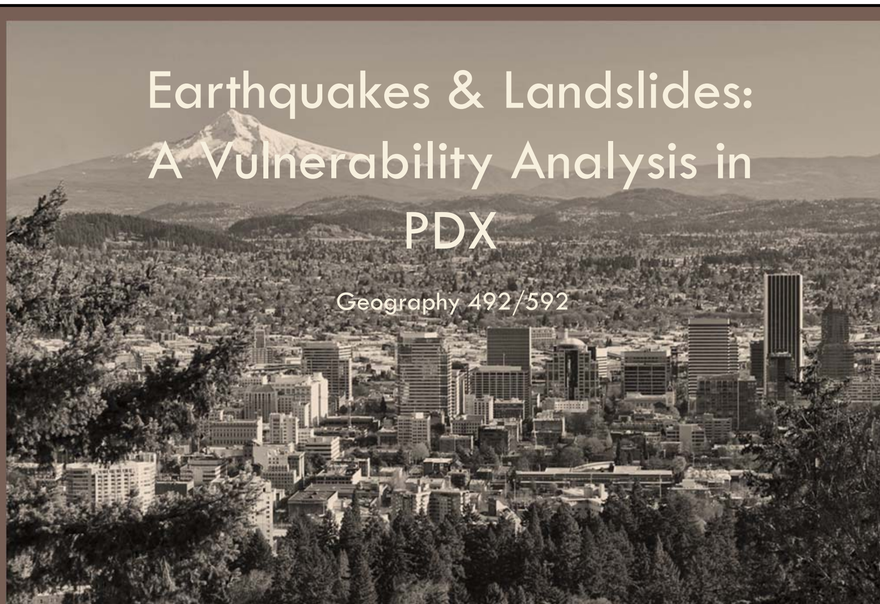
Earthquakes & Landslides: A Vulnerability Analysis in PDX

Geography 492/592



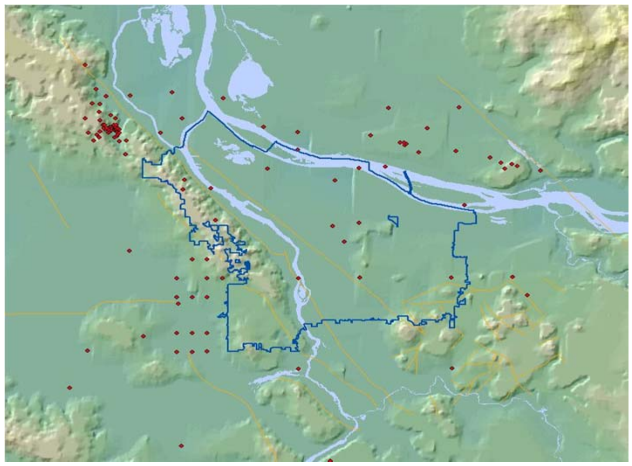
Michael Lilienthal – Lucas Edens – Robert K Miller

Background

"The Portland metropolitan area and surrounding vicinity (population near 2 million) has been the most seismically active region in Oregon in historical times. Based on the relatively brief 150-year historic record, six earthquakes of Richter magnitude (ML) 5 or greater have occurred within the greater Portland area including the damaging 1962 ML 51/2 Portland and 1993 ML 5.6 Scotts Mills earthquakes" (Bott and Wong, 1993).

Background

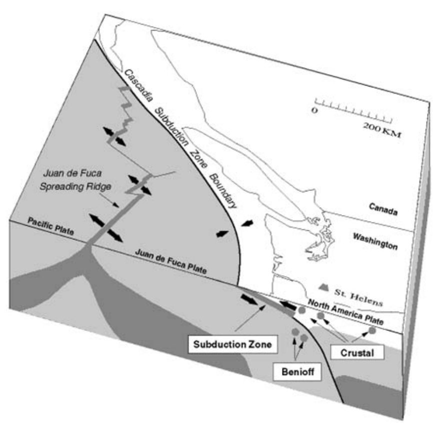
Earthquakes in Portland Area, since 1841



