Cascadia Subduction Zone Earthquake

"What you may not know about the Cascadia Subduction Zone Earthquake and Your Need to Prepare"

2014 Prepare Together Readiness Fair

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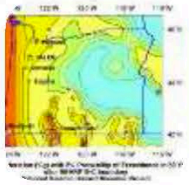
Information and Readiness

- Cascadia Subduction Zone
- Personal and Family Readiness
- Questions

Cascadia Subduction Zone

The following 6 slides are quick reference graphics from the focused presentation, adapted by Oregon Emergency Management, which follows thereafter.

Know your Cascadia Subduction Zone



600 miles long, from northern California to British Columbia

Capable of producing very large earthquakes (M9+) that impact a wide area

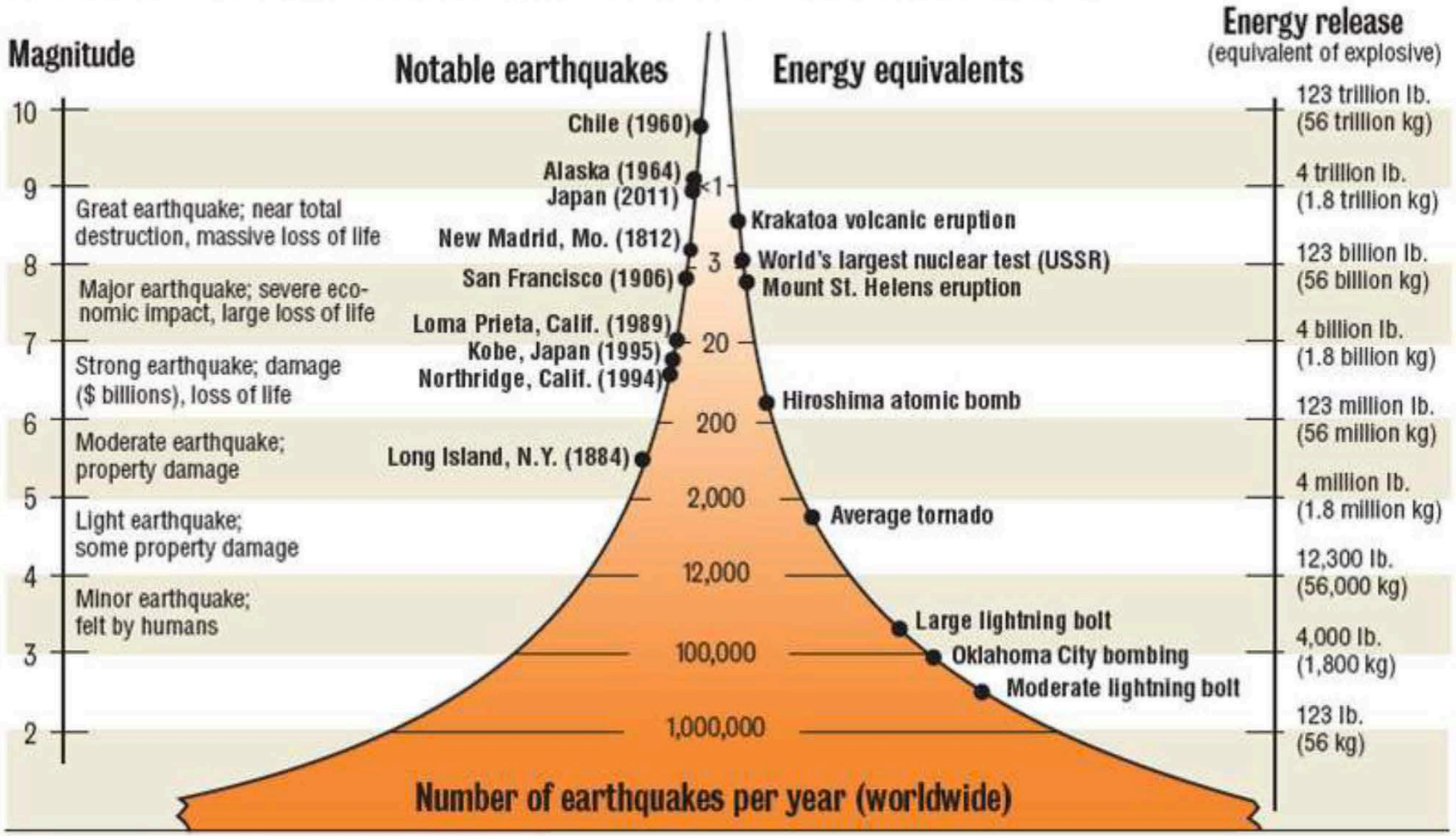
Similar in size and impact to the 2004 Sumatra earthquake

Can produce devastating tsunamis

37% chance of a mega-thrust earthquake in the next 50 years *

Earthquake frequency and destructive power

The left side of the chart shows the magnitude of the earthquake and the right side represents the amount of high explosive required to produce the energy released by the earthquake. The middle of the chart shows the relative frequencies.



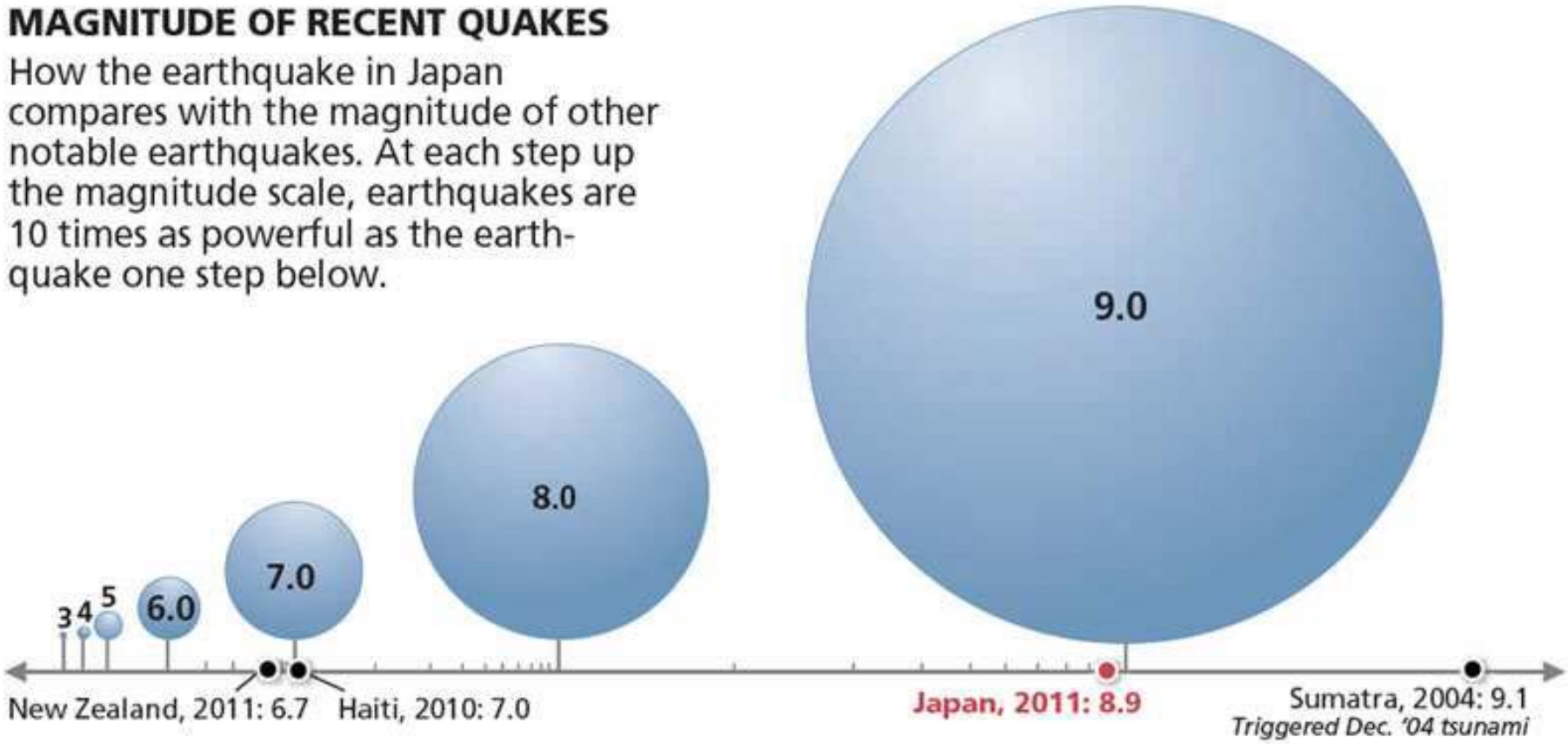
Source: U.S. Geological Survey

MCT

I	Instrumental	Not felt.	1-2
II	Just Perceptible	Felt by people sitting or on upper floors of buildings.	3
III	Slight	Felt by almost all indoors. Hanging objects swing. May not be recognized as an earthquake..	3.5
IV	Perceptible	Vibration felt like passing of heavy trucks. Windows, dishes, doors rattle. Glasses clink. In the upper range of IV, wooden walls and frames creak.	4
V	Rather Strong	Felt outdoors. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing. Pictures move. Pendulum clocks stop.	4.5
VI	Strong	Felt by all. People walk unsteadily. Many frightened. Windows crack. Weak plaster, adobe buildings, and some poorly built masonry buildings cracked.	5
VII	Severe	Difficult to stand or walk. Damage to poorly built masonry buildings. Fall of plaster, loose bricks. Some cracks in better masonry buildings.	5.5
VIII	Destructive	Extensive damage to unreinforced masonry buildings. Fall of some masonry walls. Wood-frame houses moved on foundations if not bolted	6
IX	Violent	General panic. Damage to masonry buildings ranges from collapse to serious. Wood-frame structures rack, and, if not bolted, shifted off foundations. Underground pipes broken.	6.5
X	Very Violent	Poorly built structures destroyed with their foundations. Even some well-built wooden structures and bridges heavily damaged and needing replacement.	7
XI	Extreme	Rails bent greatly. Underground pipelines completely out of service.	7.5
XII	Catastrophic	Damage nearly total.	8

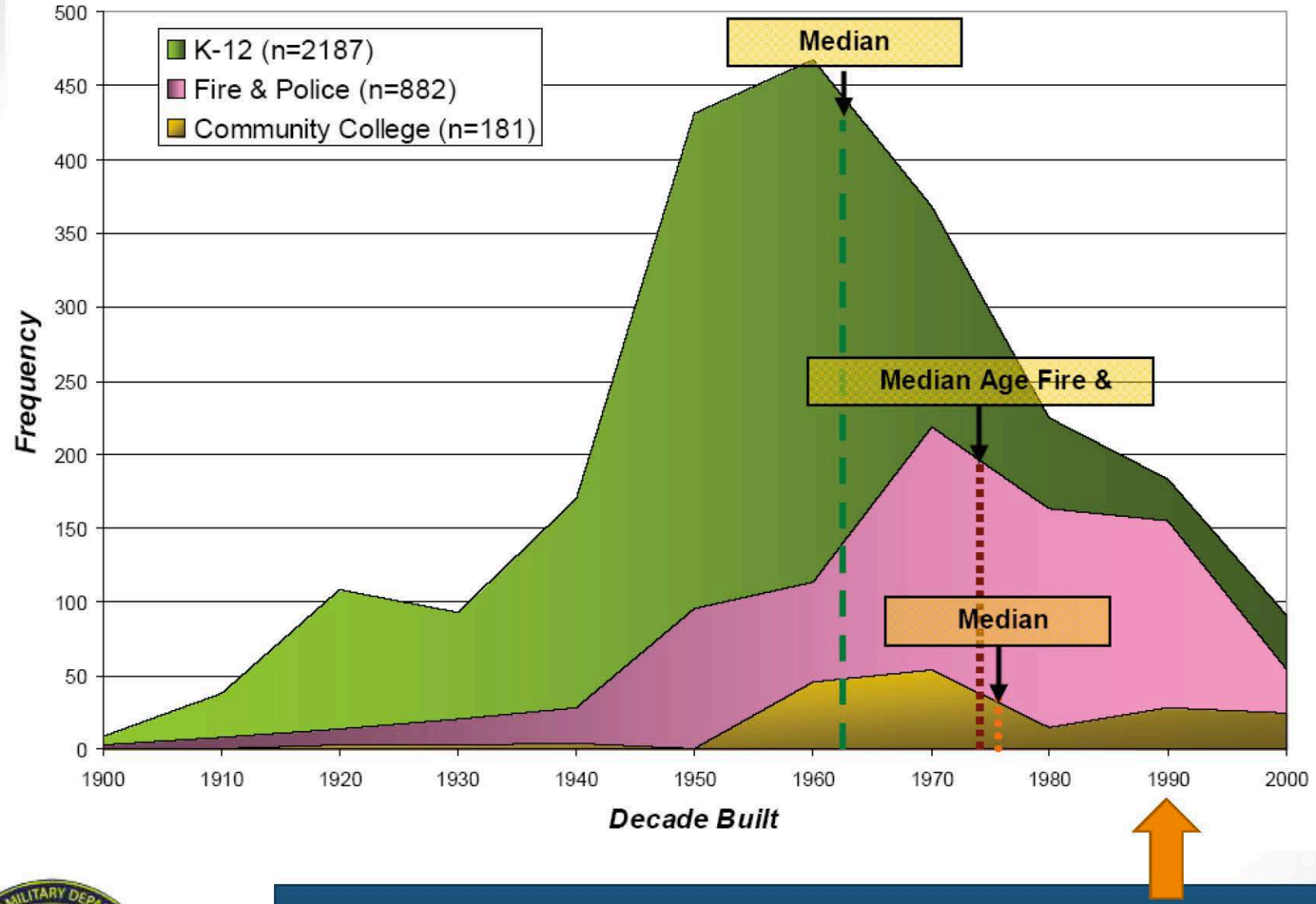
MAGNITUDE OF RECENT QUAKES

How the earthquake in Japan compares with the magnitude of other notable earthquakes. At each step up the magnitude scale, earthquakes are 10 times as powerful as the earthquake one step below.



