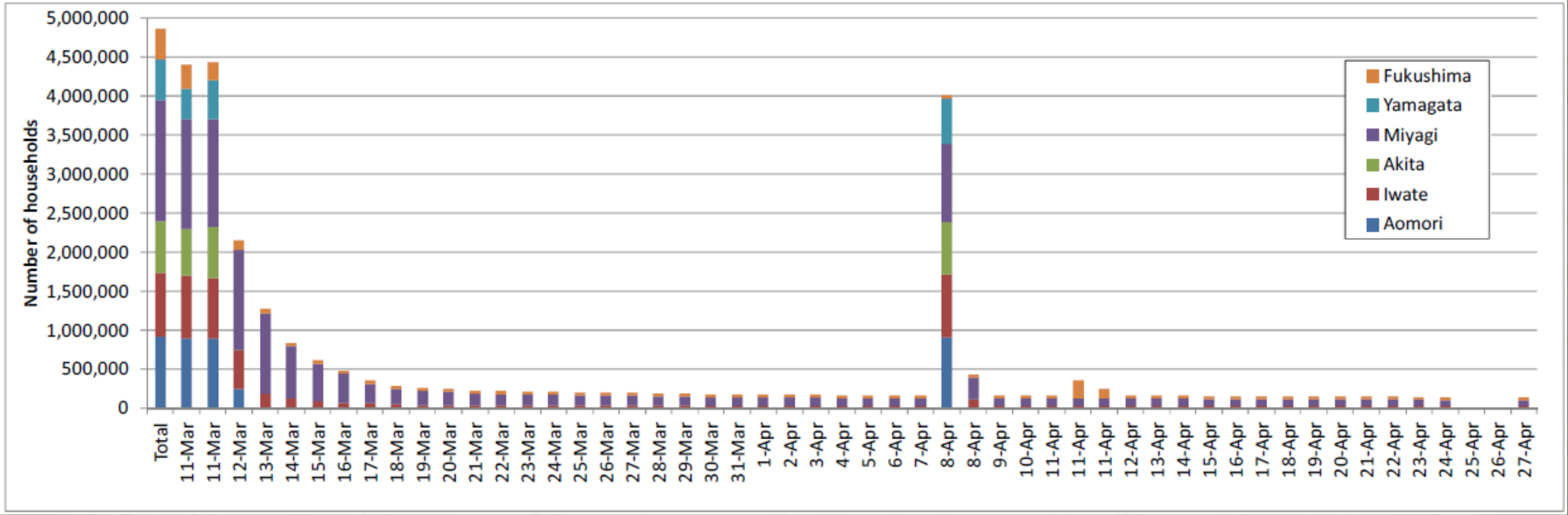
Damage in the tsunami zone was nearly total

In Miyagi prefecture, almost 60% of buildings in the inundation zone were destroyed and another 22% damaged.

Image sources unknown

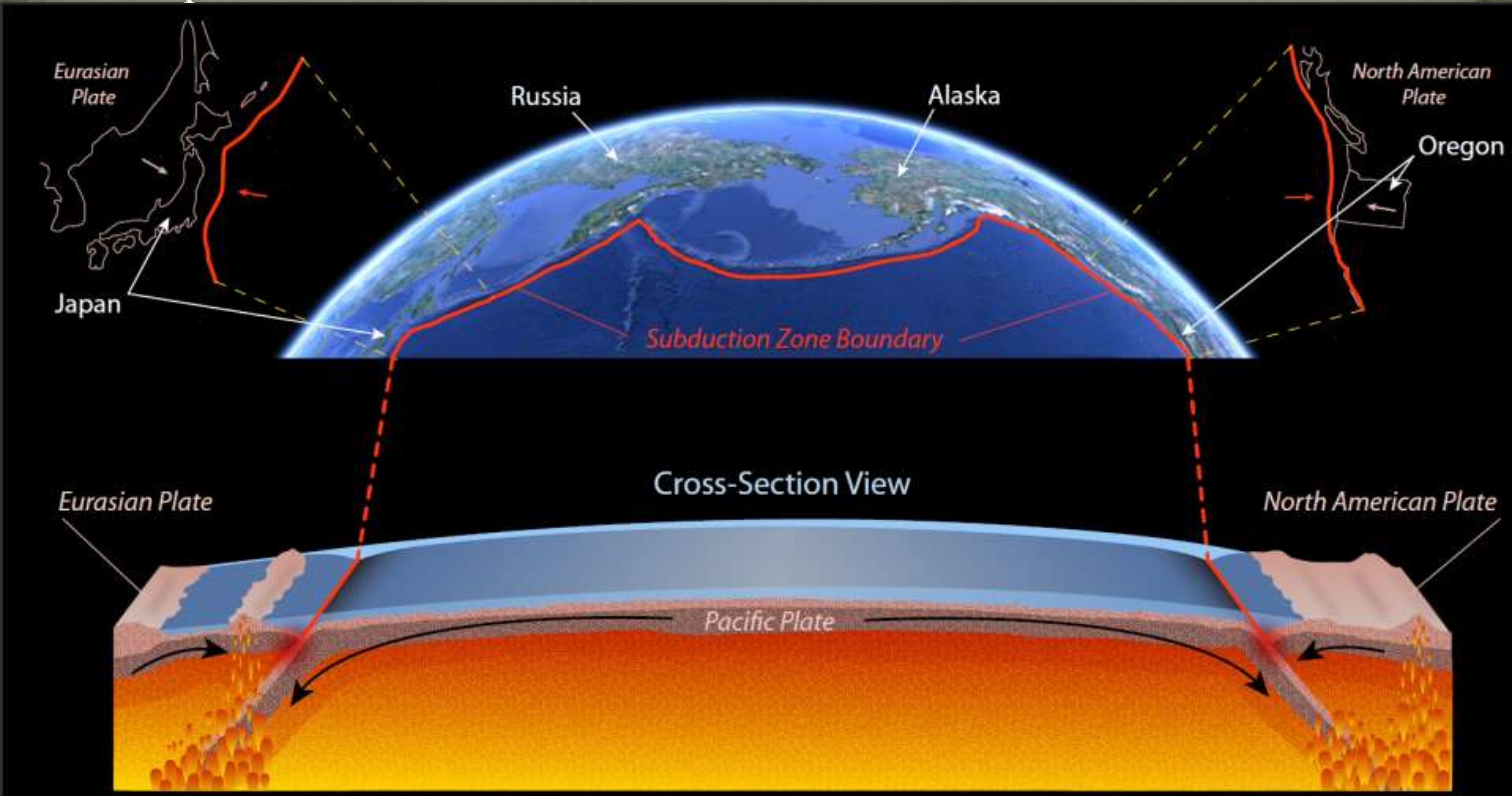
Hidden behind all the images of dramatic damage was a success story, the remarkably quick restoration of services outside the tsunami zone. Years of good seismic design and construction paid off.



Power outside of the tsunami zone was almost fully restored in one week: well prepared infrastructure makes the Japanese system very resilient.

From Nojima, 2012)

Oregon is a geologic mirror-image of Northern Japan. In both places, the Pacific Ocean floor is sliding beneath the adjacent continents along giant faults called subduction zones. Oregon will face an earthquake like the 2011 Tohoku disaster at some point in our future



(Graphic by Dan Coe, DOGAMI)

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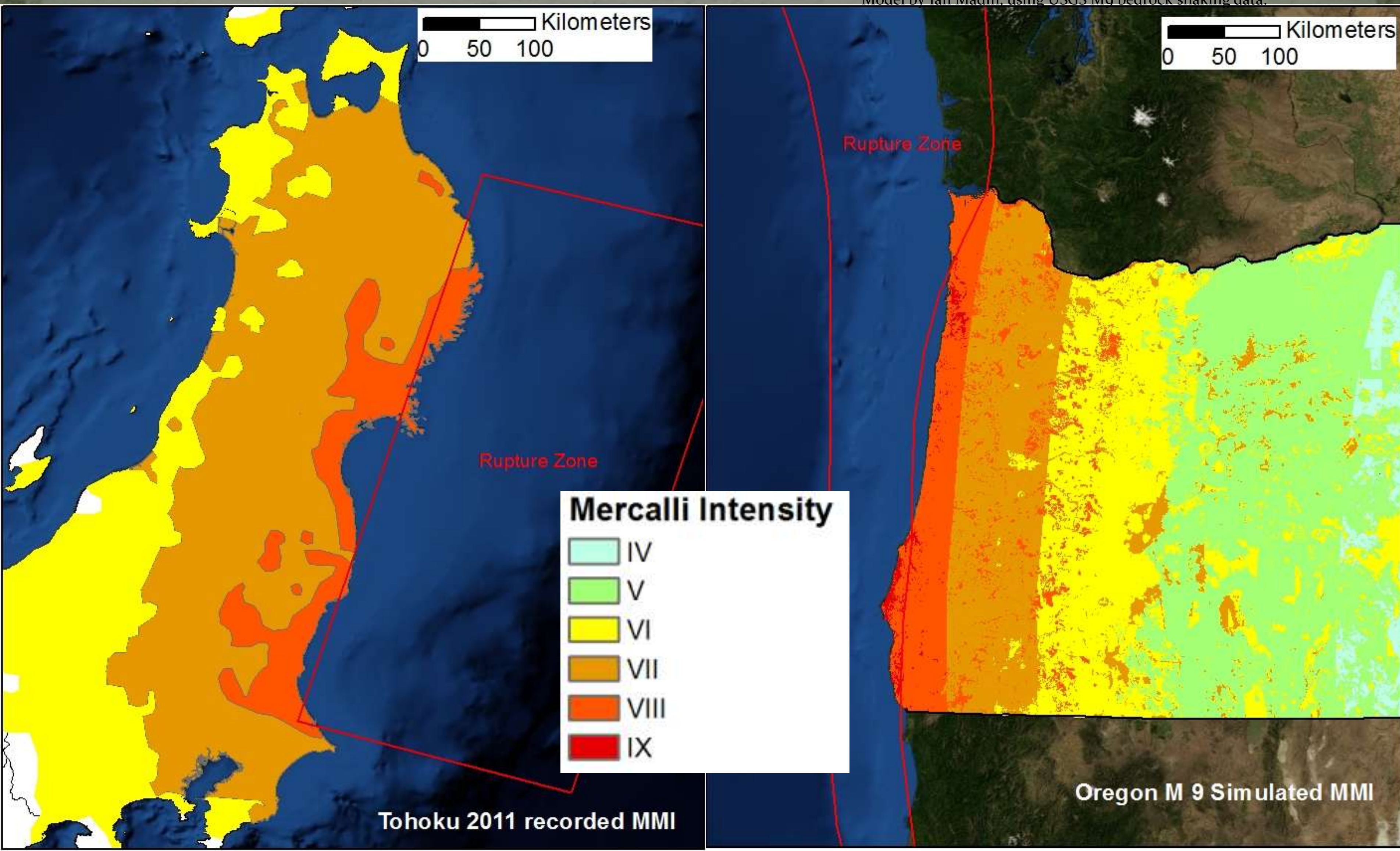
A simulation of the effects of an Oregon M 9 earthquake show shaking and damage intensity comparable to values recorded in the 2011 Tohoku earthquake.