Background

3 Sources of Risk:

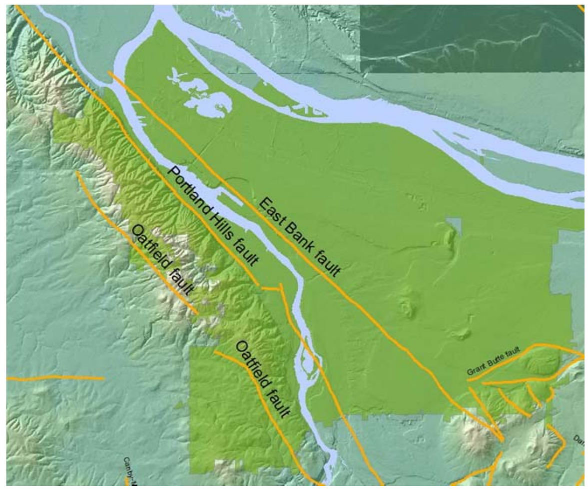
- Subduction Zone Earthquakes
- Benioff (deep) Zone Earthquakes
- Crustal Zone Earthquakes



Source: USGS Pacific Northwest geologic mapping and urban hazards
http://geomaps.wr.usgs.gov/pacnw/lifeline/eqhazards.html

Background

"In contrast, recent seismic reflection and aeromagnetic studies (Blakely et al., 1995); (Liberty et al., 2001); (Pratt et al., 2001) indicate the presence of at least three Crustal faults beneath the Portland metropolitan area which could generate much more damaging crustal earthquakes of ML 6.5 or larger." (Liberty et al 2001)

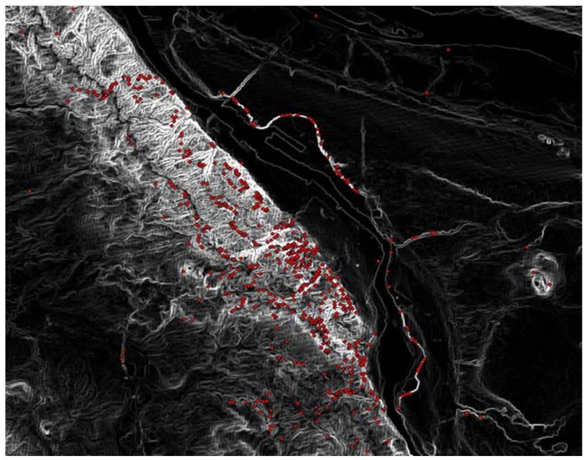


Background

- Landslides are often precipitated by seismic events, and the number of slides is grossly underestimated. (Harp et al)
- "Landslides in the United States cause approximately $3.5 billion (year 2001 dollars) in damage, and kill between 25 and 50 people annually. Casualties in the United States are primarily caused by rockfalls, rock slides, and debris flows. Worldwide, landslides occur and cause thousands of casualties and billions in monetary losses annually." (USGS Fact Sheet 2004)

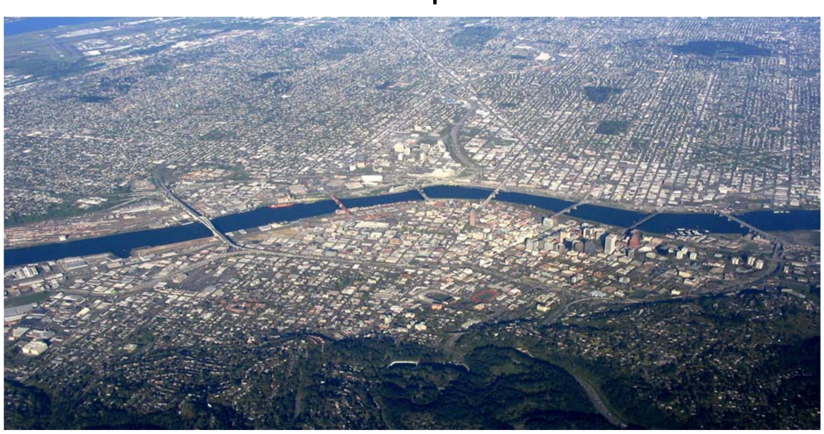
Background

Landslides in Portland area, since 1960



Research Focus

What areas within Portland's built environment are susceptible to landslide damage in the event of an earthquake?