Sources: U.S. Geological Survey, Washington Post

THE ARIZONA REPUBLIC



First seismic building codes in Oregon

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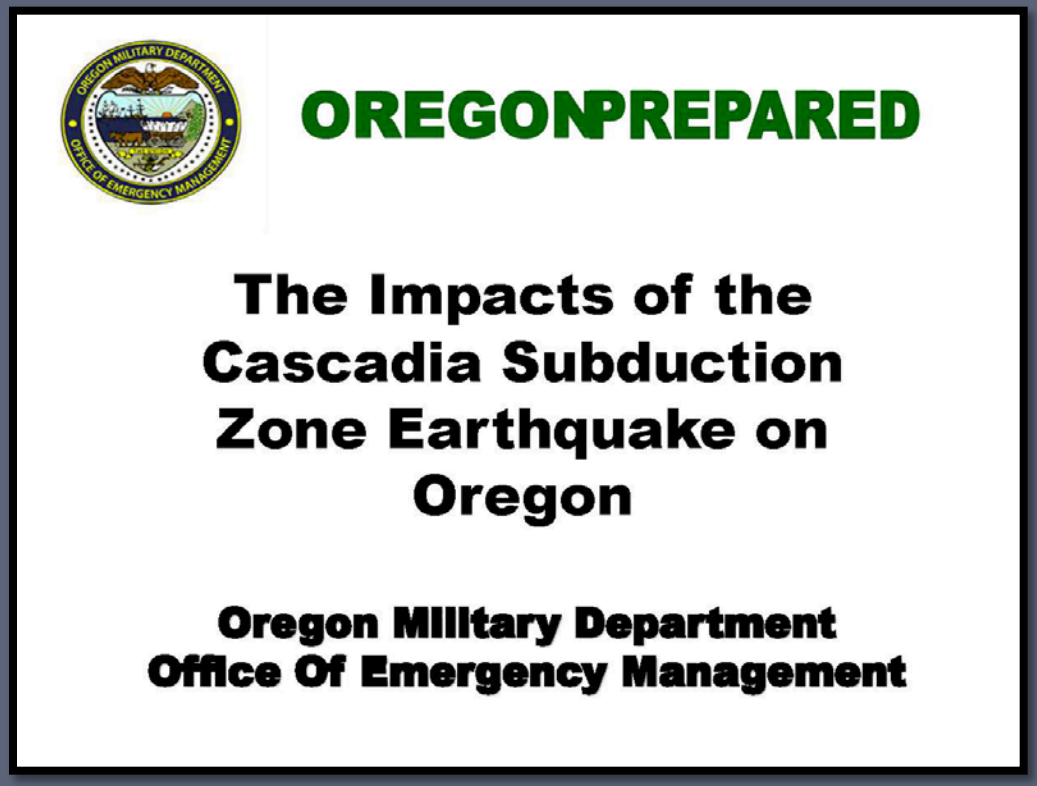
Critical Service	Zone	Estimated Time to Restore
Electricity	Valley	1 to 3 months
Electricity	Coast	3 to 6 months
Police and fire stations	Valley	2 to 4 months
Drinking water and sewer	Valley	1 month to 1 year
Drinking water and sewer	Coast	1 to 3 years
Top-priority highways (partial restoration)	Valley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

Cascadia Subduction Zone

The following slides were adapted from Oregon Emergency Management, 2014 The Impacts of the Cascadia Subduction Zone Earthquake, http://www.oregon.gov/OMD/OEM



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The Impacts of the Cascadia Subduction Zone Earthquake on Oregon

Oregon Military Department
Office Of Emergency Management

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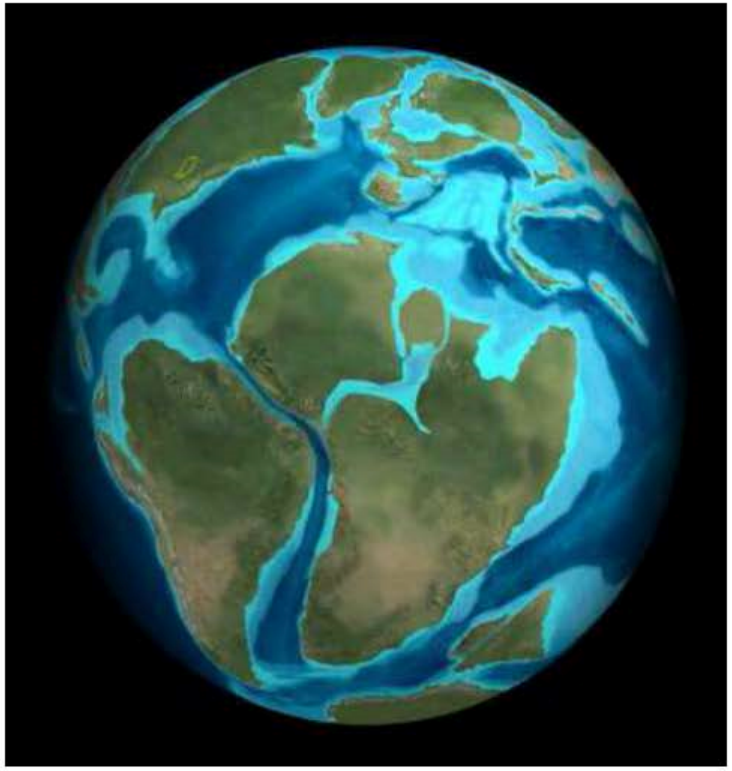
Everything you wanted to know about plate tectonics...



... In 30 seconds or less

- Tectonic Plates move around
- Tectonic Plates spread apart and create new land
- Tectonic Plates dive under each other
- Tectonic Plates roll over each other

SOURCE: http://sos.noaa.gov/videos/Scotese.mov

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What are the geologic hazards in Oregon?

- Earthquakes
- Volcanoes
- Tsunami
- Landslides

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Earthquakes

- **Earthquakes** occur when rock underground suddenly breaks along a fault. This sudden release of energy causes the seismic waves that make the ground shake.

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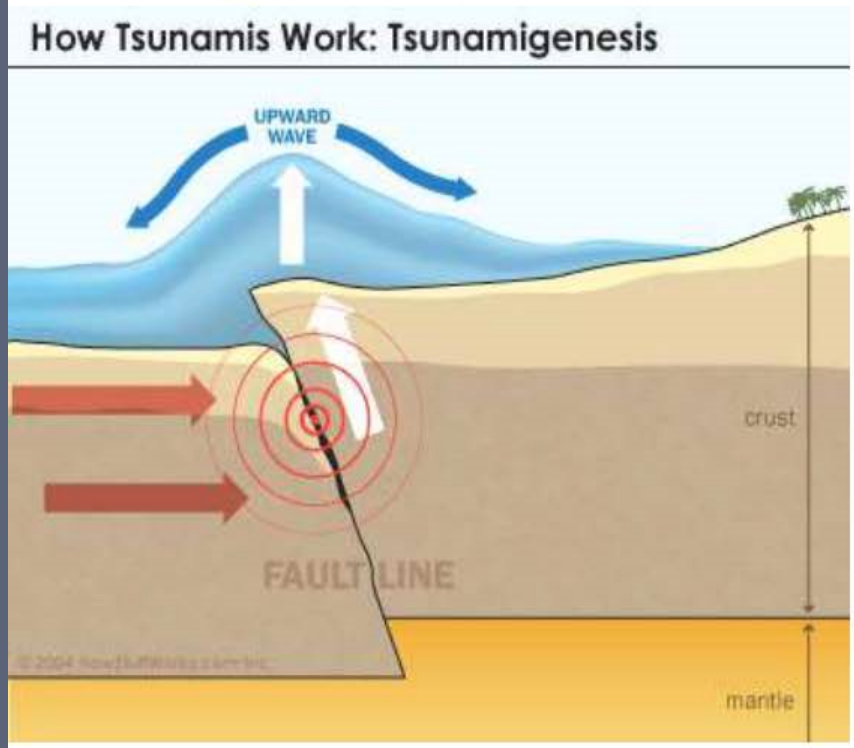

Tsunamis

- **Tsunamis are generated when geologic events cause large, rapid movements in the sea floor that displace the water column above.**
- **The Pacific Coast is at risk both from locally and distantly generated tsunamis.**

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- **Earthquakes**
  - Cascadia Subduction Zone
  - Crustal
  - Deep Intraplate
  - Volcanic
- **Tsunami**
  - Local (from subduction zone off our coast)
  - Distant (from subduction zone elsewhere)

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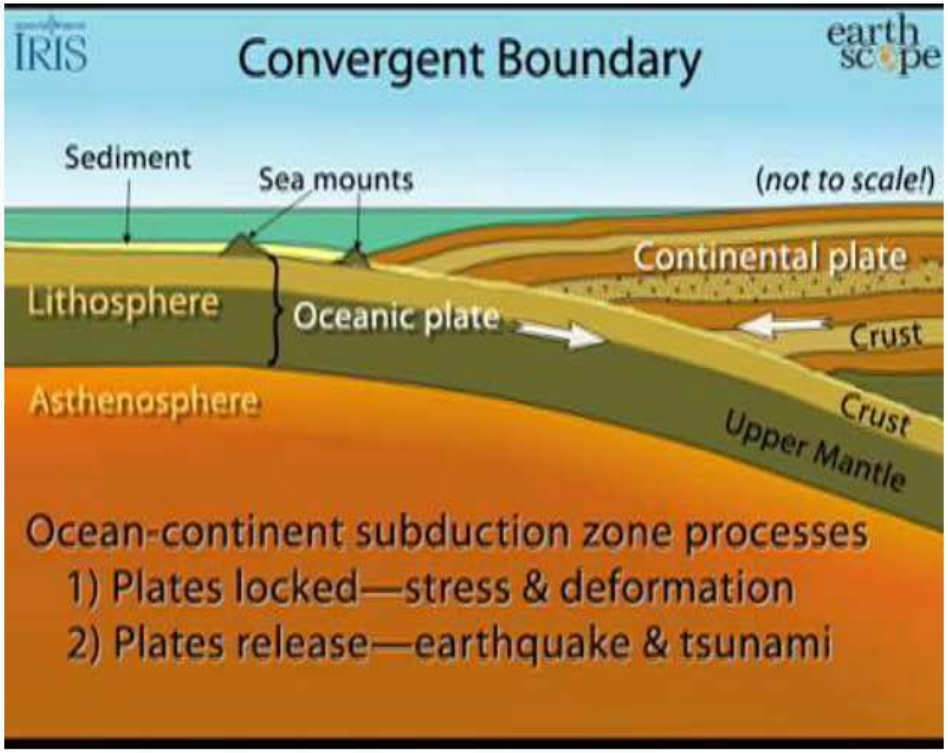
What is the Cascadia Subduction Zone?