Data from Risk Management Solutions

Model by Ian Madin, using USGS M9 bedrock shaking data.



What controls earthquake damage?

Total energy release (magnitude)

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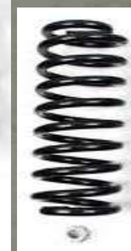
Distance from epicenter or fault

X



Site amplification

+

Liquefaction or landslides

X

Structural vulnerability

=

Damage

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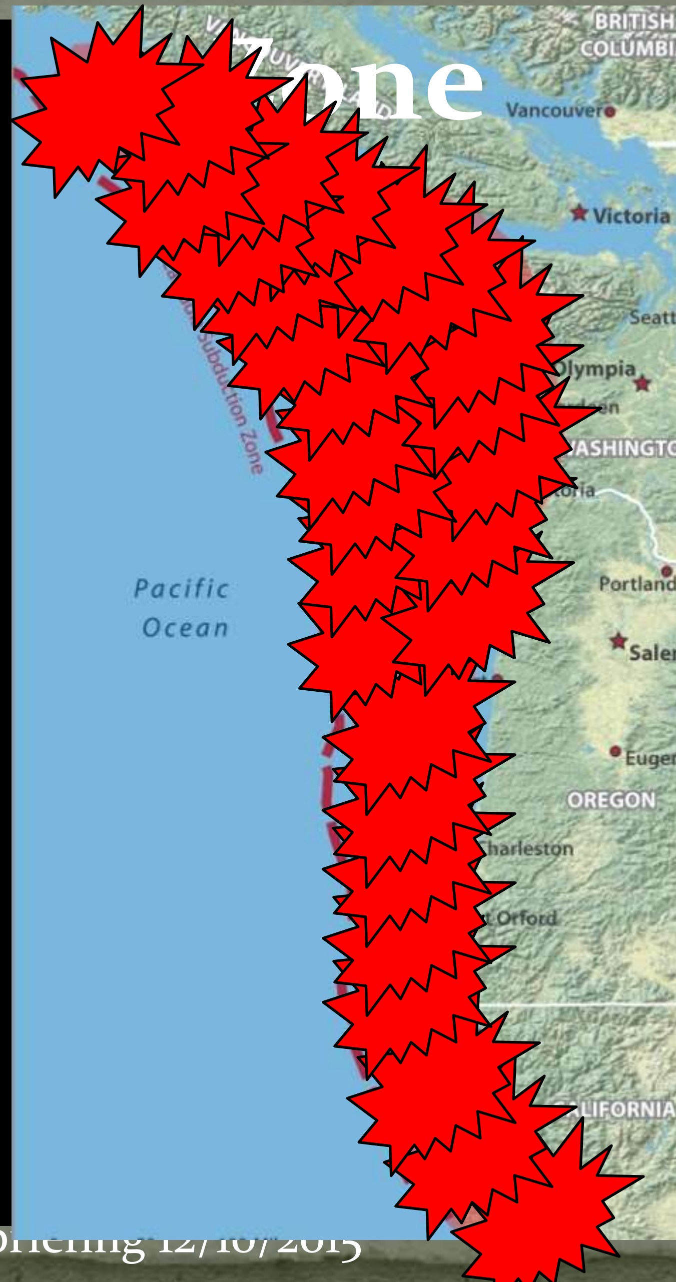
The Cascadia Subduction Zone



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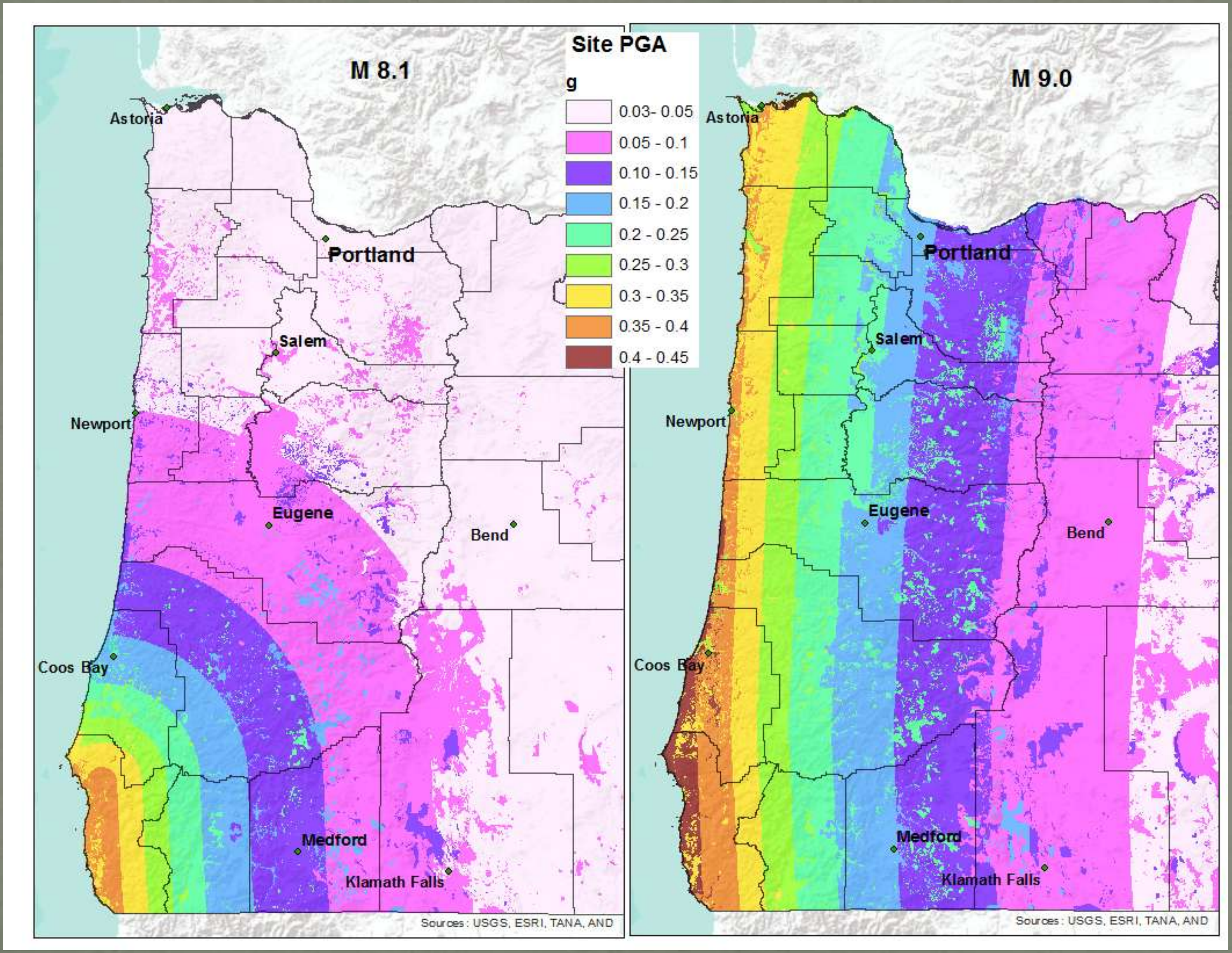
Effect of Magnitude and location: Size matters, distance matters



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How likely is our next great subduction earthquake?

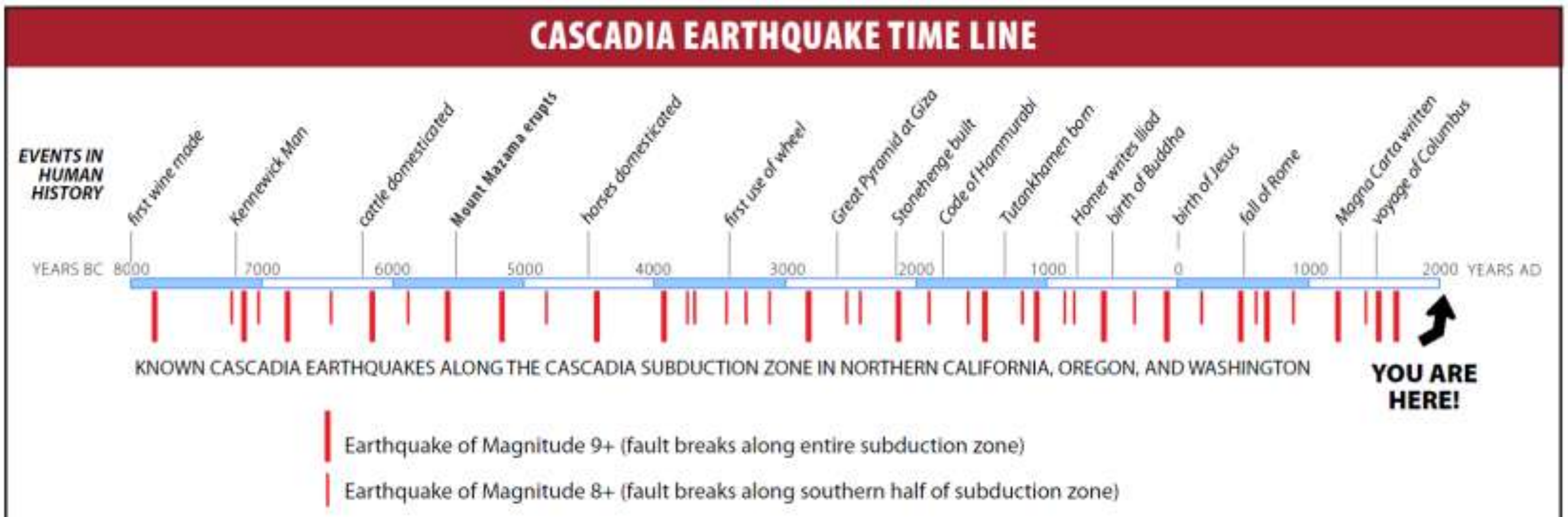
The last 10,000 years of the geologic record includes:

- 19 certain great (~M 9) earthquakes
- 12 certain not-so-great (M 8.5-8.8) earthquakes
- 10 *likely* even-less-great (but still over M 8) earthquakes

The odds of an M 9 event in the next 50 years is 7-12% (about the same probability that a 30 year old American male will die in the next 30 years)

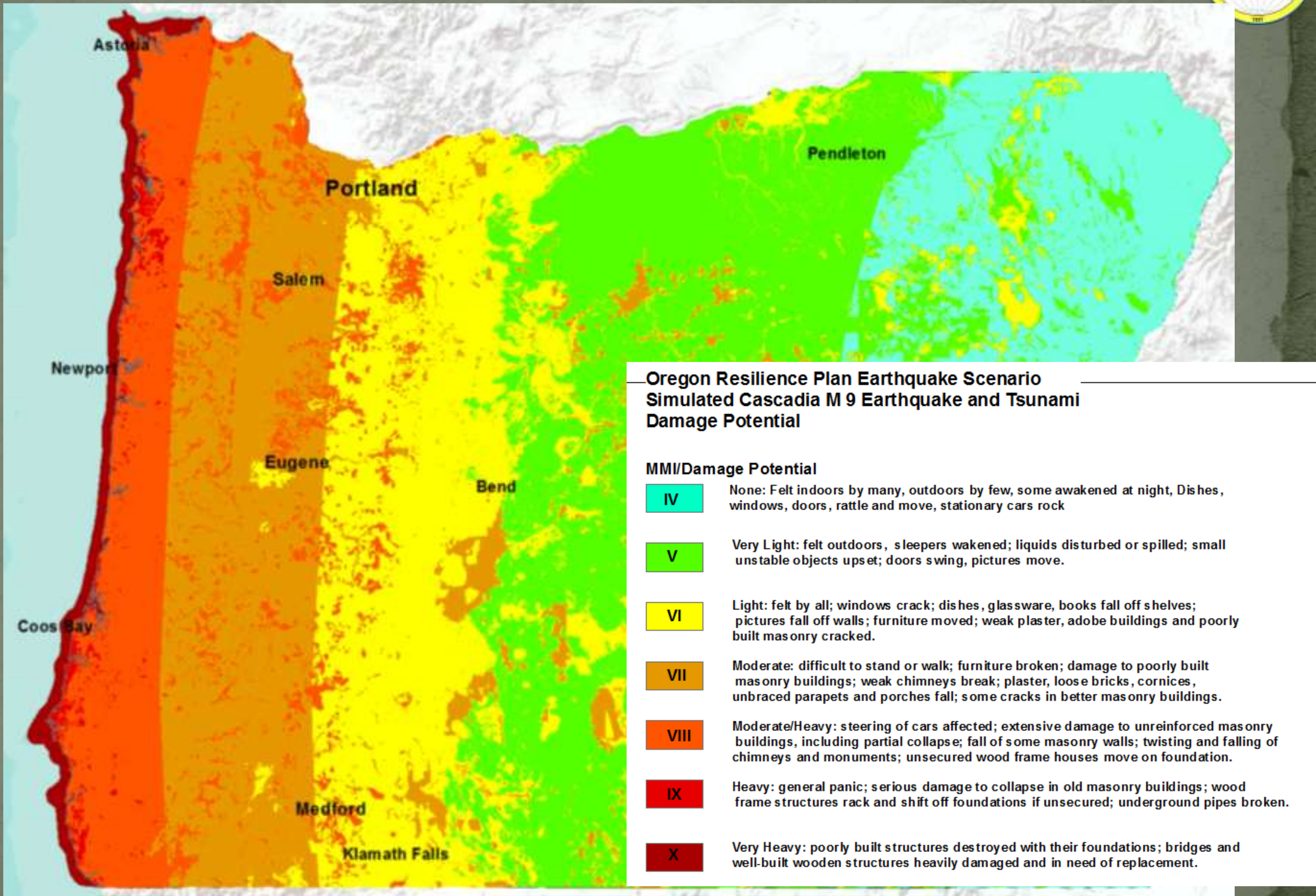
Average time between M 9 earthquakes is about 530 years, but can be as little as 100 or as great as 1000

300 years since the last event, we are not overdue!



Comparison of the history of subduction zone earthquakes along the Cascadia Subduction Zone in northern California, Oregon, and Washington, with events from human history. Ages of earthquakes are derived from study and dating of submarine landslides triggered by the earthquakes. Earthquake data provided by Chris Goldfinger, Oregon State University; time line by Ian P. Madin, DOGAMI.

Site amplification due to soft soil will increase damage at many locations



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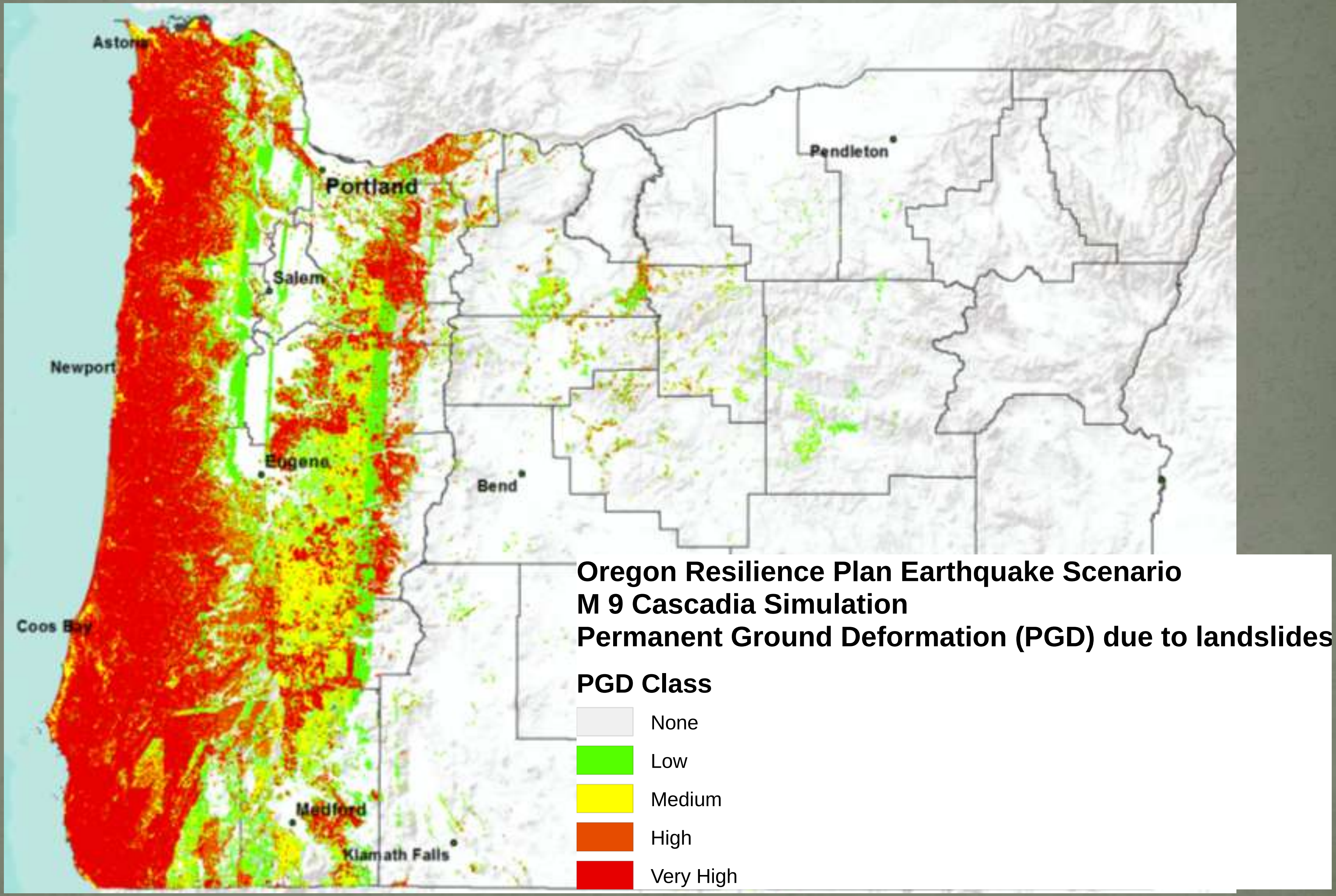
A magnitude 9 earthquake will cause landslides on sloping terrain over much of the western half of the state, many will be severe, particularly in the Coast Range .



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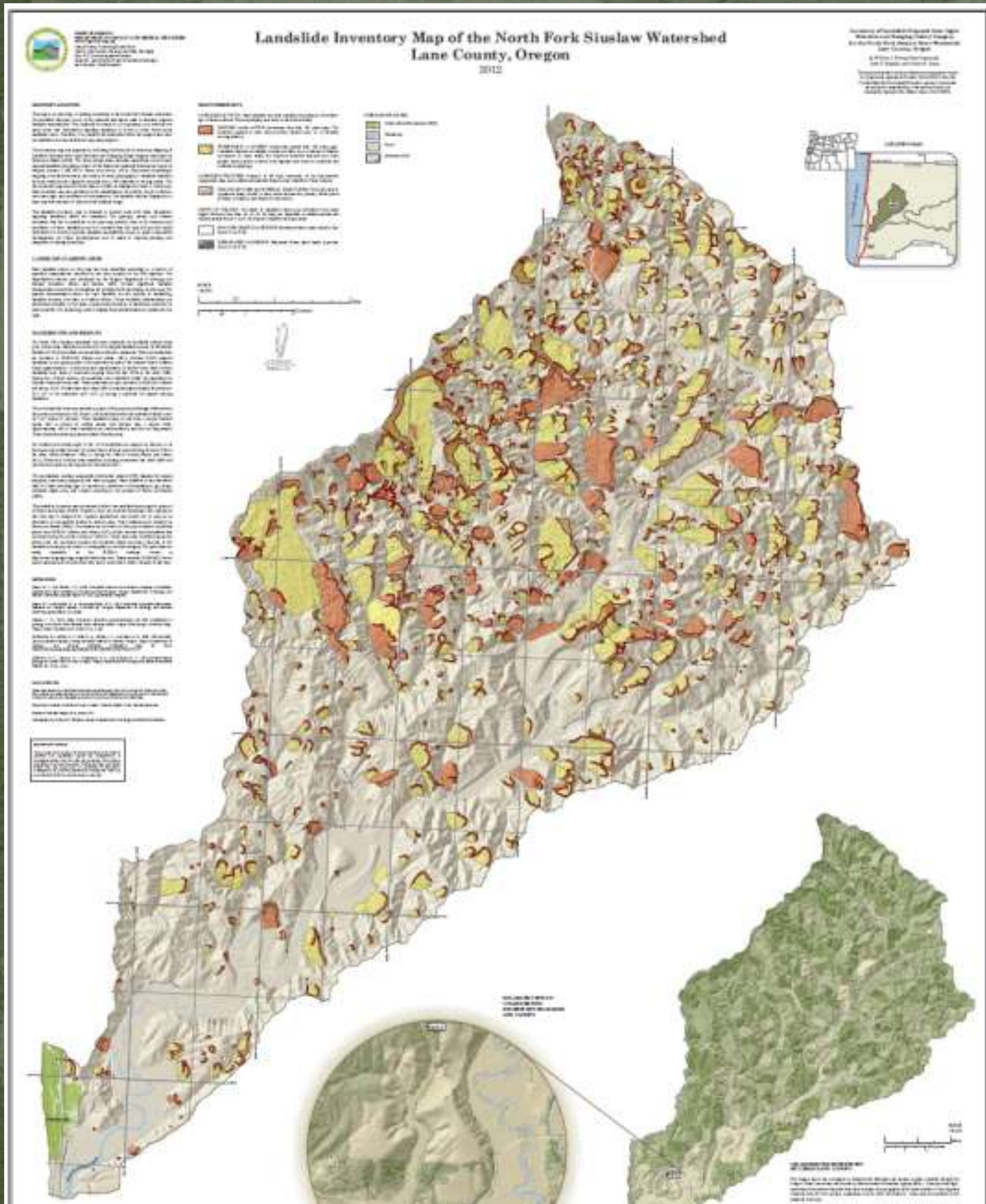

