Earthquake and Infrastructure Damage Analysis in Multnomah and Clackamas Counties: The Application of LiDAR In The Development of an Emergency Response Plan

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Digital Terrain Analysis GEOG 593

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Overview

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- Focus
- Data
- Assumptions
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Background

The ability to determine hazardous at risk building collapse sites in the event of a earthquake has produced enormous advances in the field of disaster management and relief efforts across metropolitan Portland, Oregon.

-LiDAR

-GIS

Though it's history of seismic activity is brief, Portland's most significant and current major earthquakes have generated great interest in earthquake probability and severity in the last few decades.

-Earthquake of 1962,
-Scott Mills Earthquake, 1993

-Greater than 5 Mw

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Most Seismically Active Area In Oregon (Bott and Wong, 1993)

Literature Review and research alludes to fact that:

- The Portland metropolitan area and its neighboring areas is the most seismically active region in Oregon
- Six earthquakes of Richter magnitude in the Last 150 Years.
- **Portland Hills Fault,** in particular, would be a likely candidate to induce a high magnitude scale earthquake in the future with significant repercussions.

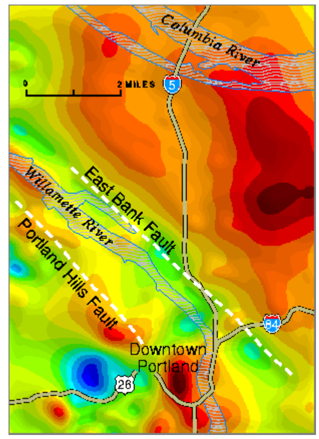
Why the Portland Hills Fault?

Origins of Seismic Activity Risk in Oregon
- -Subduction Zones (Cascadia)
- -Benioff Zones (Below)
- -Crustal Zones (Shallow)

Portland Crustal Zones
- -Portland Hills Fault
- -East Bank Fault
- -Oatfield Fault

Crustal Faults
- -Crustal earthquakes initiate below the earth's surface,
- -Origins range from five to ten miles in depth
- -Typically produce short ruptures of a mile or so.

Portland Hills Fault Proximity to Earths surface
- -Below the city
- -Rare instance rupture distance is significantly closer to the surface
- -Shockwaves ripple up toward the surface
- -Produce more significant shaking associated with earthquakes of greater magnitude



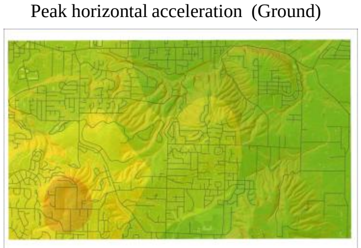
(http://earthquake.usgs.gov/learn/publications/portland)

Significance

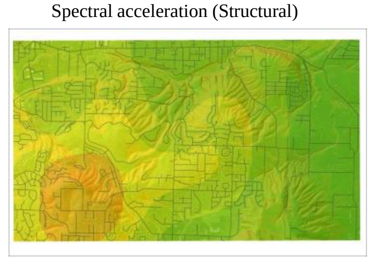
Portland Hills fault is highly scrutinized
- -Suggested that its fault could be exposed at the earth's surface
- -Would generate 6.8 Mw (moments of magnitude) earthquake with rupture lengths of 17-38miles
  - -building collapse
  - -landslides
  - -impedance and damage to road networks

Physical Impact (g-force)

Peak horizontal acceleration (Ground)



Spectral acceleration (Structural)



Though there is no physical evidence of this theory, seismologist surmise that the presence of dense vegetation, the effects intense flooding, and urbanization have left the faults location at the top of the surface undetected.

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Focus

- Utilize the application of LiDAR technology and data to visualize how diverse terrain in relation to spectral and peak acceleration influence significant structural damage to buildings constructed prior to set date
- Identify where they are located
- Locate areas that are susceptible to landslide and tree collapse
- Estimate emergency response times and routes that could be used by relief teams in the region

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Data

LiDAR LAS files – OpenTopography
http://www.opentopography.org

Landslide data and ground acceleration data– DOGAMI (Department of Geology and Mineral Industries)
Oregon Geospatial Enterprise Office
http://www.oregon.gov
http://www.oregongeology.org
http://nwdata.geol.pdx.edu/DOGAMI/IMS-16/

Building age data, streets and boundary layers - RLIS

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Assumptions

- All buildings created prior to 1976 and taller than 25ft would block roads if collapsed
  -25ft is the width of a typical two lane road
  -collapse zone would be 1.5 times the buildings height
- Areas of steep slope were susceptible to landslides
- Trees taller than 41ft (Maximum value of average height in our building data) would be susceptible to blocking the roads if grouped in high density clusters of equal or greater height.