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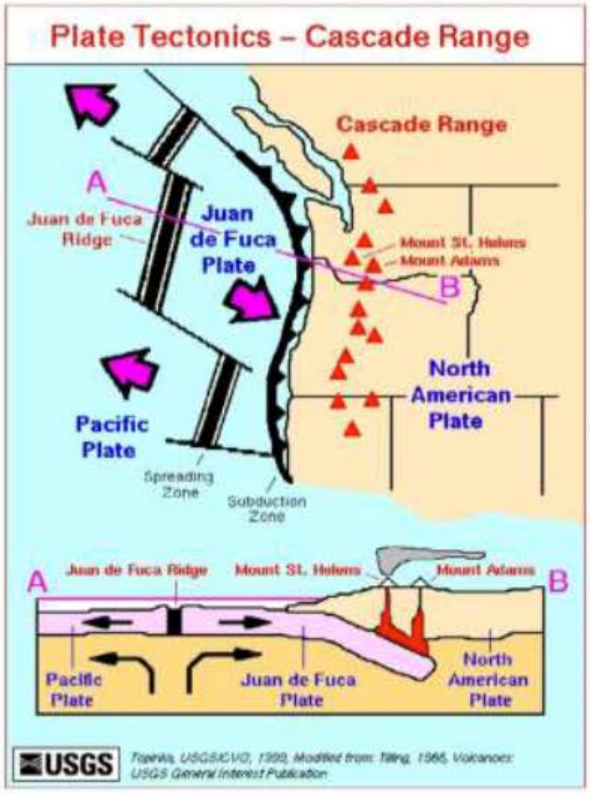
Know your Cascadia Subduction Zone



- **600 miles long, from northern California to British Columbia**
- **Capable of producing very large earthquakes (M9+) that impact a wide area**
- **Similar in size and impact to the 2004 Sumatra earthquake**
- **Can produce devastating tsunamis**
- **37% chance of a mega-thrust earthquake in the next 50 years ***

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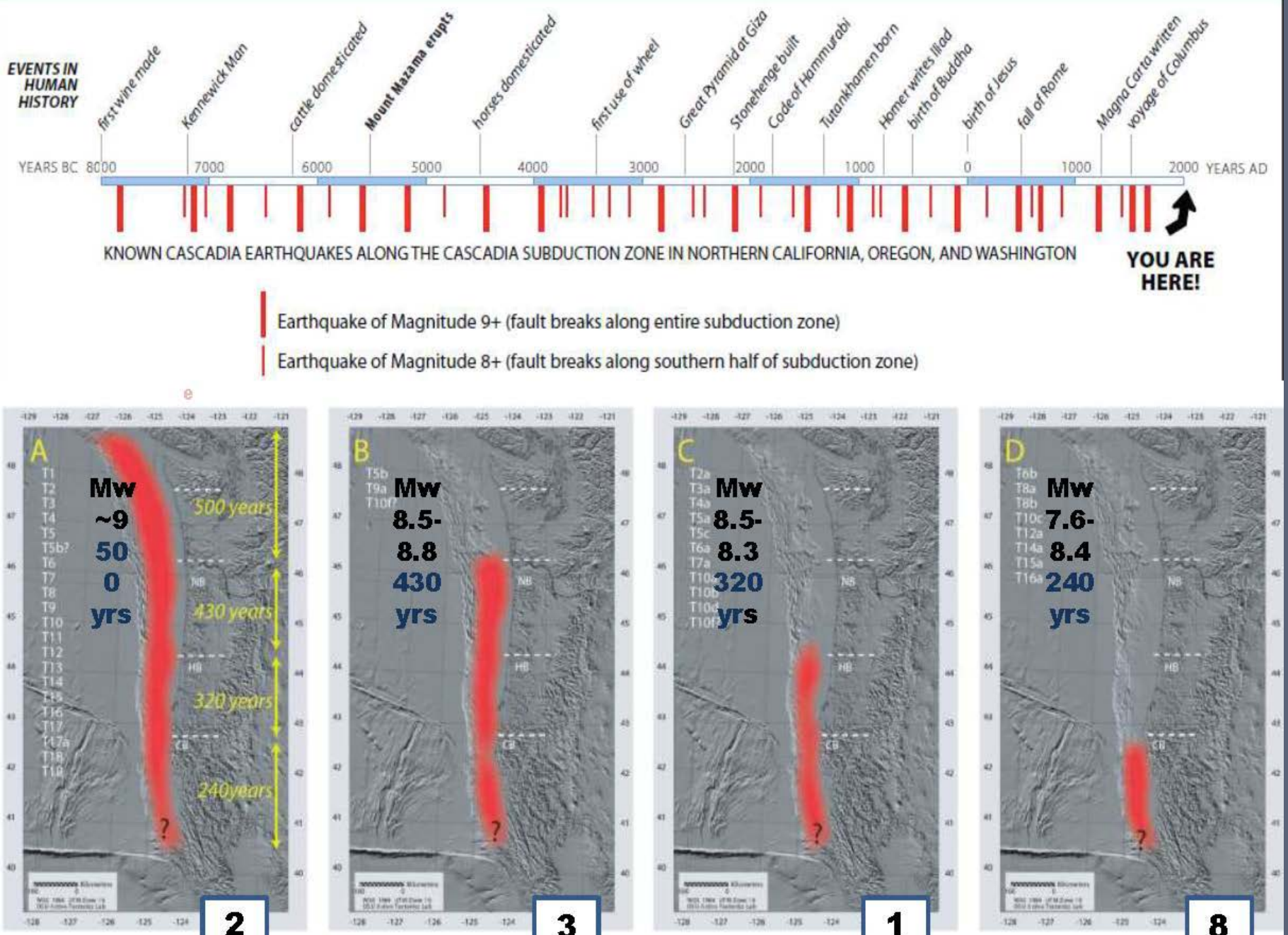
Ghost forest at Copalis River, WA

- **Last Cascadia Subduction Zone earthquake occurred in 1700**
- **When will the next one occur?**
  - **We just don't know**
- **Average recurrence:**
  - **240 years (south of Cape Blanco)**
  - **5-600 years (entire length)**
  - **190-1,200 years between EQ**



(Modified fro nger et al. (in press) by addi
magnitude estimates and some labels)

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- **Past 10,000 years**
  - **19 earthquakes that extended along most of the margin, stretching from southern Vancouver Island to the Oregon-California border**
  - **8.7 to 9.2 – really huge earthquakes.**
- **22 additional earthquakes that involved just the southern end of the fault**
  - **slightly smaller – more like 8.0 – 8.2**

We're in the Zone
And it WILL happen again

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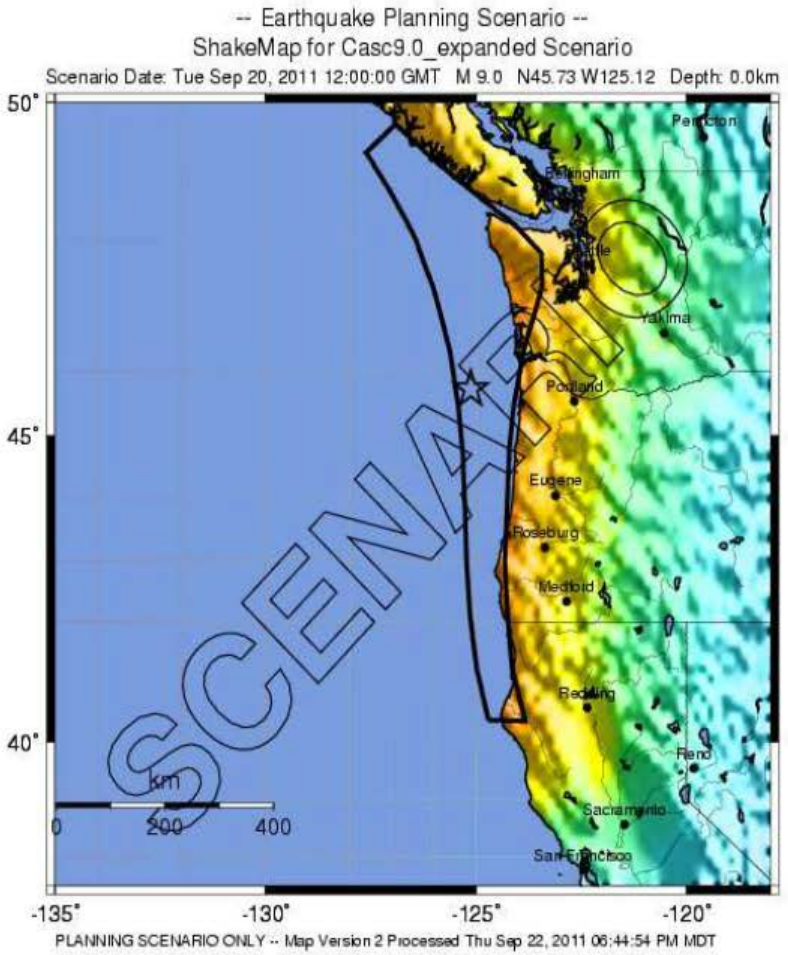
Cascadia
=
Strong Shaking and Tsunami

- **Strong Ground Shaking**
  - **M9 w/ 2 - 4 min shaking**
- **Tsunami**
  - **within 15 to 25 minutes**



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

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Strong ground shaking

2010 Haiti earthquake

1993 Molalla High School

2011 Tohoku earthquake

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Source: http://www.oregongeology.org/hazvu

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Coastal subsidence

2004 Sumatra

Mainichi Shimbun, Reuters

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Landslides

Landslides in Ferndale, WA

2010 Taiwan

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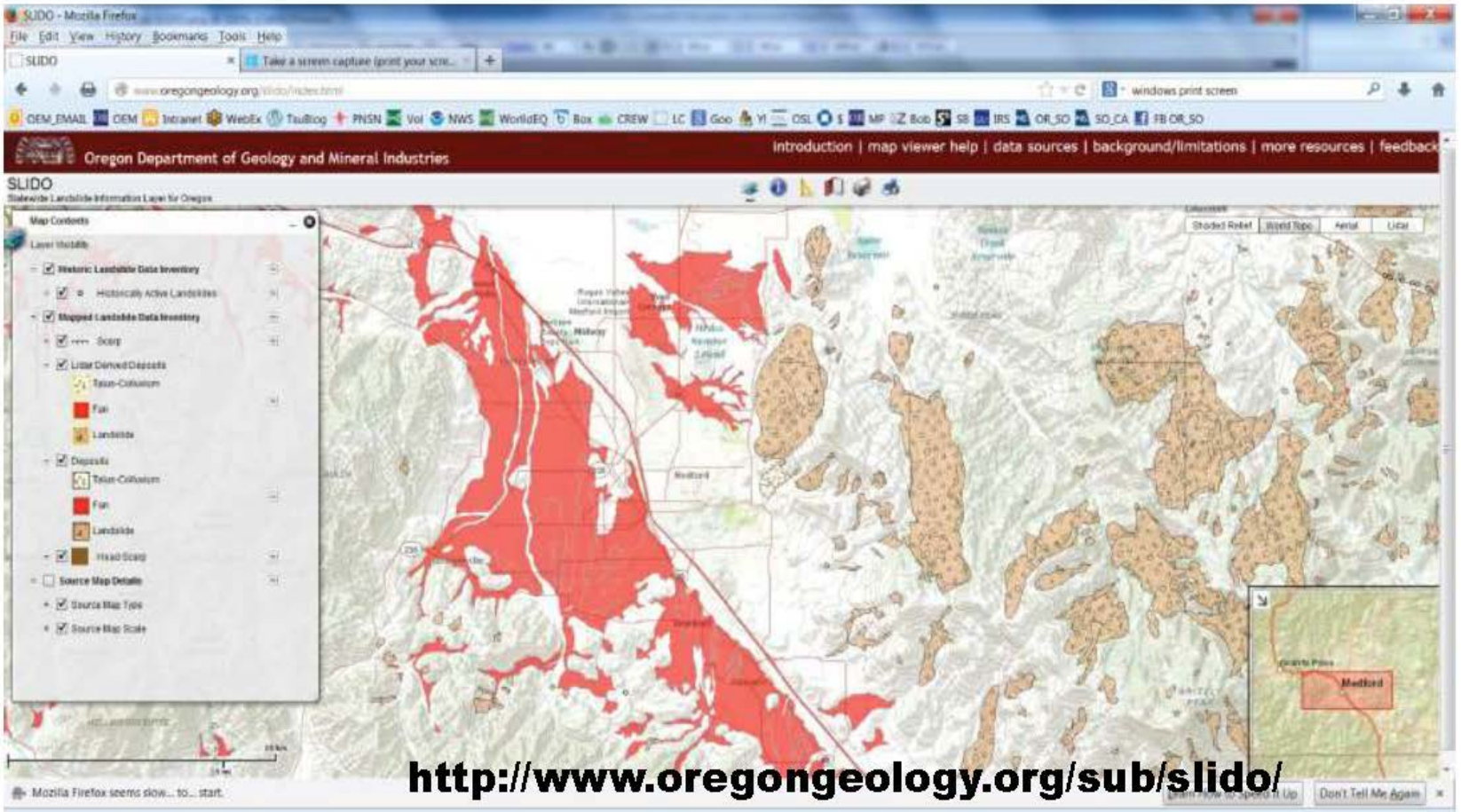
Landslides in Jackson County