If the models show high landslide susceptibility during Cascadia earthquakes and there have been over 40 in the last 10,000 years, shouldn’t the Coast Range be full of old landslides?
It is! The North Fork Siuslaw watershed contains 1,316 mapped landslides, covering 22% of the basin.
Map by Bill Burns, DOGAMI

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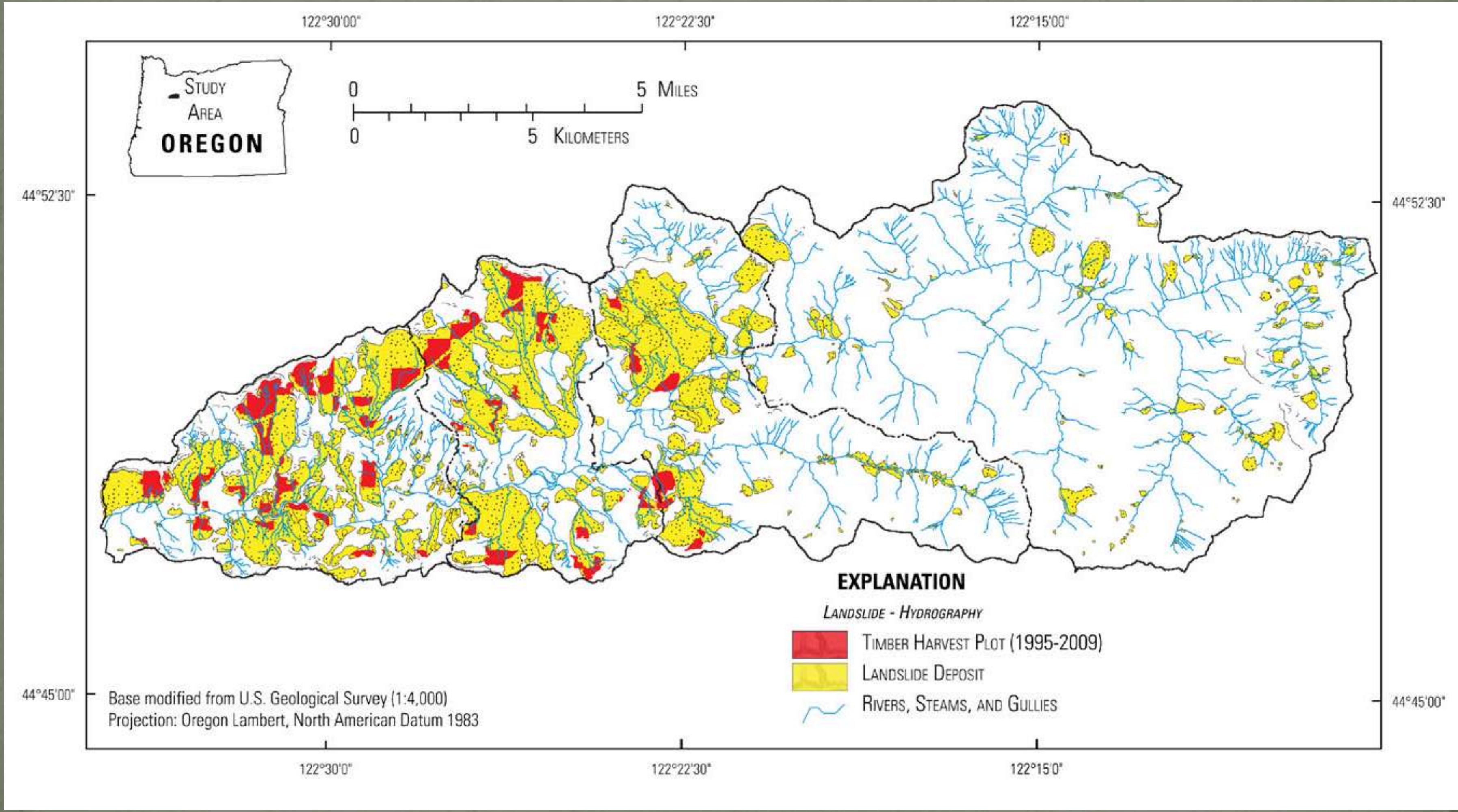
In the Little North Santiam, landslides occupy 37% of the lower basin and 4% of the upper basin. 91% of the suspended sediment came from the lower half of the basin, and 28% came from a single 23 acre landslide that covers only .0004% of the basin.



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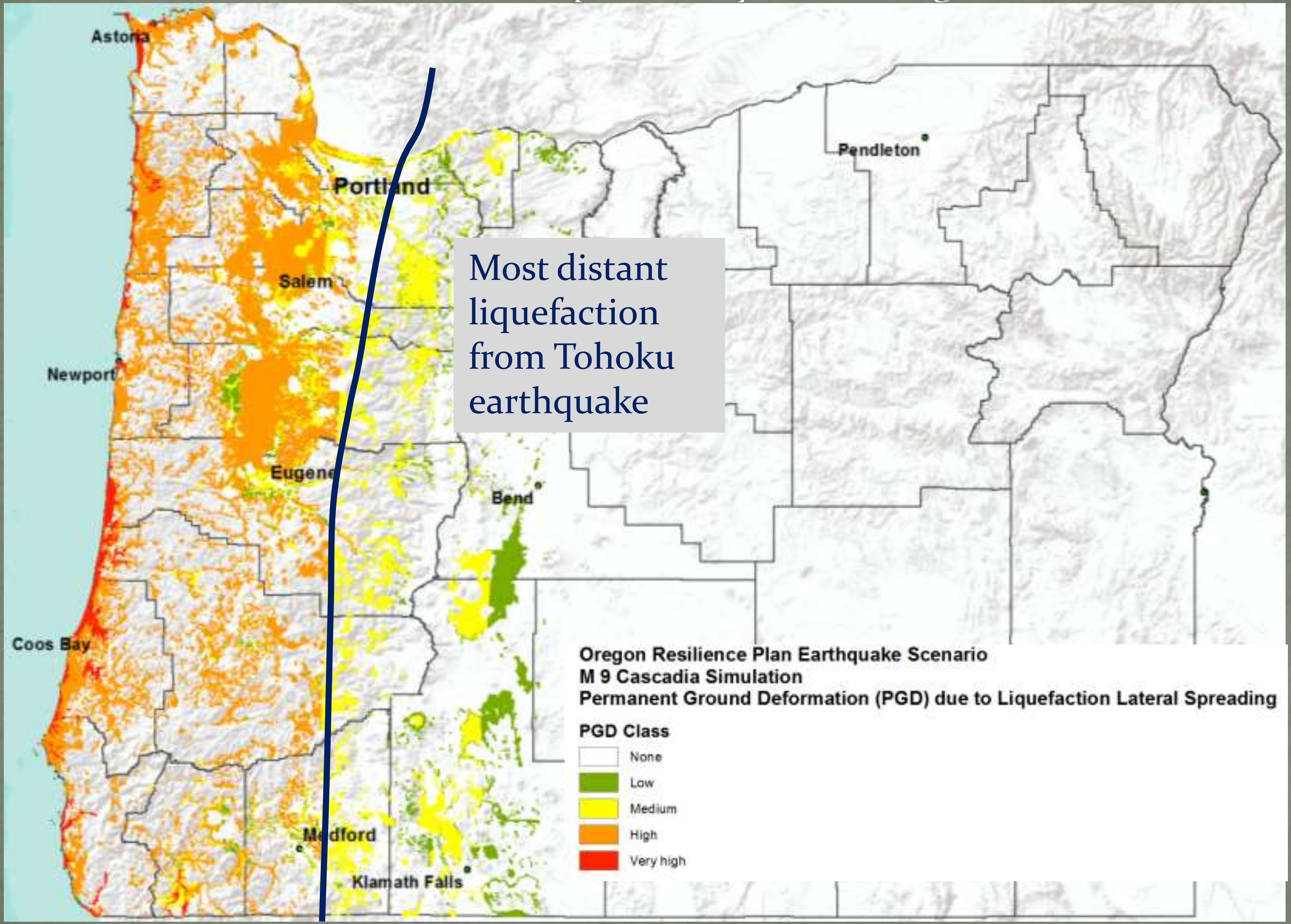
A magnitude 9 earthquake will cause liquefaction of susceptible soil over much of the western half of the state, it will be particularly severe along the Coast.