Research Focus

Identify:

- Areas where landsides have previously occurred, determine current risk and proxy factor(s)
- Areas that have the greatest seismic disturbance potential
- Structures or areas of human habitation which coincide with these
- Characteristics of these structures which may make them at risk

Data

- 10m DEM (RLIS)
- Landslide point data (Oregon Geospatial Enterprise Office)
- Earthquake point data (Oregon Geospatial Enterprise Office)
- Portland infrastructure data (RLIS)
- Quaternary fault location data (USGS)
- DOGAMI earthquake ground acceleration polygons (http://nwdata.geol.pdx.edu/DOGAMI/IMS-16/)

Data

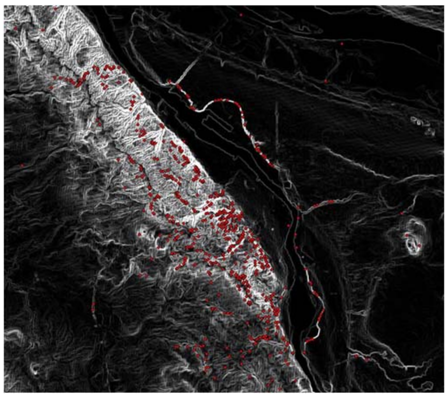
- DOGAMI (Department of Geology and Mineral Industries) study: "Earthquake Scenario and Probabilistic Ground Shaking Maps for the Portland, Oregon, Metropolitan Area"
- Study assumes a 6.8 MW (moment magnitude) event on the Portland Hills Fault
- A complex range of factors were considered for their model; geology, fault location, geometry, orientation, and sense of slip
- Data for 3 scenarios was acquired, 1.0 sec acceleration (long wave), 0.2 acceleration (short wave), and pga (peak ground acceleration)

Methodology

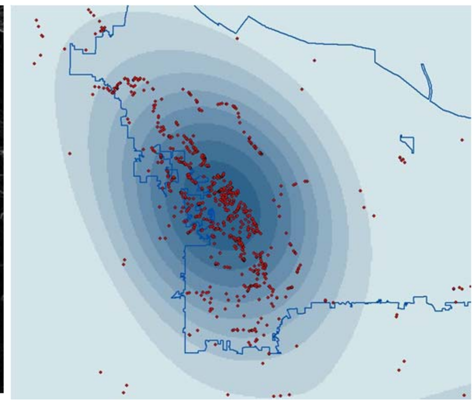
- Combine 3 types of data showing:
  - Landslide Hazard Potential
  - Seismic Disturbance Potential
  - Structure Location
- 2 Ways to show landslide hazard potential:
  - Surface (using 10k kernel density)
  - Slope model (using DEM)

Methodology

Slope Model



Kernel Density Surface



Methodology

Assumptions:

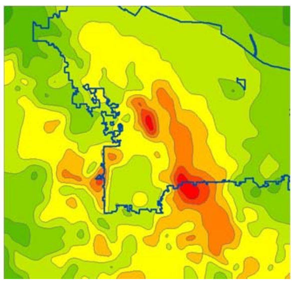
- Scenario based (Portland Hills Fault)
- Seismic events increase the likelihood landslide occurrence
- Buildings are at risk of damage based on date (methods and materials used from construction era)

Methodology

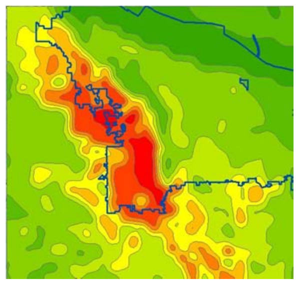
Identifying landslide-prone areas with high seismic disturbance potential:

DOGAMI ground shaking map polygon layers

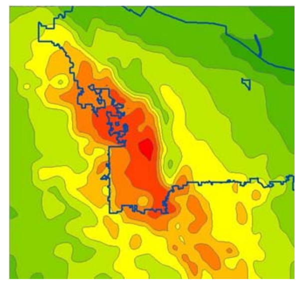
1.0 second spectral acceleration



0.2 second spectral acceleration



peak ground acceleration

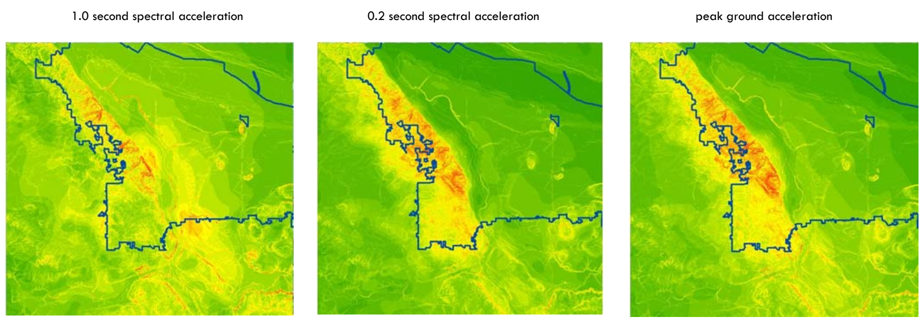


Methodology: Slope Model Approach

- **Reclass** slope into 10 classes
- **Rasterize** based on GA (ground acceleration) values
- **Reclassify** into 9 classes arranged sequentially
- Use the **Raster Calculator** to create a surface combining the *reclassed slope* and the *reclassed GA surfaces*
- Function: slope + GA value; 16 total values in output