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Liquefaction

1964 Alaska

2011 Christchurch, New Zealand

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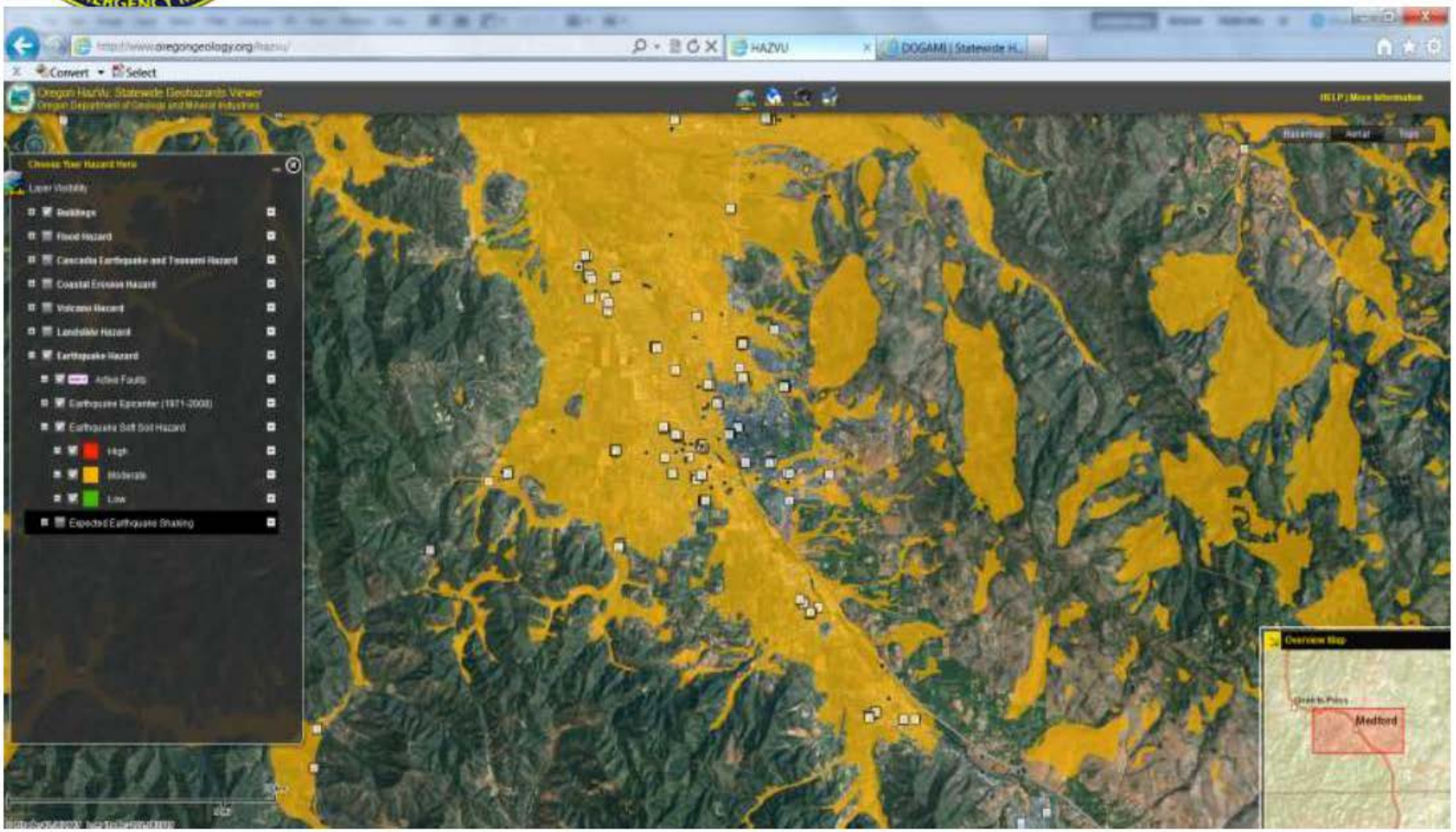

Source: http://www.oregongeology.org/hazvu

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Tsunami

2004 Indonesian tsunami

2011 Tohoku tsunami

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Tsunami

- **Local –** Caused by a subduction zone earthquake near the Oregon shore
- **Distant –** Caused by a subduction zone earthquake far away from the Oregon shore

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Distant Tsunami

- **Arrives 4 + hours after the earthquake**
- **Lower damage and flooding than local tsunamis**
- **National Tsunami Warning System can warn you**
  - **Warning and Advisory require protective action**
- **National Tsunami Warning Center**
  - **http://wcatwc.arh.noaa.gov/**

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Local Tsunami

- **Arrives minutes after the earthquake**
- **Much higher waves**
- **Much further inland penetration**
- **NOAA Tsunami Warning System ineffective**
- **Earthquake = Only Warning**
  - **NO OFFICIAL WARNING!**
  - **Self Evacuation required**

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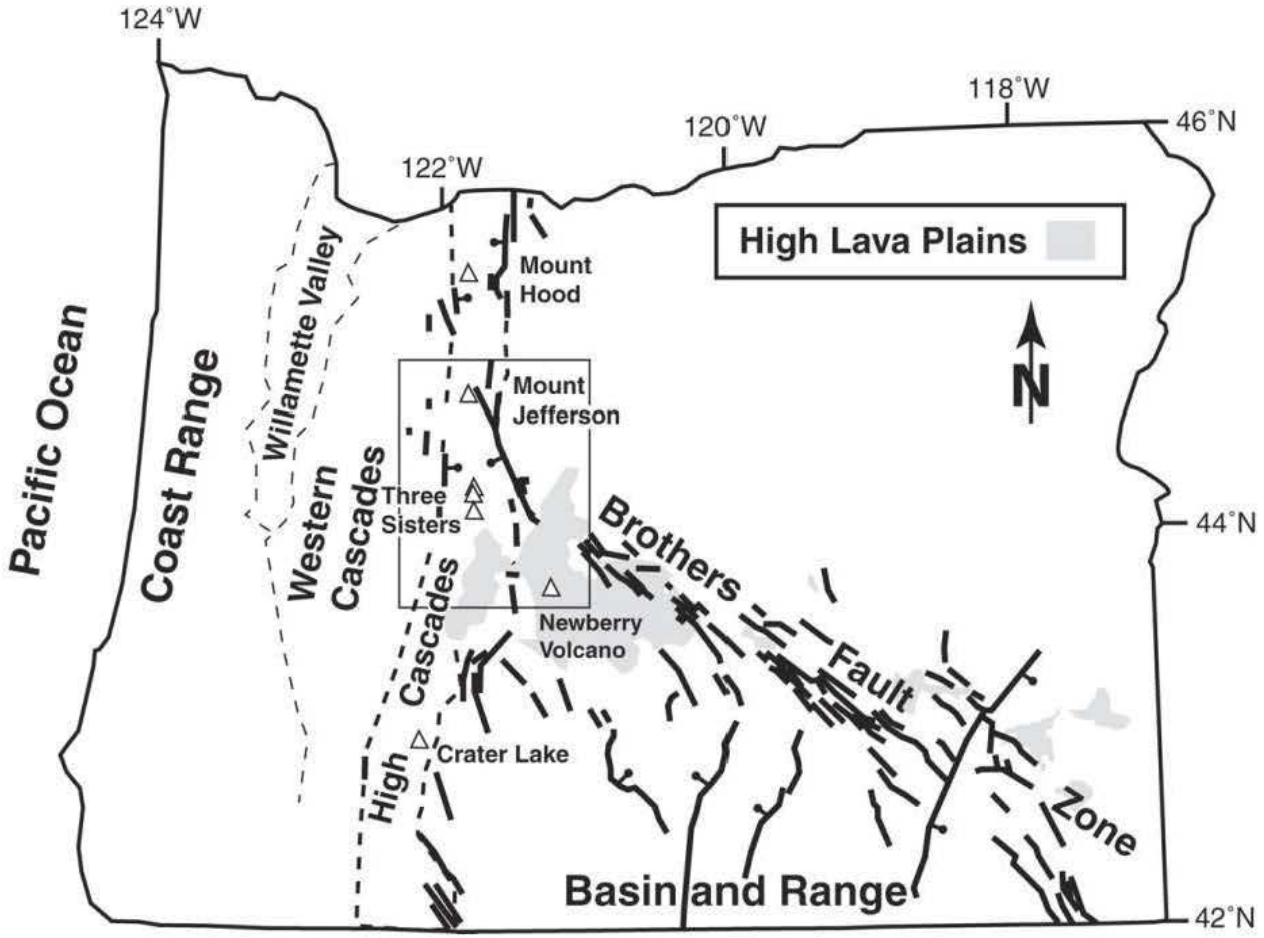
Crustal faults




What are the Implications?

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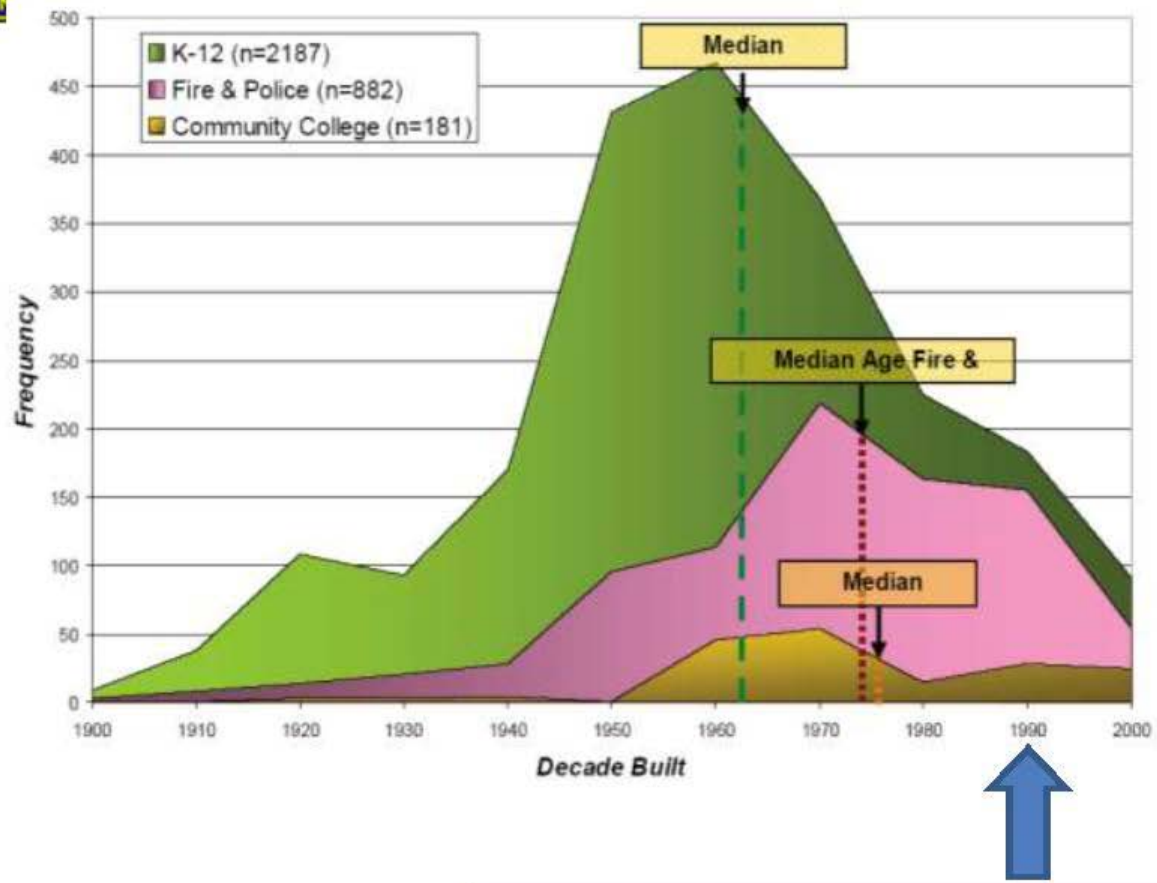