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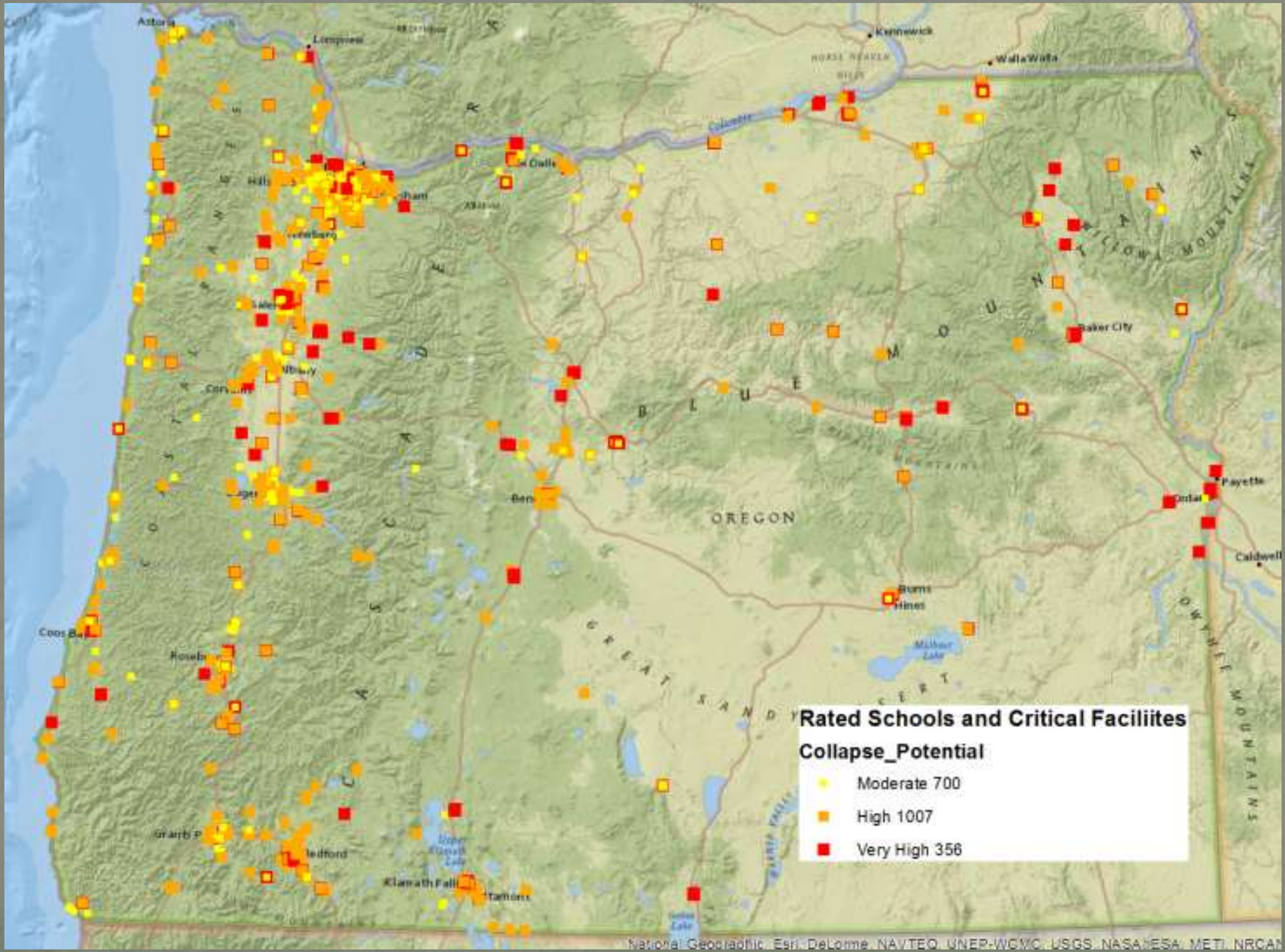
Oregon has many highly vulnerable critical buildings and schools. Buildings designed before 1974 did not consider earthquakes in their design. Subduction zone earthquakes have only been considered in design since 1993.Even today, the building code earthquake design goal is to protect the lives of the building occupants, not to ensure that the building will be useable after the earthquake.



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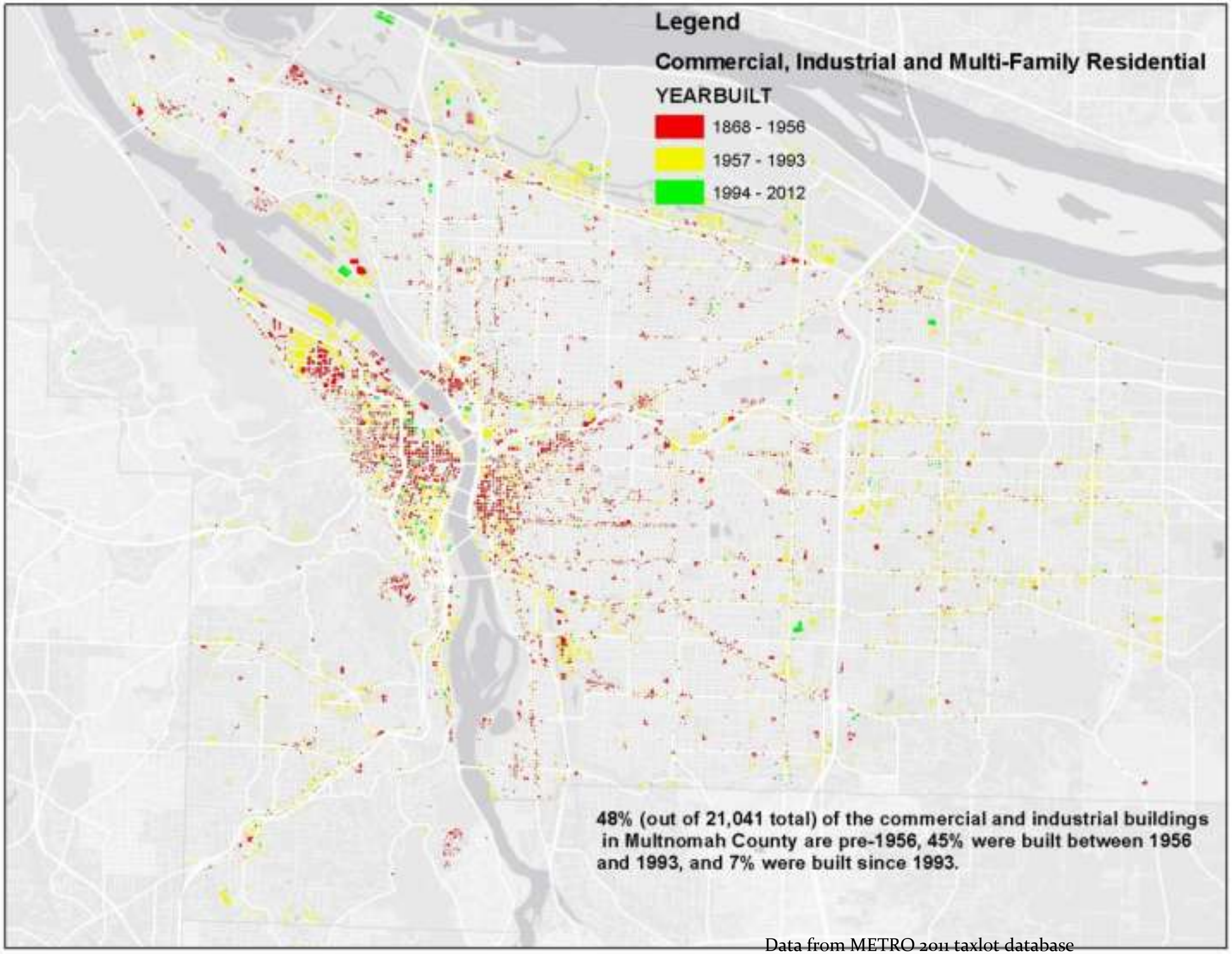
Data from DOGAMI Statewide Seismic Needs Assessment

In Portland earthquakes were not considered in building design before 1956, and subduction earthquakes were not considered before 1993, leaving large numbers of potentially vulnerable buildings.