Methodology: Slope Model Approach

Identifying landslide-prone areas with high seismic disturbance potential

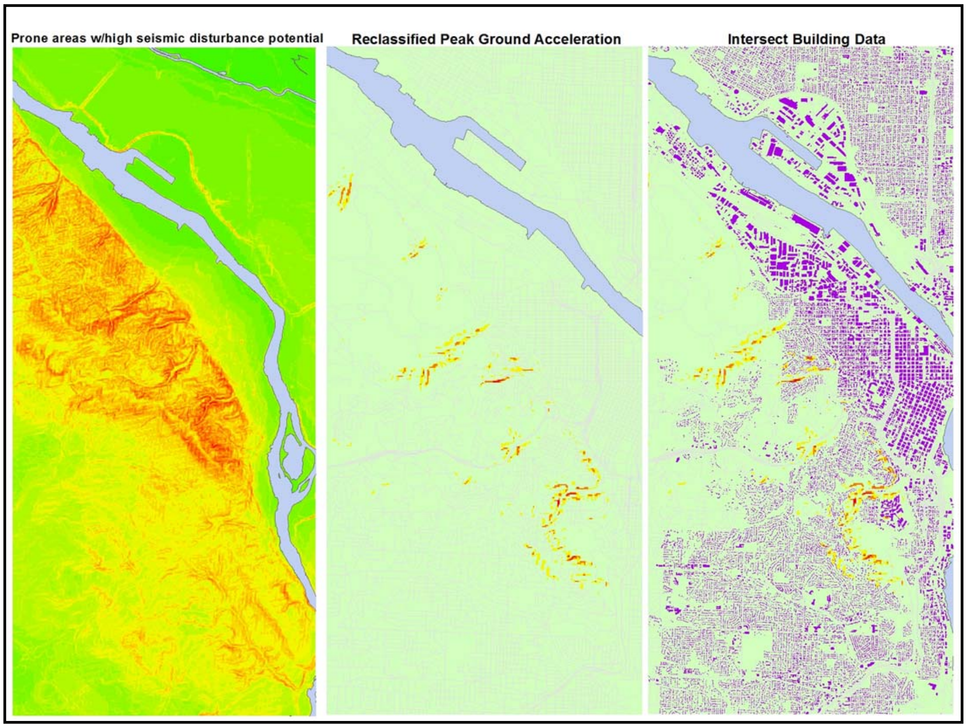


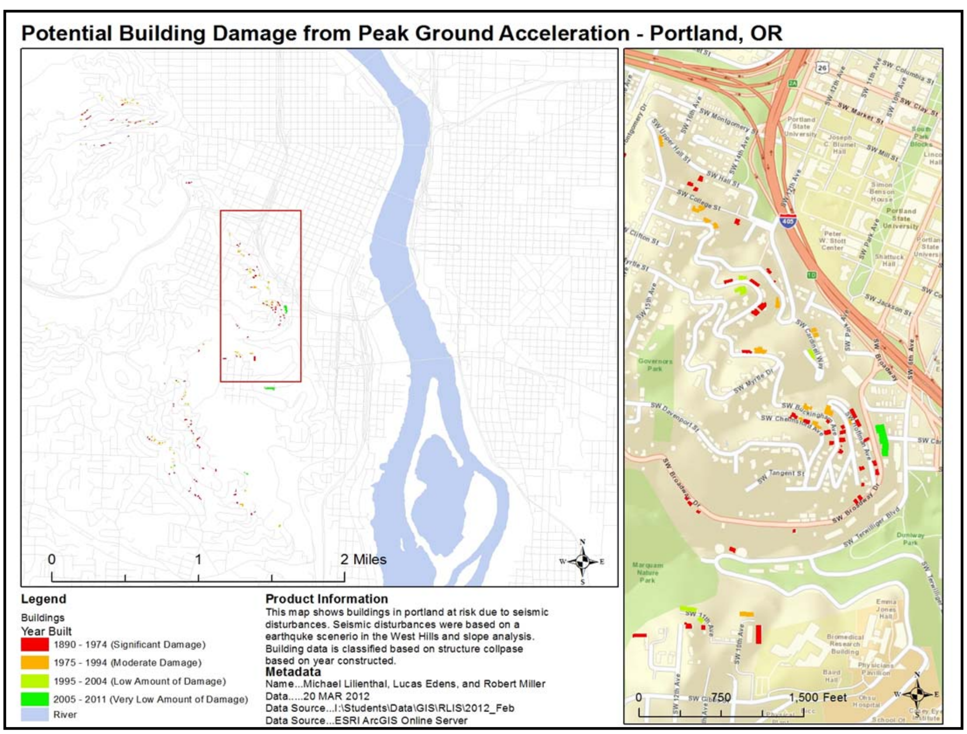
Methodology: Slope Model Approach

- Identify structures or areas of human habitation which coincide with these
  - Prone Areas of reclassed slope and GA surface
  - Converted Raster to Polygon for Spatial Analysis
  - Intersect w/building data
- Identify characteristics of these structures which may make them at risk
  - Classify buildings

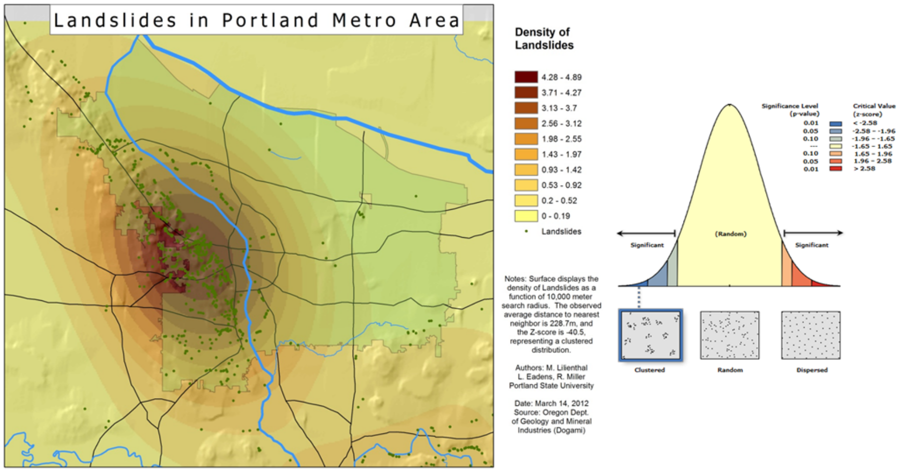
Table 2.2: Structure collapse potential relative to year constructed

Year Constructed	Structure Collapse Potential
Prior to 1975	Significant
1975-1994	Moderate
1995-2004	Low
2004-present	Very Low


Prone areas w/high seismic disturbance potential
Reclassified Peak Ground Acceleration
Intersect Building Data