First seismic building codes in Oregon

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Damage to Homes

- **Displaced households**
  - **17,300***
- **Short-term shelter needs**
  - **12,400 People***

(Taken from a DOGAMI study (1999) of an 8.5M CSZ quake) - *this study does not include tsunami damage

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Damage to Schools

- 300,000 students in buildings subject to collapse during a Cascadia event
- Non-structural damage
- Needed for cultural continuity

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Damage to Businesses

- **$12-$50 Billion in Economic damages***
- **30,000-80,000 buildings destroyed***

(Taken from a DOGAMI study (1999) of an 8.5M CSZ quake) - *this study does not include tsunami damage

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Roads Damaged

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State of Oregon's bridges

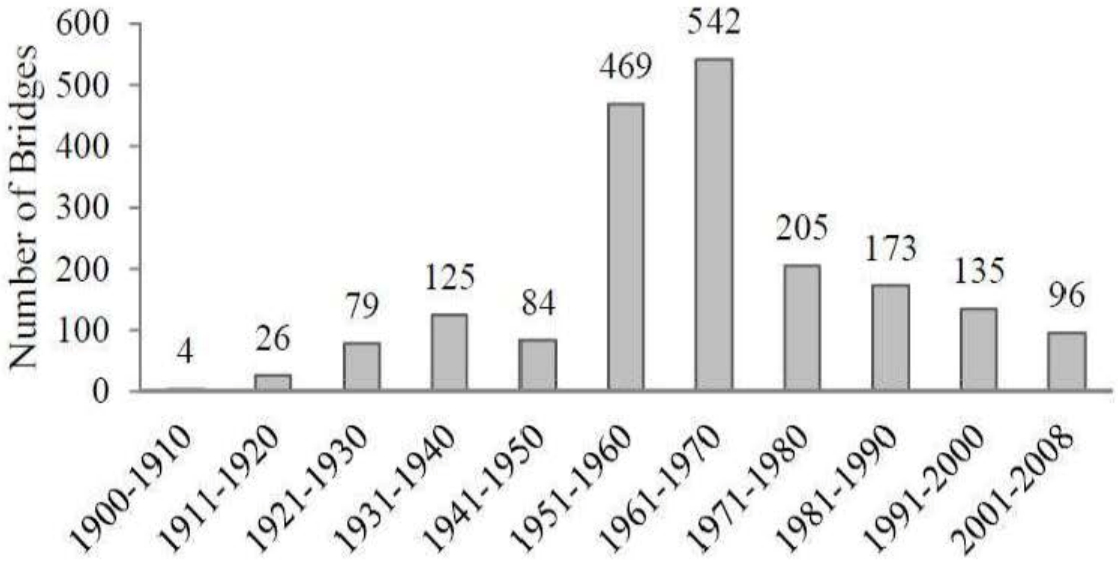

Figure 3: Distribution of year of construction completion

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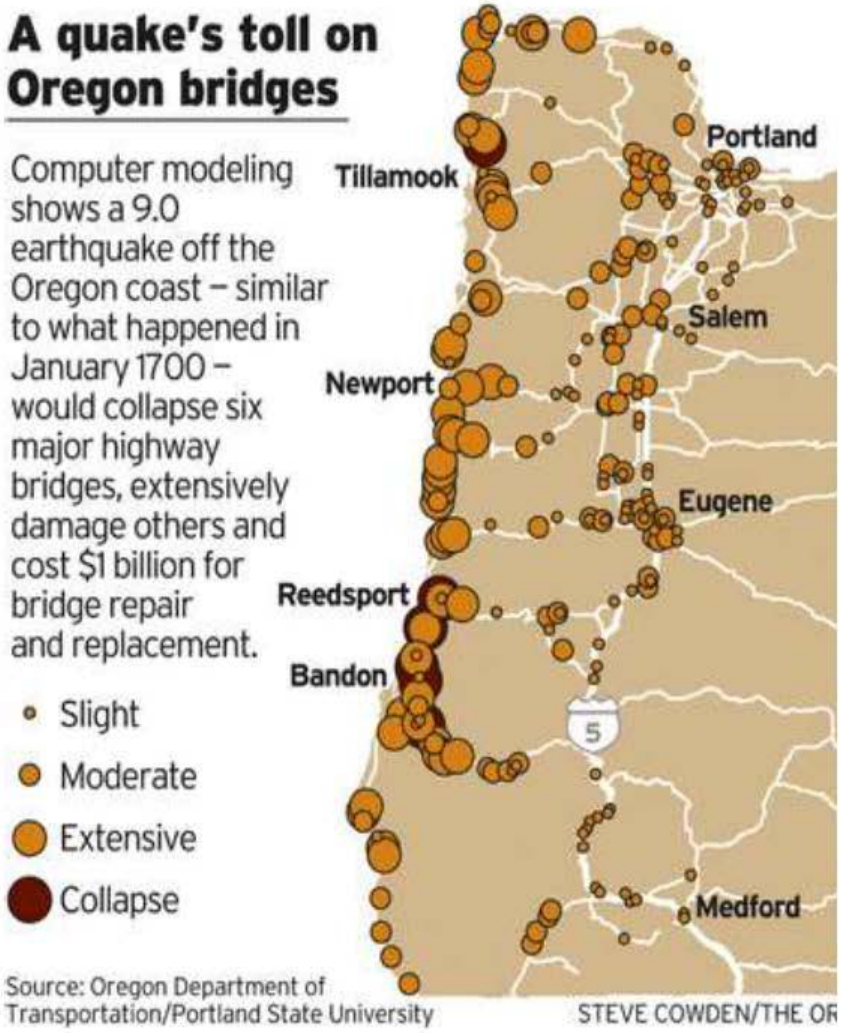
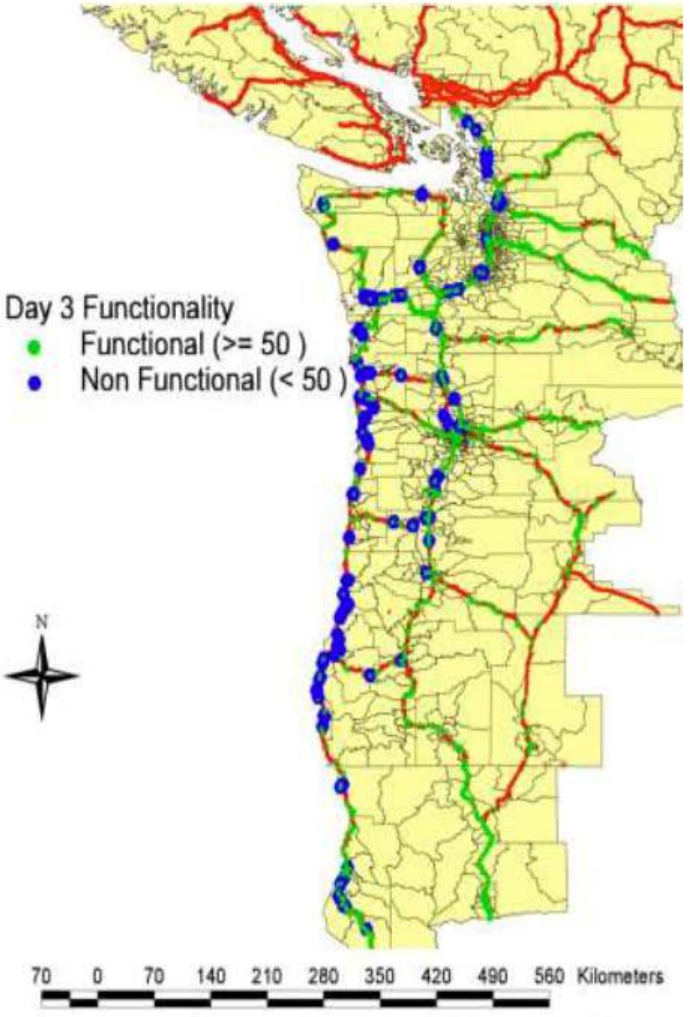
State of Oregon's bridges





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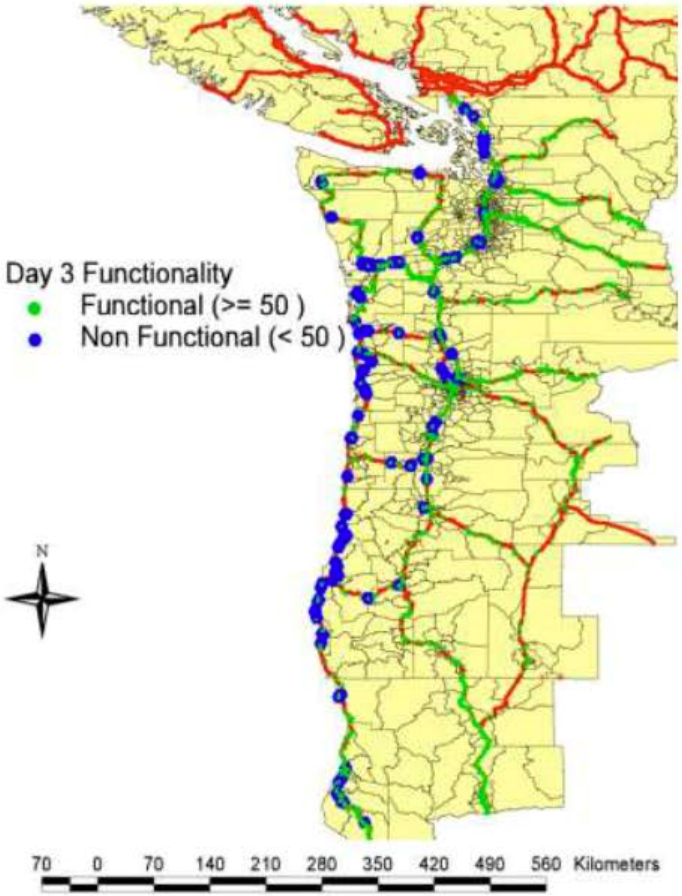
What are the risks & impacts based on our assumptions?



Cascadia Scenario Bridge Functionality

- **Infrastructure and lifelines will be seriously damaged**
  - **In Oregon, 399 bridges would have totally or partially collapsed under an M 9.0 Cascadia Subduction Zone earthquake, and 621 bridges would have been heavily damaged.**
  - **Most state routes connecting Interstate I-5 with the Oregon Coast Highway would be closed. The estimated time of closure could be 3 to12 months.**
  - **The restoration of the entire transportation network could take 3 to 5 years, and would require a nationwide effort.**

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Oregon is at risk

from an earthquake and tsunami that can significantly impact our people and economy for decades.