Data from METRO 2011 taxlot database

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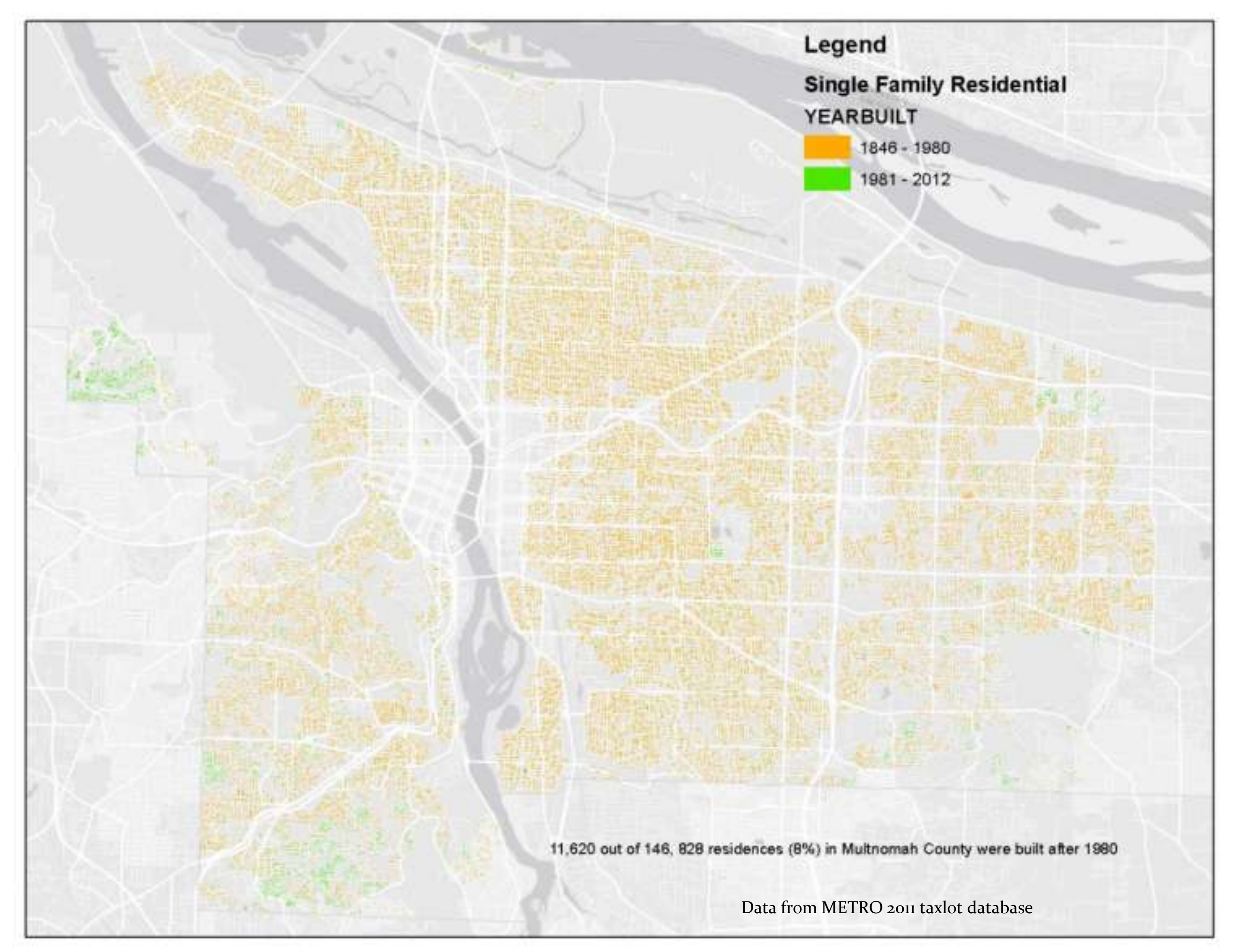
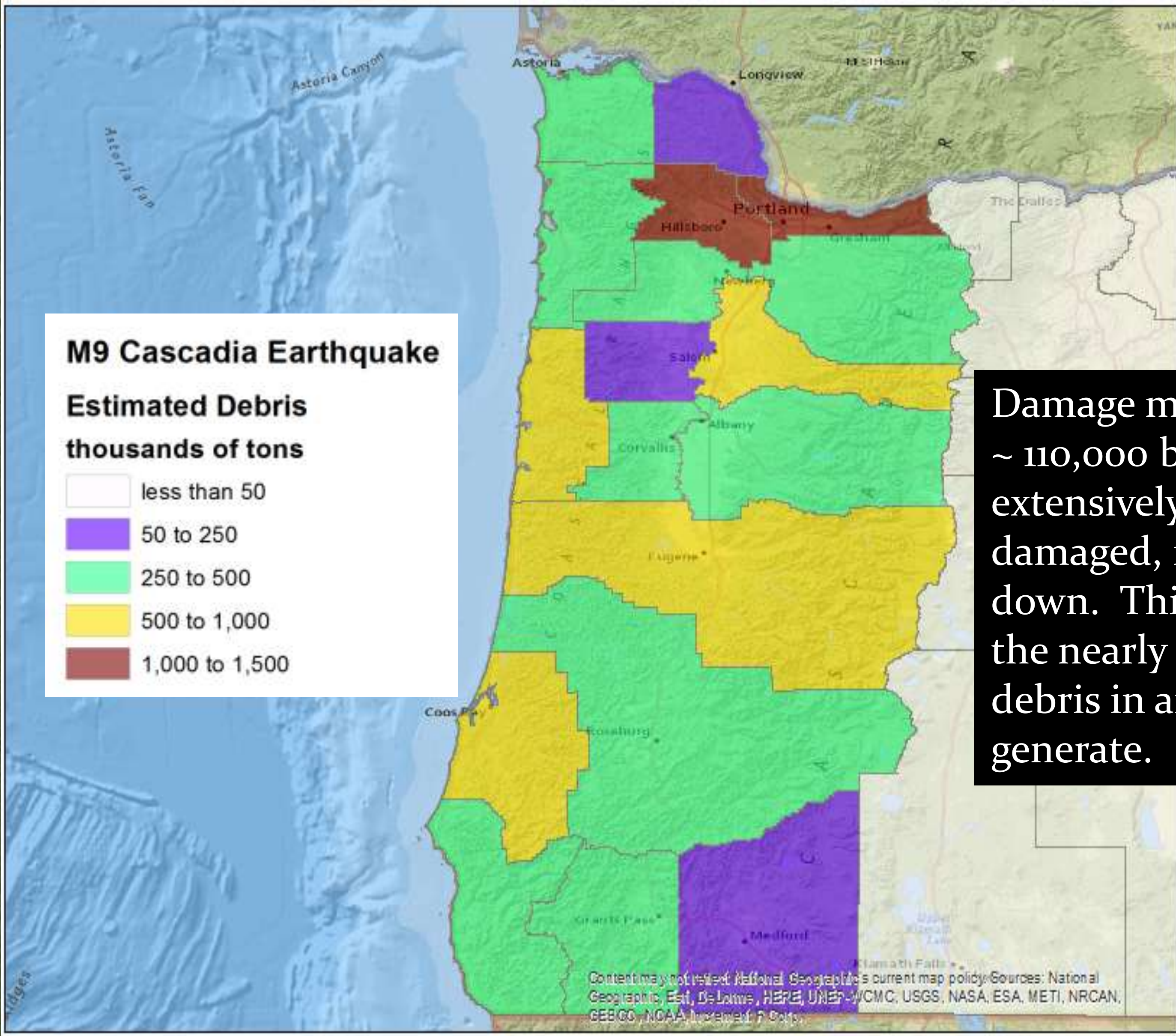
The majority of residences in Portland were built before codes required that houses be bolted to their foundation, leaving large numbers potentially vulnerable to damage that would make them uninhabitable.





Damage models show that ~ 110,000 buildings will be extensively or completely damaged, most will be torn down. This will contribute to the nearly ten million tons of debris in an M9 is estimated to generate.

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Lifelines; power, water, gas sewer, fuel, transportation and communication systems are both critical and vulnerable.

Coos Bay Bridge for Hwy 101, built in 1936

Earthquake-resistant Lake Oswego Sewer Interceptor

Fuel storage tanks on potentially liquefiable soil in Portland harbor

Oregon State Capitol, in need of $250 M seismic retrofit

Transmission towers on liquefiable soil

Washington Park reservoir on historically active landslide

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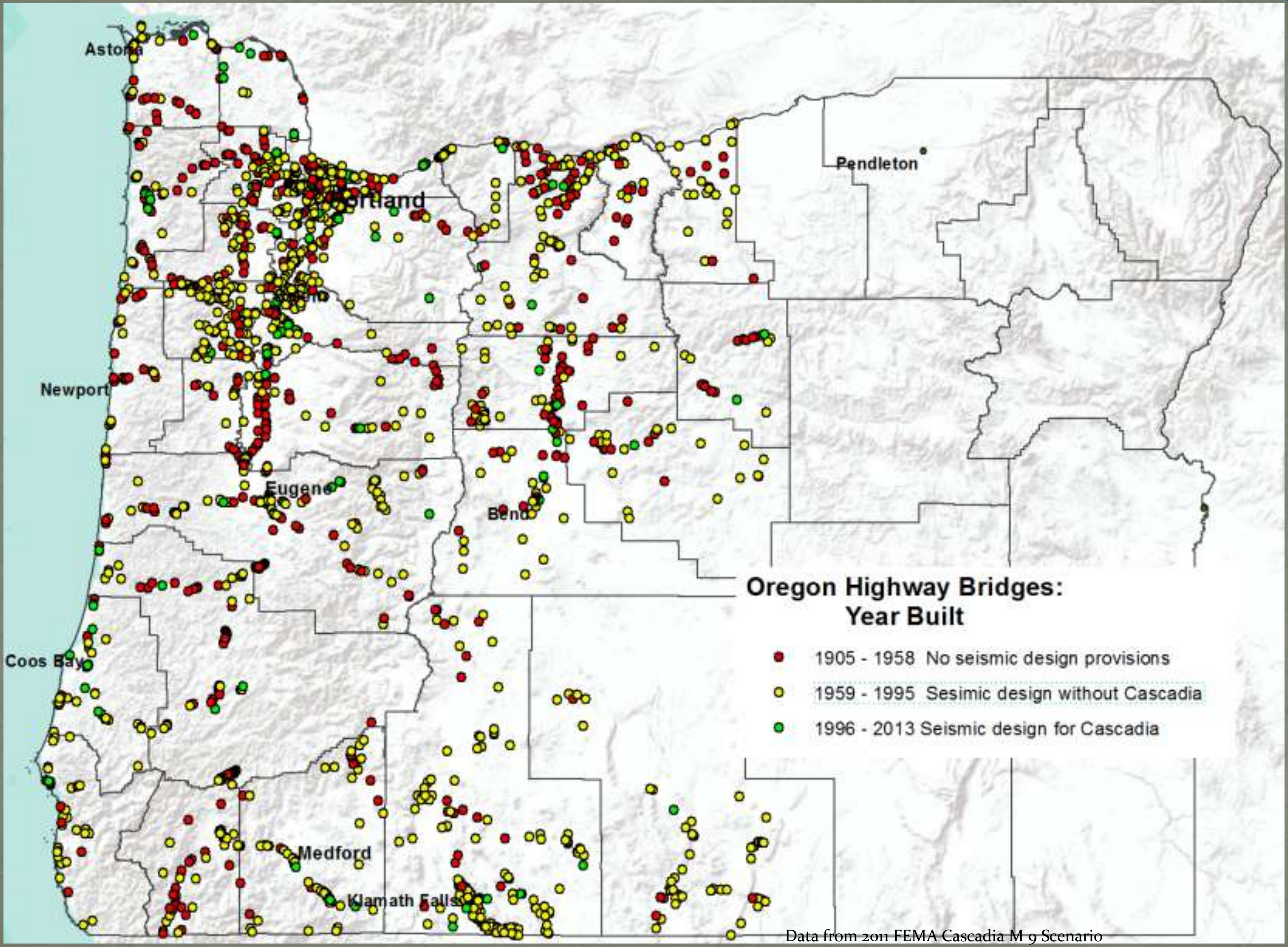
Lifeline Vulnerability: Most ODOT bridges are not designed for Cascadia Earthquake