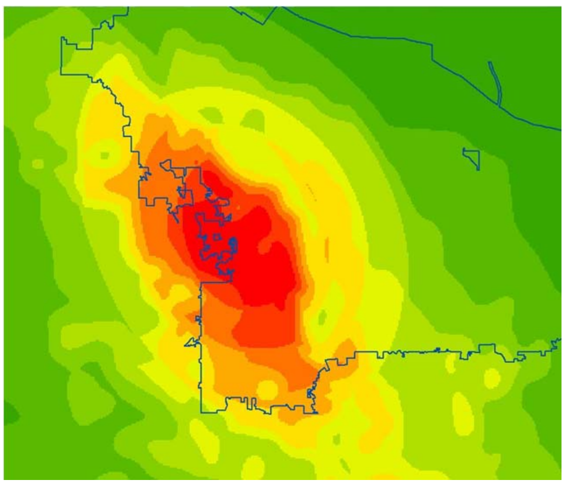

Potential Building Damage from Peak Ground Acceleration - Portland, OR
0
1
2 Miles
0
750
1,500 Feet
Legend
Buildings
Year Built
1890 - 1974 (Significant Damage)
1975 - 1994 (Moderate Damage)
1995 - 2004 (Low Amount of Damage)
2005 - 2011 (Very Low Amount of Damage)
River
Product Information
This map shows buildings in portland at risk due to seismic disturbances. Seismic disturbances were based on a earthquke scenerio in the West Hills and slope analysis. Building data is classified based on structure collpase based on year constructed.
Metadata
Name...Michael Lilienthal, Lucas Edens, and Robert Miller
Data.....20 MAR 2012
Data Source...I:\Students\Data\GIS\RLIS\2012_Feb
Data Source...ESRI ArcGIS Online Server

Methodology: Kernel Density Approach



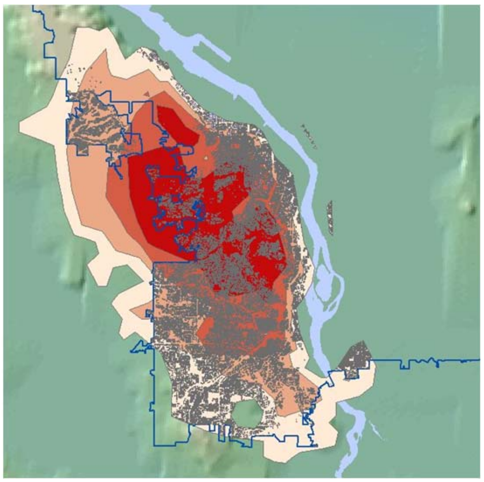
Methodology: Kernel Density Approach

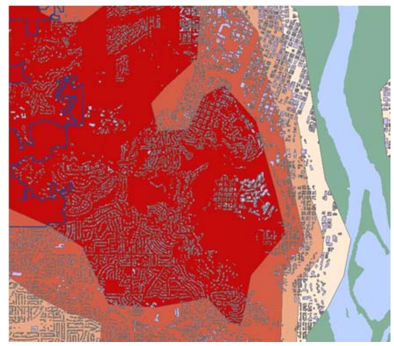
Kernel density surface & DOGAMI PGA surface, raster calculated



Methodology: Kernel Density Approach

Top 4 classes, vectorized with building data overlay





Results

- Kernel density approach probably lacks the detail necessary to be useful
- Using slope as a proxy for landslide hazard allows for finer-grain analysis

Study Issues/Limitations

- A more complex landslide model, incorporating shape, material, and area of effect could be used
- Uncertainty present in the DOGAMI data
- Kernel Density: appropriate method? Is there a better one?
- Reclassing raster data can introduce arbitrariness
- Using the raster calculator creates ordinal data
- No verification

Sources

- Bott, J.D.J., and Wong, I.G., 1993, Historical earthquakes in and around Portland, Oregon: Oregon Geology, v. 55, p. 116-122.
- Wong, I., Silva, W., Bott, J., Wright, D., Thomas, P., Gregor, N., Li, S., Mabey, M., Sojourner, A., and Wang, Y., 2000, Earthquake Scenario and Probabilistic Ground Shaking Maps for the Portland, Oregon, Metropolitan Area; State of Oregon, Department of Geology and Mineral Industries, 1:62,500.
- USGS Fact Sheet, 2004 http://pubs.usgs.gov/fs/2004/3072/fs-2004-3072.html
- Seismic Vulnerability of Oregon State ftp://ftp.odot.state.or.us/Bridge/bridge_website_chittirat/2009_Seismic_Vulnerability_final.pdf.
- Harp, E. L., Keefer, D. K., Sato, H. P., & Yagi, H. (2011). Landslide inventories: The essential part of seismic landslide hazard analyses. *Engineering Geology*, *122*(1/2), 9-21. doi:10.1016/j.enggeo.2010.06.013
- Rogers, Albert M.; Walsh, Timothy J.; Kockelman, William J.; Priest, George R. Assessing earthquake hazards and reducing risk in the Pacific Northwest (vol.2)