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Cascadia Planning Assumption

- Widely accepted that a very large, 9+ subduction zone earthquake is not just possible, but probable
- Strong to Very Strong shaking inland to Cascade mountains
- Three metropolitan cities in impact zone
  - Portland
  - Seattle
  - Vancouver, B.C.
- Heavy urbanization along the I-5 corridor
- Approximately 15 million people live in the hazard zone

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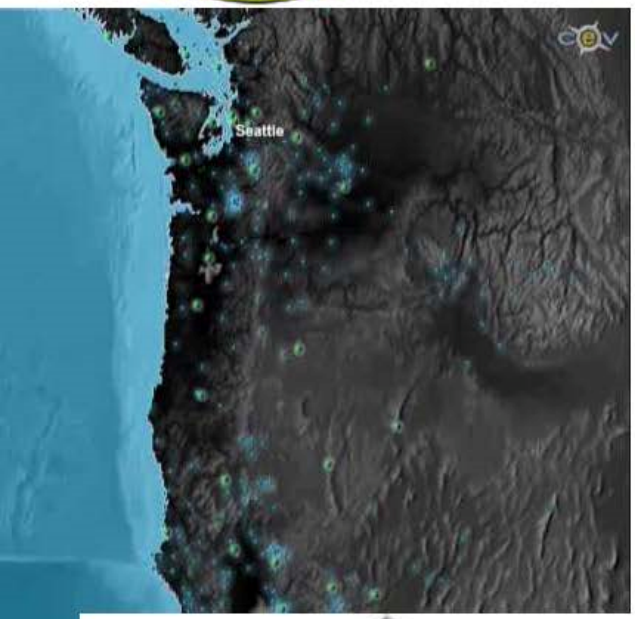

What will Oregon look like if Cascadia happened today?

- **15 million people live in the impact zone**
  - No power for weeks/months/years
  - No fuel for weeks/months/years
  - No deliveries of food/water for weeks/months
  - No running water for weeks/months/years
  - No sewer system for weeks/months/years

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Critical Service	Zone	Estimated Time to Restore
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

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Earthquake mitigation in Oregon

- **Oregon Resiliency Plan (OSSPAC)**
  - http://www.oregon.gov/OMD/OEM/Pages/osspac/osspac.aspx
- **Cascadia Catastrophic Plan (OEM)**
  - http://www.oregon.gov/OMD/OEM/Pages/plans_train/CSZ.aspx
- **Land-use planning guidance (DLCD)**
- **Natural Hazards Mitigation Plan (DLCD)**
- **Tsunami inundation mapping (DOGAMI)**
  - http://oregontsunami.org

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House Resolution 3, adopted in April 2011, directed the Oregon Seismic Safety Policy Advisory Commission (OSSPAC)

> **"to lead and coordinate preparation of an Oregon Resilience Plan that reviews policy options, summarizes relevant reports and studies by state agencies, and makes recommendations on policy direction to protect lives and keep commerce flowing during and after a Cascadia earthquake and tsunami."**

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The Oregon Resilience Plan:

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)
- February 2013
- http://www.oregon.gov/OMD/OEM/osspac/docs/Oregon_Resilience_Plan_Final.pdf

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Key Findings

- **Casualties (1,250 to more than 10,000)**
- **Economic Loss (close to 20% state GDP)**
- **More than one million truck loads of debris**

Liquid fuel vulnerability

How much liquid fuel do you use in one month?

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Key recommendations

- Complete an inventory
  - critical buildings
  - local agency, transit, port, and rail assets
  - energy and information and communications sectors
  - water and wastewater

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- **Launch a sustained program of capltal Investment in Oregon's public structures, including**
  - **Fully funding Oregon's Seismic Rehabilitation Grants Program for K-12 schools, community colleges, and emergency response facilities**
  - **Seismically upgrading lifeline transportation routes into and out of major business centers statewide by 2030**

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- **Craft a package of incentives to engage Oregon's private sector**
  - **Developing a seismic rating system for new buildings to incentivize construction of buildings more resilient than building code compliance requires and to communicate seismic risk to the public**
  - **Tasking the Oregon Public Utilities Commission to provide oversight for seismic preparedness of the energy providers currently under its jurisdiction**
  - **Working with the hospitality industry to develop plans to assist visitors following a major earthquake and tsunami and to plan strategies to rebuild the tourism industry**

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- **Update Oregon's public policies**
  - Revising **individual preparedness communications** to specify preparation from the old standard of 72 hours to a minimum of two weeks, and possibly more
  - Developing a policy and standards for installation of **temporary bridges** following earthquake disruption

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- Tasks the Resilience plan workgroup to develop an implementation plan
- Report due to Oregon State Legislature
  - October 1, 2014

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ORP Key Findings

- **Oregon is far from resilient to the impact of a great Cascadia earthquake today**
  - **Casualties (1,250 to more than 10,000)**
  - **Economic Loss (close to 20% state GDP)**
  - **More than one million truck loads of debris**
- **Liquid Fuel vulnerability**


It doesn't take collapse to make a building unusable

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Resiliency CAN be achieved

- **After the February 27, 2010 M8.8 Maule Earthquake, Chile**
  - **90% communication services and 95% power supply within two weeks, and re-start commercial flights after ten days.**
- **After the March 11, 2011 M9.0 Tohoku Earthquake,**
  - **90% power supply in ten days, 90% telephone lines in two weeks, and 90% cellular base stations in 19 days.**

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What your community can do

- **Assess your risk**
  - **Inventory public buildings**
    - **FEMA 154 - Rapid Visual Screening of Buildings for Potential Seismic Hazards**
  - **Assess lifelines and infrastructure**

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Survive the Earthquake

Prevention

- Modify Your Environment

Protection

- Modify Your Behavior

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Community actions

- **Educate**
  - **Public**
  - **Public officials**
  - **Continuity of operations**
- **Mitigate**
  - **What does your community value?**

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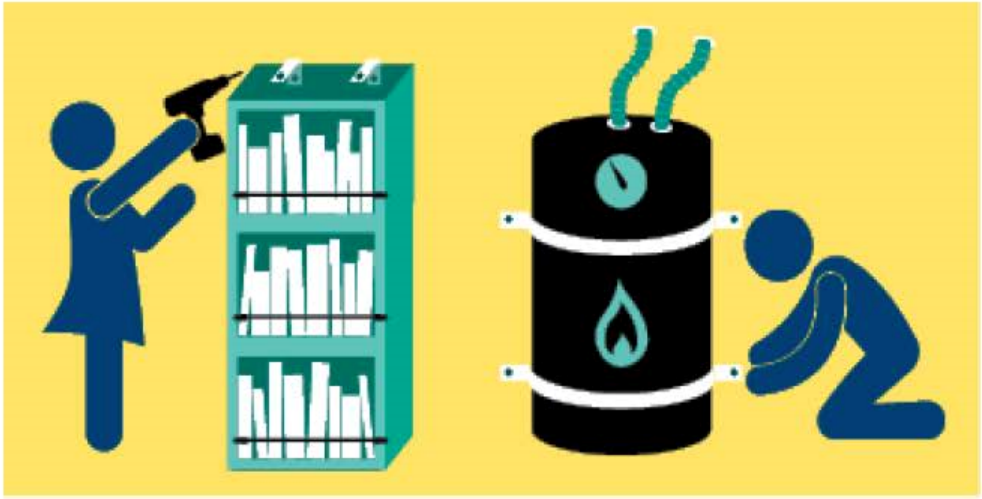
Key Preparedness Messages

- **Secure your space by identifying hazards and securing moveable items.**



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* **Plan on how to respond after an earthquake or tsunami**

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- **Go-Kit – minimum of 72 hours**
- **Car – 7 to 10 days**
- **Home – 3+ weeks**

http://www.ready.gov/america/getakit/

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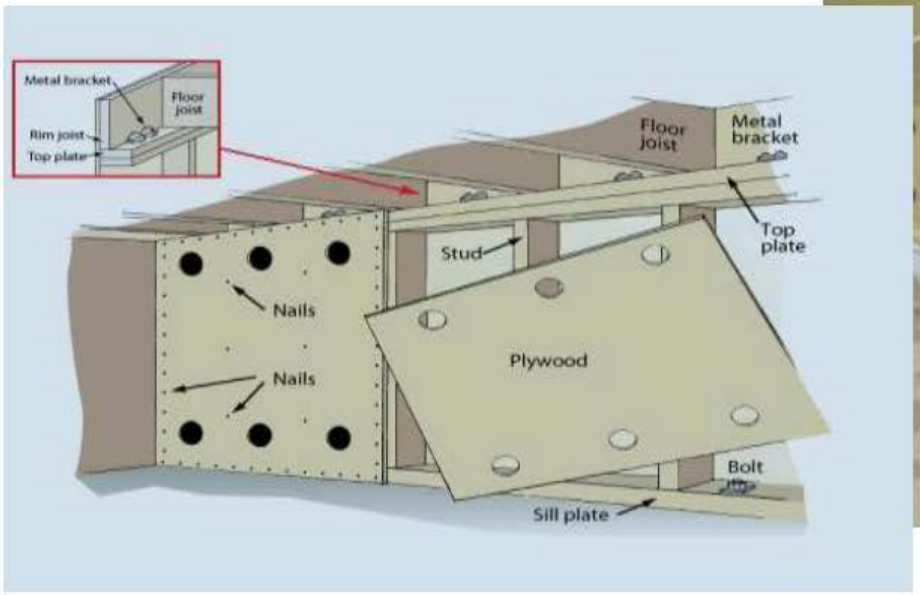
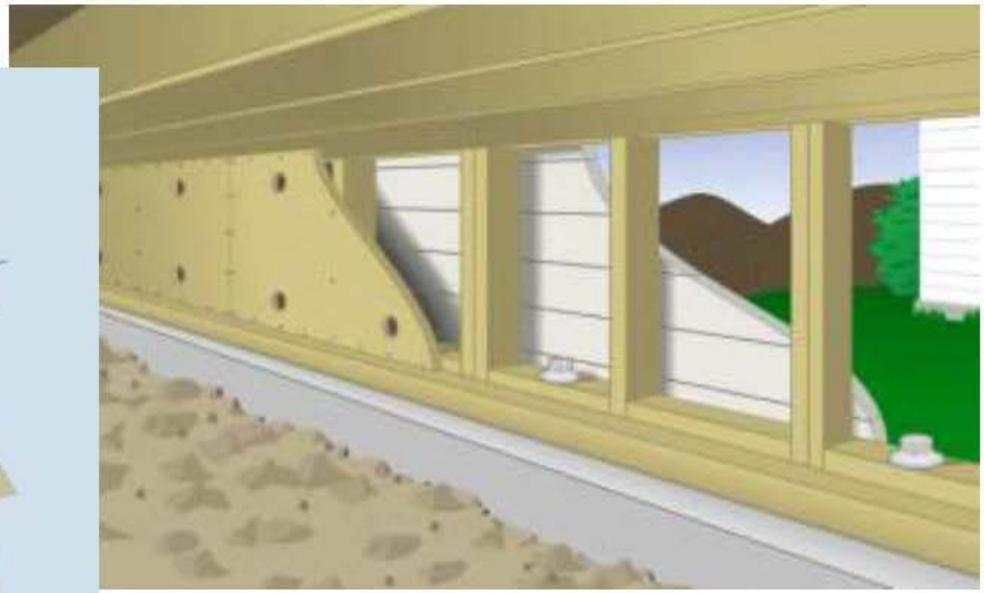
- **Inadequate foundations**
- **Un-braced cripple walls**





Earthquake Safety Guide for Homeowners

http://www.fema.gov/media-library/assets/documents/1017?id=1449

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- **DO NOT** run out of the building!

Run

- **DO NOT** get in a doorway!

Doorway

- **DO NOT** believe the triangle of life!

Triangle of Life

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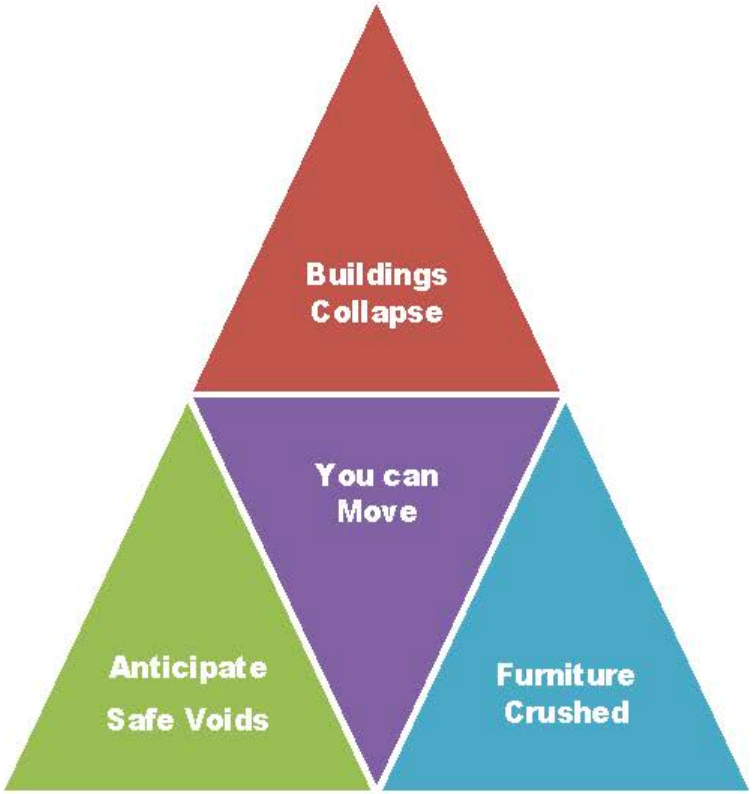
The Triangle of Life MYTHS

MYTHS



TRUTH

1. **Collapse:** Most buildings do not collapse
2. **Moving:** Strong shaking makes moving very difficult and dangerous
3. **Voids:** The direction of shaking and unique structural aspects of the building make this impossible.
4. **Furniture:** People DO survive under furniture or other shelters.