Data from 2011 FEMA Cascadia M 9 Scenario

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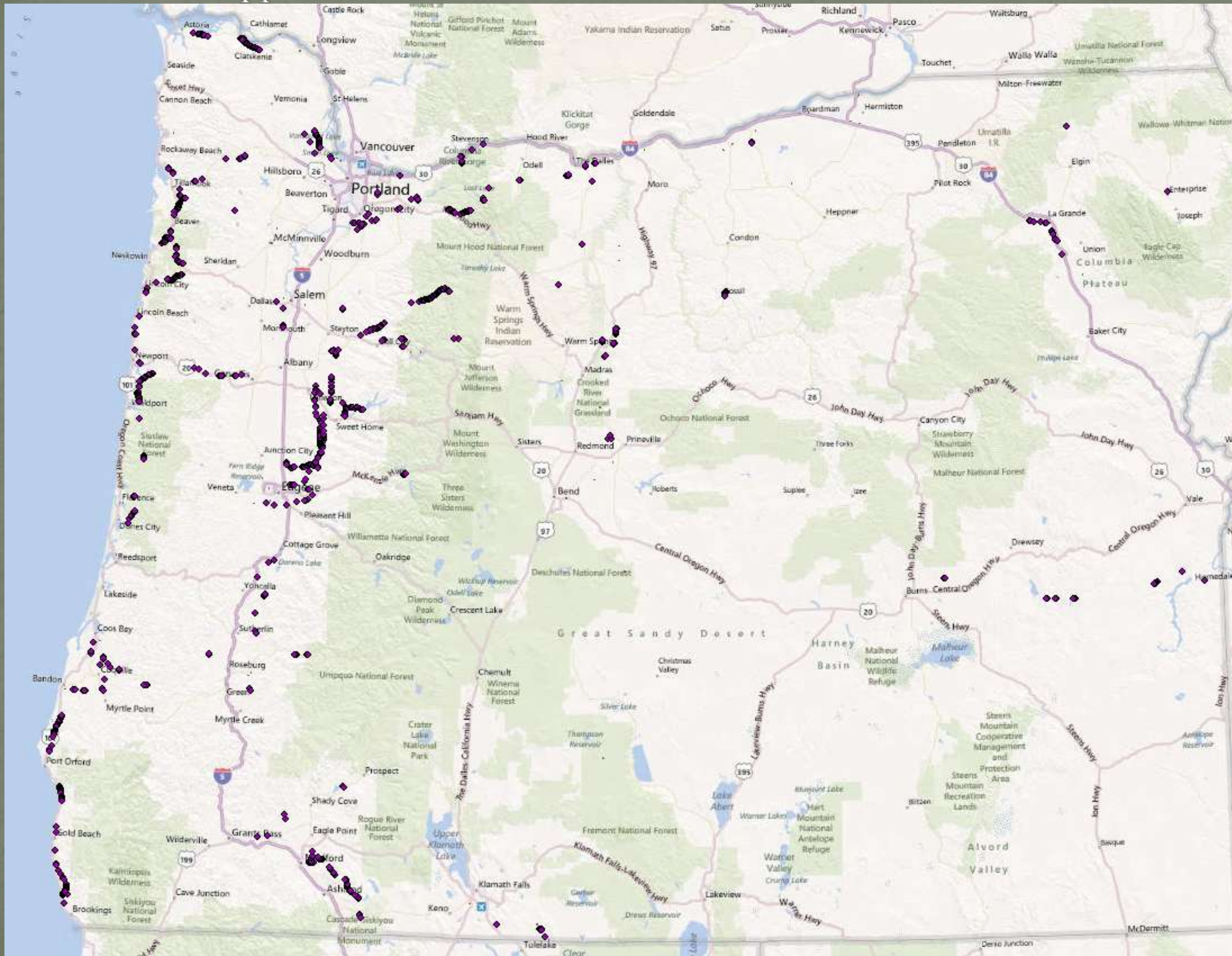
Lifeline Vulnerability: 1238 out of 24,528 inventoried transmission towers in Oregon are located on mapped landslides



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ORWARN 9/24/2012

Ian Madin, Chief Scientist, DOGAMI

Energy Facilities on Liquefiable Ground

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Damage in the tsunami zone will be nearly complete. The M 9 tsunami zone in Oregon contains 1900 businesses and 10,500 housing units occupied by 22,000 residents.

M 9 tsunami at Rockaway Beach

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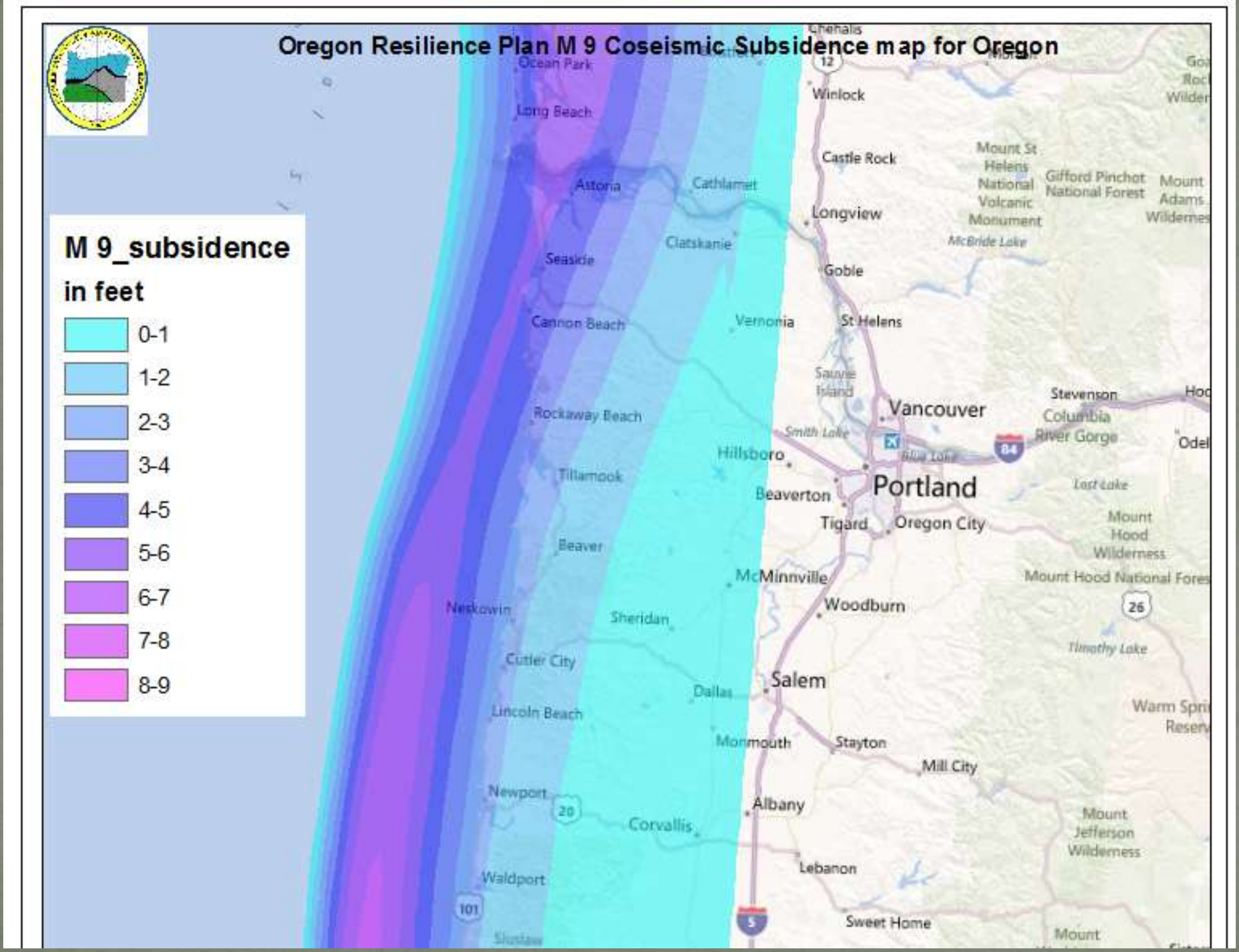
Co-seismic subsidence will accompany the next Cascadia earthquake, instantly and permanently changing local sea level



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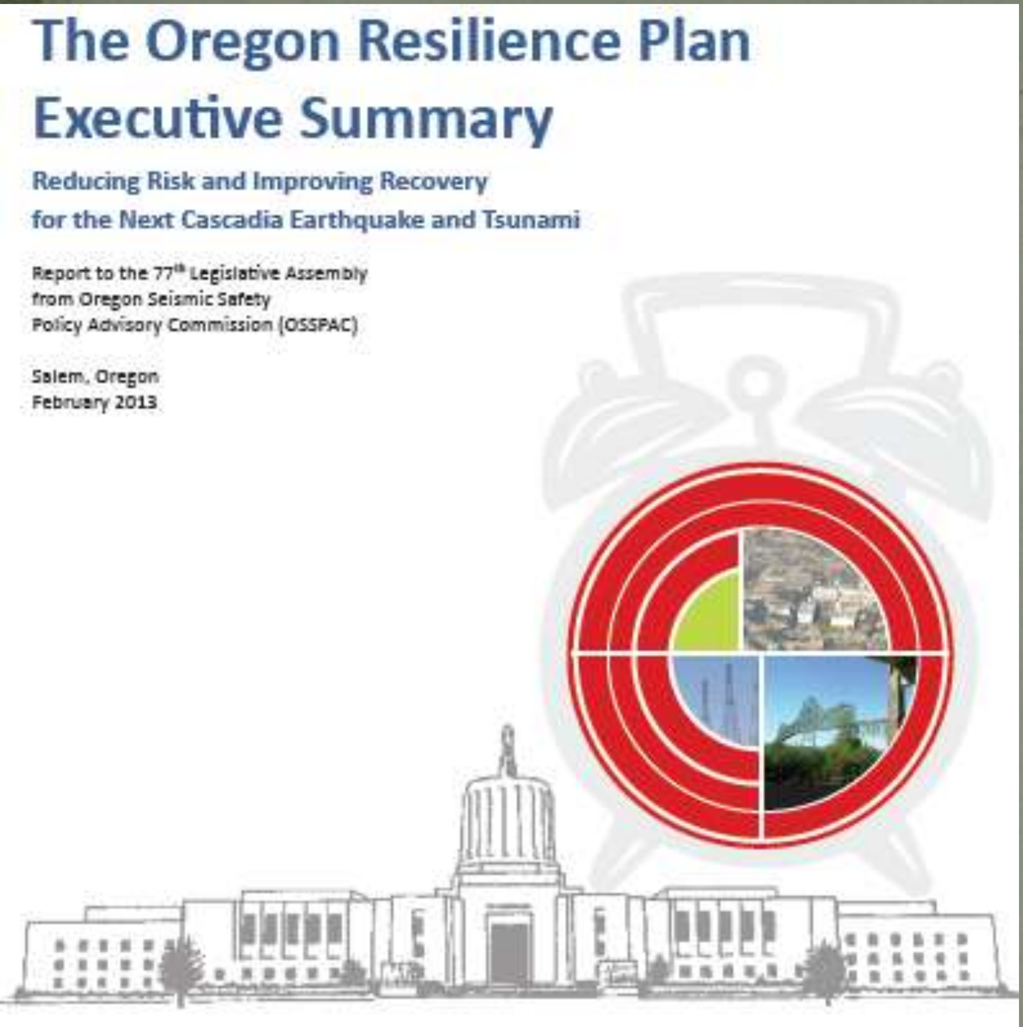