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Improve safety immediately after an earthquake by evacuating if necessary, helping the injured and preventing further injuries or damage.

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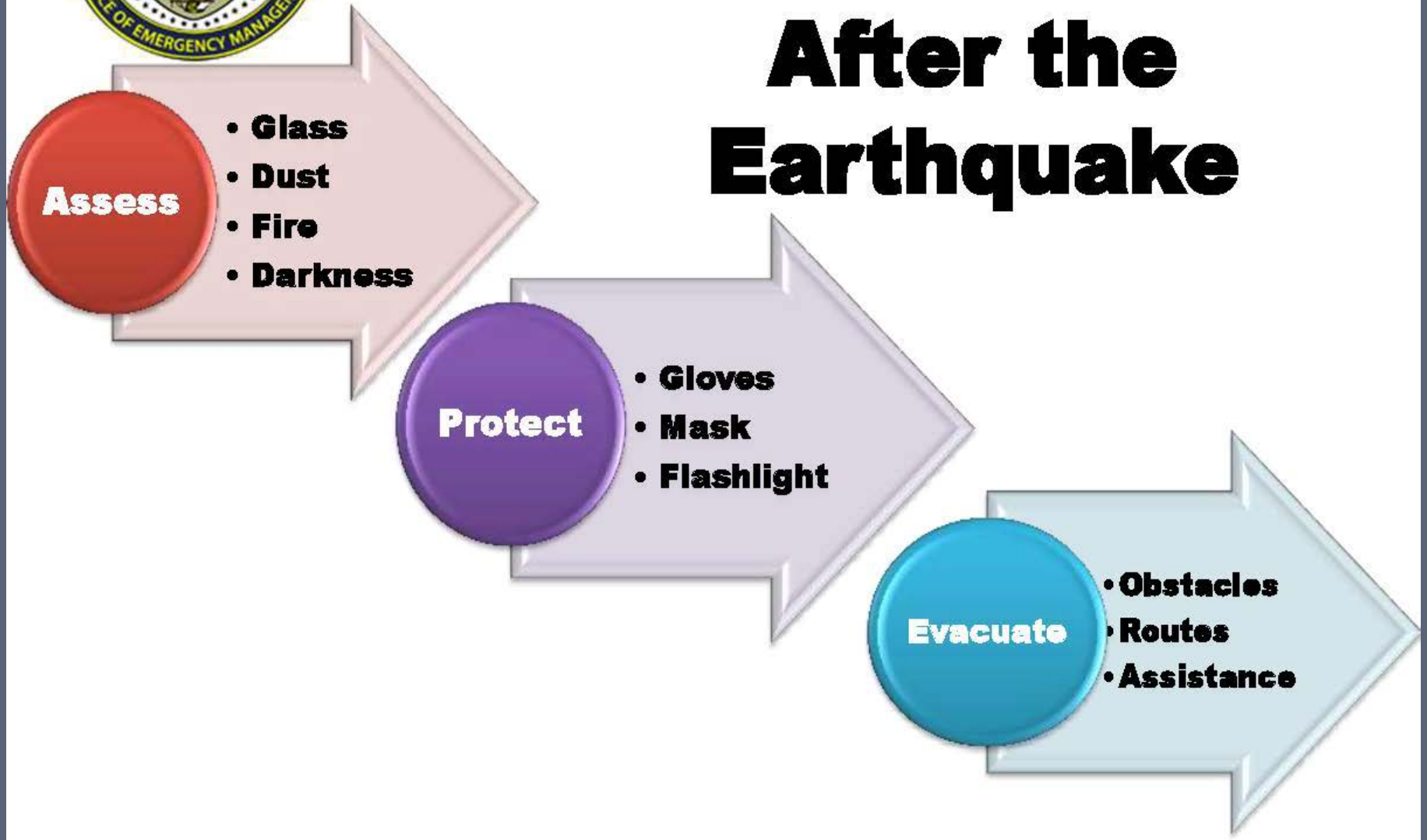
After the Earthquake



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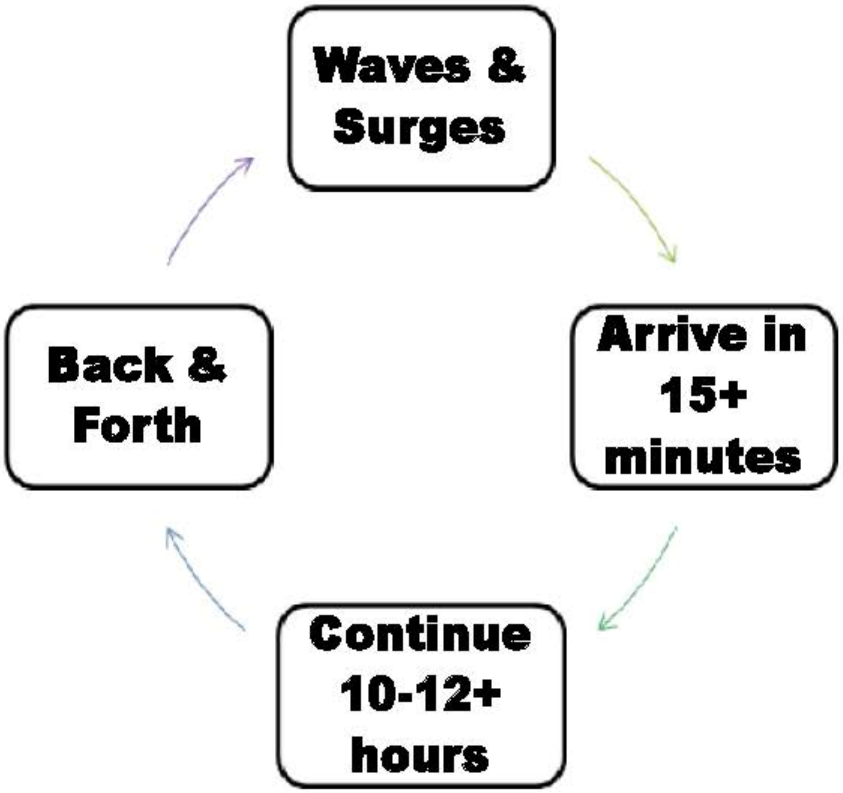
Local (Cascadia) Tsunami



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Identify High Ground

- Signs
- Evacuation Routes
- Safe Areas
  - Temporary Assembly Areas
  - Vertical Evacuation Options

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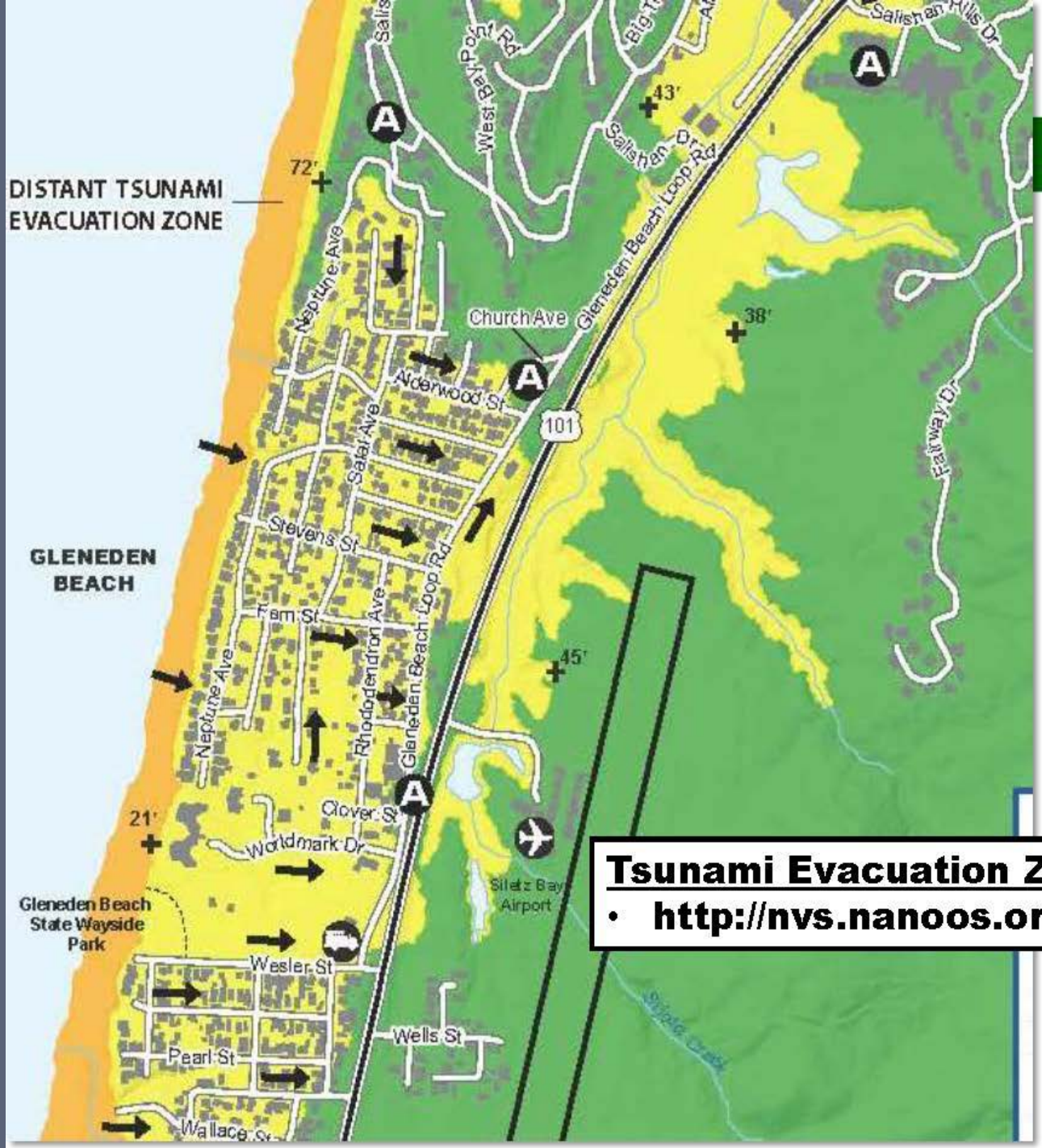
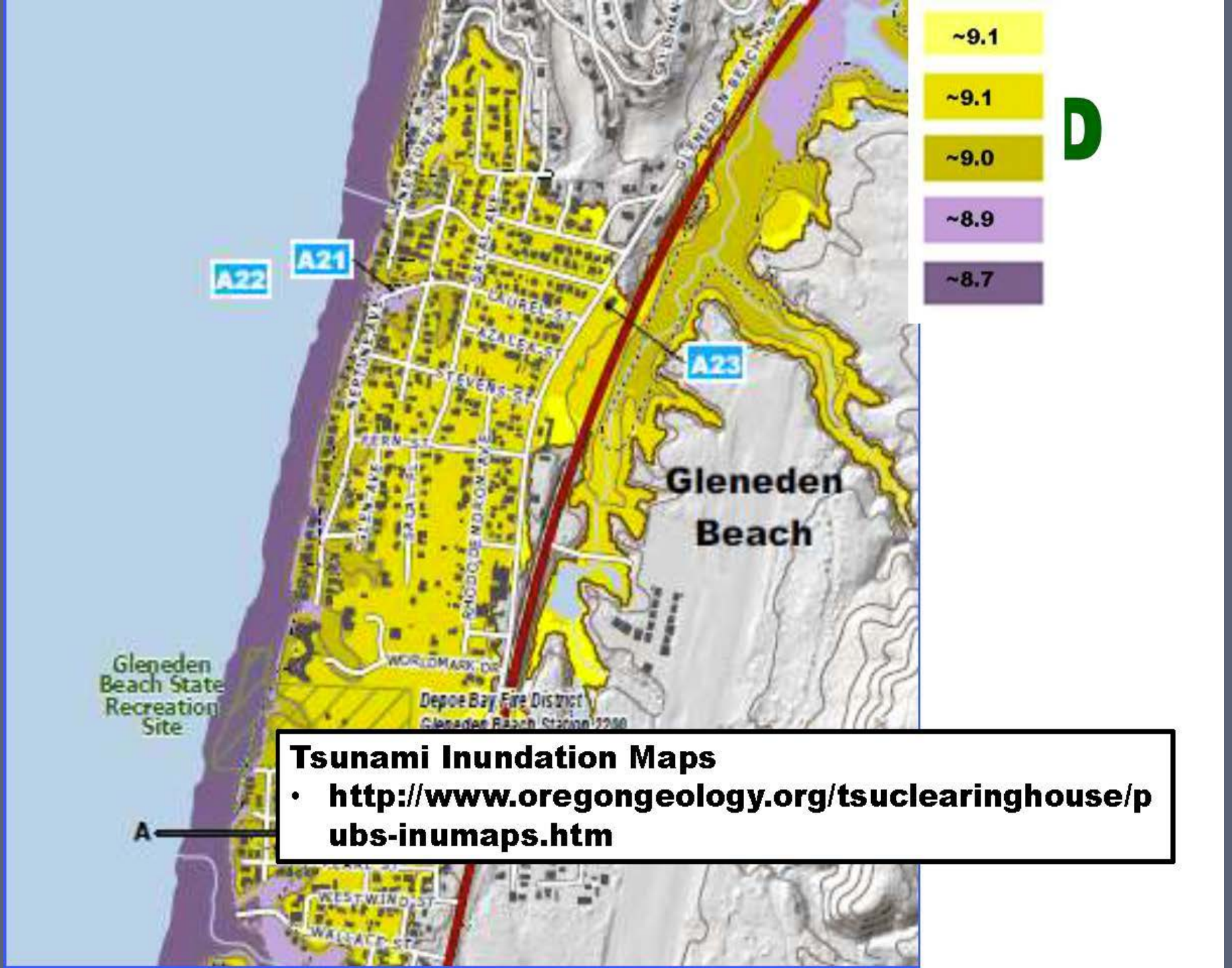


Tsunami Evacuation Zone Map Viewer

- **http://nvs.nanoos.org/TsunamiEvac**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A22
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Gleneden Beach
Gleneden Beach State Recreation Site
Depoe Bay Fire District
A
Tsunami Inundation Maps
• http://www.oregongeology.org/tsuclearinghouse/pubs-inumaps.htm

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Distant Tsunami

- Earthquake Far Away
- You won't feel the ground shake
- 4+ hours before waves arrive
- Limited Inundation

Local Planning Guidance on Distant Tsunami Response

http://www.oregon.gov/OMD/OEM/plans_train/Tsunami/Guidance_for_Distant_Tsunami_Response.pdf

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- **Beaches**
- **Harbors**
- **Rivers, Inlets**
- **Other low-lying areas**

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Tsunami Alert Messages

Alert Level	Threat	Action
Information Statement	Minor waves at most	No action suggested
Watch	Danger level not yet known	Stay alert for more info
Advisory	Strong currents likely	Stay away from the shore
Warning	Inundating waves possible	Full evacuation suggested

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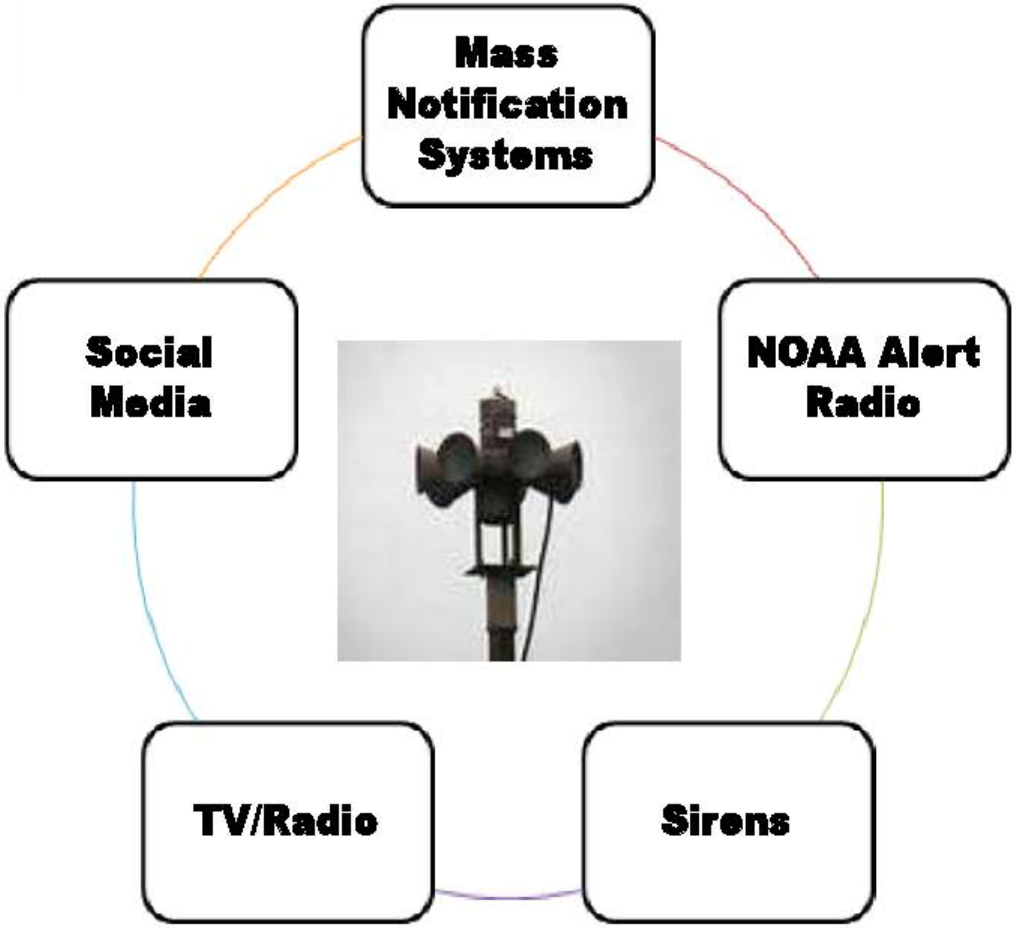

Distant Tsunami Notification

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Distant Tsunami Evacuation

- **WHO: Only those in the distant tsunami zone**
- **HOW: Probably by car**
- **WHERE: ???**

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- Cancellation Message
- Re-enter with Caution
- Damage
  - Harbors
  - Beaches
  - Low-lying areas
  - Roads, Bridges
- Clean up

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SHOULD ANYONE DIE

FROM A DISTANT TSUNAMI?

NO

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Great Oregon ShakeOut
October 16, 2014

A state-wide
Drop, Cover and Hold On
Earthquake drill.
Shakeout.org/Oregon

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Contact Information

Geological Hazard Program Coordinator

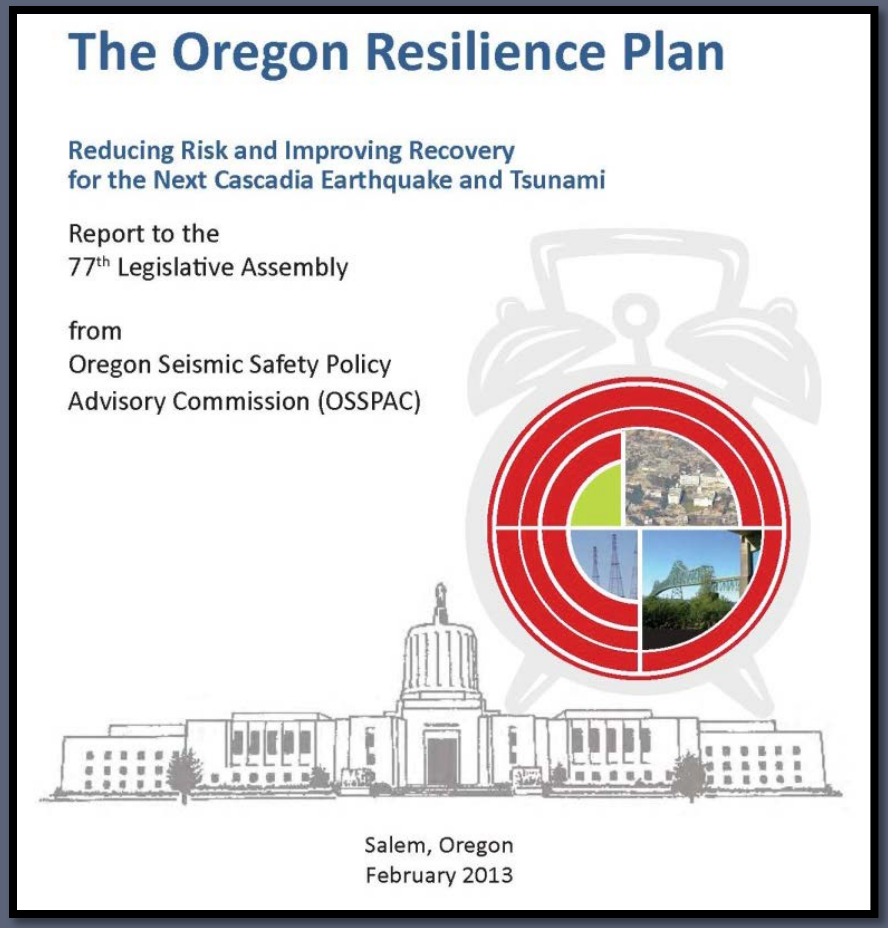
Althea Rizzo

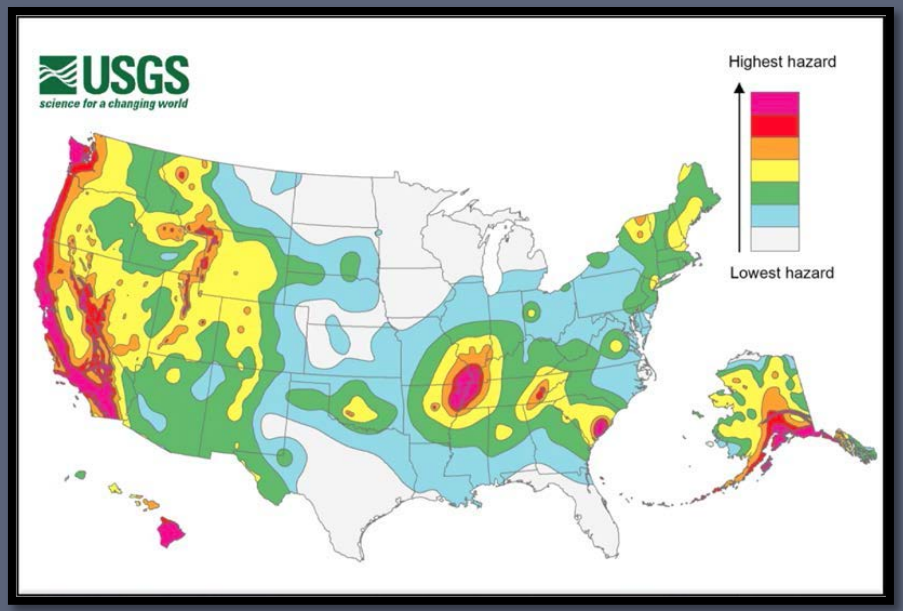
(503) 378-2911 ext. 22237

Althea.rizzo@state.or.us

Cascadia Subduction Zone

- Additional reference points





Personal and Family Readiness

- Personal and Family Readiness
  - Ready.Gov http://www.ready.gov/
  - Lincoln County Emergency Management www.lincolncountysheriff.net

Questions

- Are you better informed?
- Will you do anything different?
- Is there more we can do to better prepare you?