The Oregon Resilience Plan
Executive Summary

Reducing Risk and Improving Recovery
for the Next Cascadia Earthquake and Tsunami

Report to the 77th Legislative Assembly
from Oregon Seismic Safety
Policy Advisory Commission (OSSPAC)

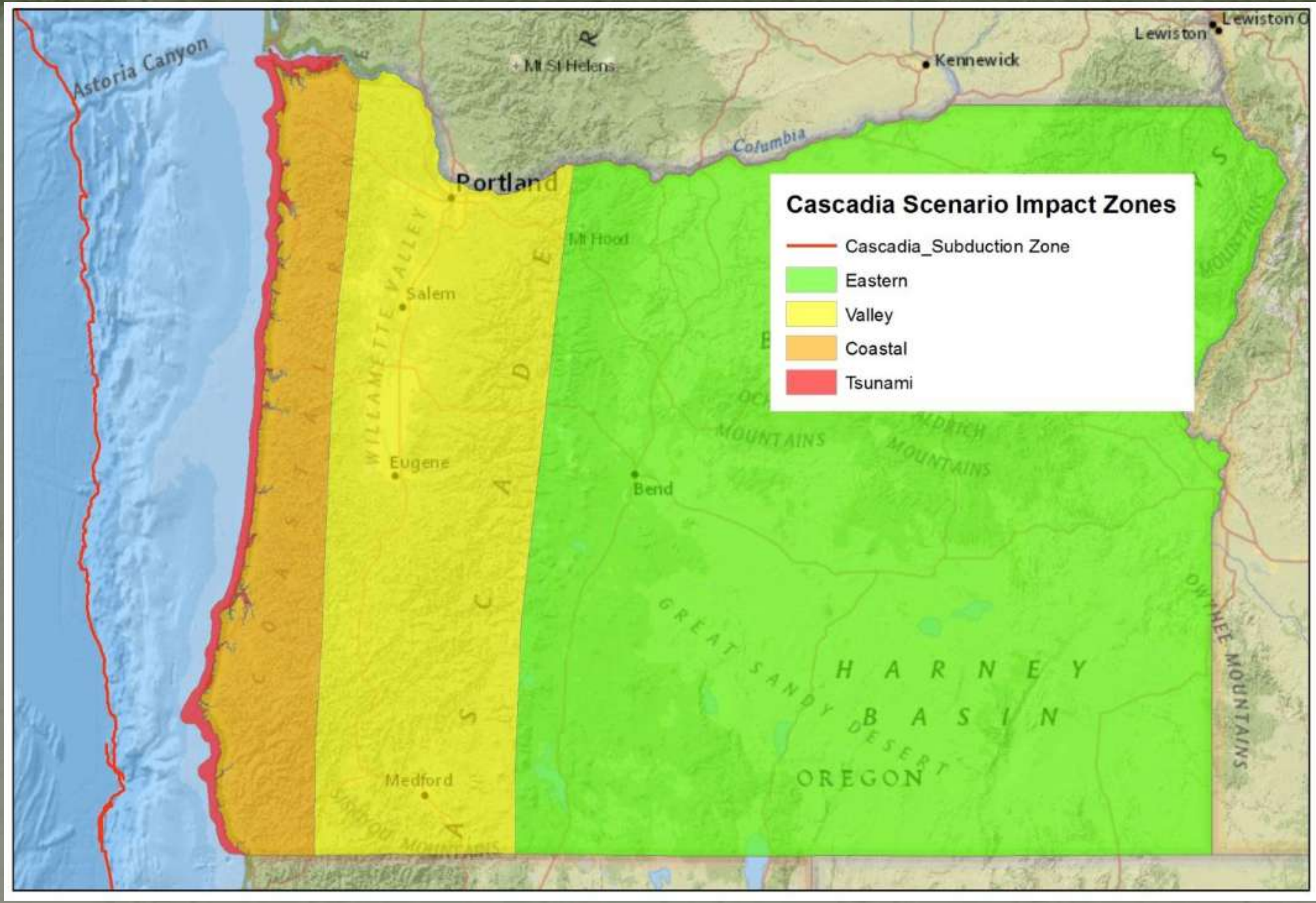
Salem, Oregon
February 2013

2013 Oregon Resilience Plan

Prepared by OSSPAC at request of Legislature

- 18 month effort by ~200 volunteers
- Evaluated likely performance of systems needed to sustain commerce
- Identified desired post earthquake performance goals
- Gap analysis and recommendations to close the gap

http://www.oregon.gov/OMD/OEM/osspac/docs/Oregon_Resilience_Plan_Final.pdf



Resilience Plan defines Cascadia M 9 Scenario impact zones

- Damage in the Tsunami zone will be extreme
- Damage in the Coastal zone will be heavy
- Damage in the Valley zone will be moderate, but affect most of Oregon's population
- Damage in the Eastern zone will be light

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Oregon Resilience Plan evaluates the gap between expected and desired seismic performance: The gap is large!

ENERGY SECTOR

Target Timeframe For Recovery

KEY TO THE TABLE

Desired time to restore component to 80-90% operational - In 50 Years	Resilient	G
Desired time to restore component to 50-60% operational - In 50 Years	Resilient	Y
Desired time to restore component to 20-30% operational - In 50 Years	Resilient	R
Current state restoration to 90% operational	Today	X

TARGET STATES OF RECOVERY

	Event Occurs	0-24 Hours	1 - 3 Days	3-7 Days	1 - 3 Weeks	3 Weeks - 1 Month	1 Month - 3 Months	3Months - 6 Months	6 Months - 1 year	1 year - 3 Years
ELECTRIC	ZONE: WILLAMETTE VALLEY									
All - see notes below										
Transmission						X				
Substation							X			
Distribution						X				
NATURAL GAS										
Transmission						X				
Gate Stations						X				
Distribution						X				
LIQUID FUEL										
Transmission										
Storage										
ELECTRIC	ZONE: EASTERN OREGON									
All - see notes below										
Transmission				X						
Substation					X					
Distribution				X						
NATURAL GAS										
Transmission						X				
Gate Stations						X				
Distribution						X				
LIQUID FUEL										
Transmission										
Storage										
ELECTRIC	ZONE: COAST (Non Tsunami Zone)									
All - see notes below										
Transmission							X			
Substation								X		
Distribution						X				
NATURAL GAS										
Transmission						X				
Gate Stations						X				
Distribution						X				
LIQUID FUEL										
Transmission										
Storage										

Colored blocks show desired performance, X marks current conditions

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Businesses will start to leave after one month without services, and the gap analysis shows that most services will take much longer to restore.

Critical Service	Zone	Estimated Time to Restore Service
Electricity	Valley	1 to 3 months
Electricity	Coast	3 to 6 months
Police and fire stations	Valley	2 to 4 months
Drinking water and sewer	Valley	1 month to 1 year
Drinking water and sewer	Coast	1 to 3 years
Top-priority highways (partial restoration)	Valley	6 to 12 months
Healthcare facilities	Valley	18 months
Healthcare facilities	Coast	3 years

DRAFT

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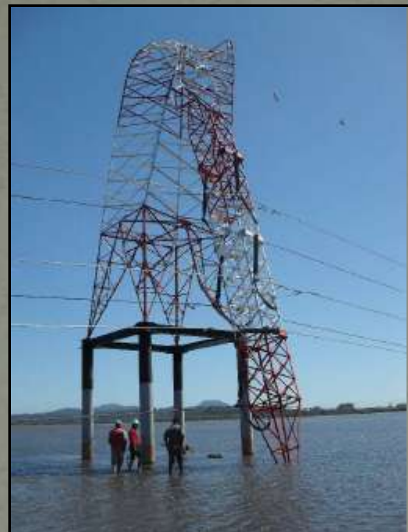
Interdependencies will make disaster recovery much more difficult. The earthquake will damage all systems at the same time.



To restore electric service, you need to reopen roads

To restore water service, you need electricity

To restore fuel supplies you need electricity

To reopen roads, you need to restore fuel supplies

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Oregon Resilience Plan
Some Plan recommendations include:

Assess

Inventory public and private buildings and lifeline systems and evaluate their seismic vulnerability. Improve earthquake damage and loss estimates

Upgrade

Seismically retrofit or replace public buildings, transportation systems, lifelines, privately owned dangerous buildings.

Educate

Teach Oregonians about Cascadia earthquake threats, tsunami evacuation and the need for two-week self-sufficiency Train additional post earthquake damage inspectors

Lead

Establish State Resilience office, building seismic safety rating system, improve seismic design review.

Engage

Develop community preparedness rating to inform residents, build business partnerships with Emergency Operations Centers,

Plan

Plan for business continuity, for shelter and transport for resident and tourist populations, for effective tsunami evacuation, for relocating critical facilities out of tsunami zone and rebuilding of coastal economies

Are we doomed?

Not necessarily. Odds are that we have decades to prepare, and slow steady progress can result in a much more resilient society. An important first step is to institutionalize awareness, when organizations shift from asking why they need to take action to asking how they are going to pay for it, we are on the right track.

•Our building codes now recognize the threat and we design accordingly. ODOT and large water districts are undertaking system-wide evaluations and developing upgrade programs.
•Substantial state funding is now available to retrofit of schools and critical facilities.
•Coastal school districts are replacing schools in the tsunami inundation zone.

We are making progress, let's hope we have time.

Institutional Preparedness

Address structural hazards at your facilities $$$

Address non-structural hazards at your facilities $$

Plan for post-earthquake continuity $

Engage Customers and vendors $

Engage state and local government $

Engage trade and professional associations $

Support your staff! $

Personal Preparedness

Make a family disaster plan
Prepare for 2 weeks of self sufficiency
Secure your home; water heater, chimney, foundation bolts.
Engage your neighbors
Engage state and local politicians

Know your tsunami evacuation route

Red Cross, Oregon Emergency Management, FEMA are good resources

Short Term Environmental Impacts

- Fires following earthquake
- Spilled materials
- Dust
- Limited Response Capacity

Long Term

- Tsunami debris: wide range of materials distributed onshore, in estuaries, nearshore
- Inland Debris: volume, sorting/recycling, transportation, hazardous materials
- Sewage: long restoration times for urban systems, large population sheltered in place or in shelters/camps
- Interdependency: long times to regain monitoring, inspection and remediation capacity
- Sediment: long term input of sediment from co-seismic landslides.

Questions?