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Methodology

- Establish study area
- Process LiDAR data (LAS to Multipoint)(DEM, DSM, FEATURE HEIGHT)
- Identify buildings of desired age and height
- Run Buffer and Intersect analysis tools to identify areas of hazards
- Compare locations of steep slope and tree height against historic landslide data
- Combine results to create a road service network using Network Analysis tools.
- Assess the results

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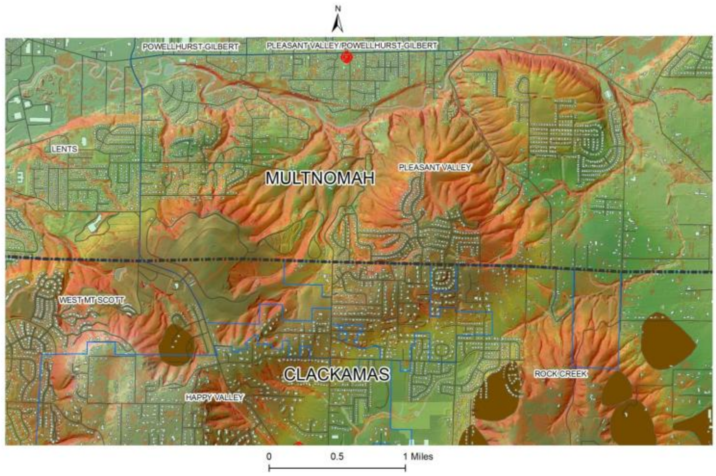
Study Area, DEM, DSM, Feature Height



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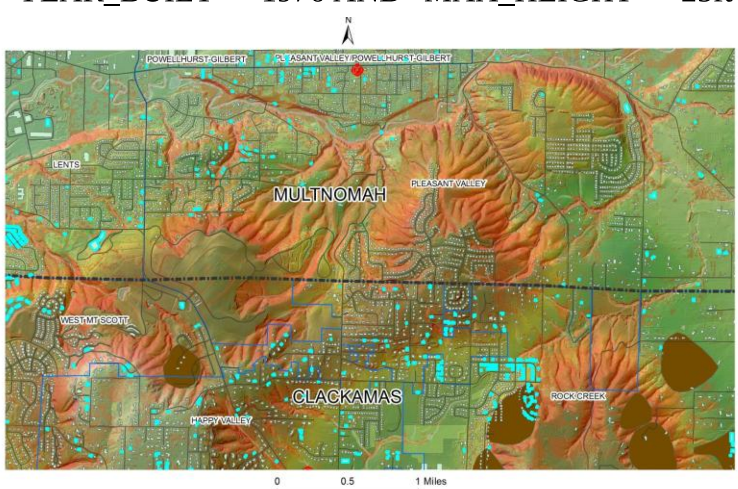
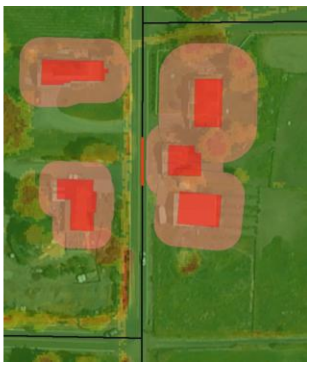
"YEAR_BUILT" < 1976 AND "MAX_HEIGHT" > 25ft

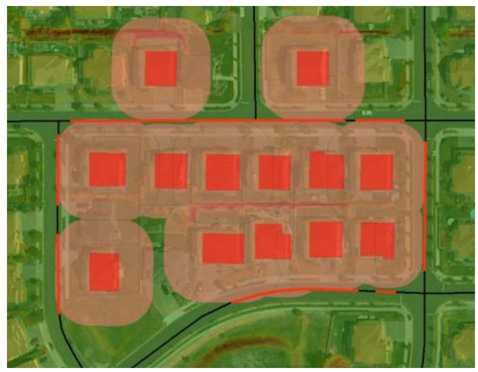


Buffer and Intersect

1.5 times Building Height of
Buildings > 25ft
5ft intersect tolerance



Re-query for buildings of all heights
1.5 times Building Height of all
5ft intersect tolerance



Methodology

Percent slope with historic landslide data

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Methodology

Feature Height with reclassified heights to display features greater than 41 feet in height (tree canopy)

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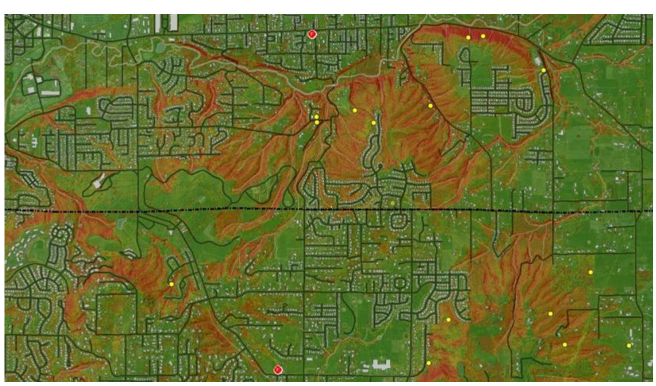
Methodology

Feature height combined with percent slope



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Methodology

Pre-disaster response time
1 min rings

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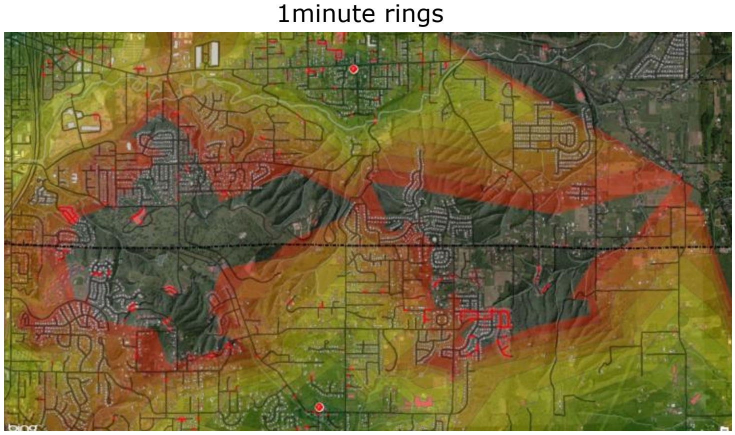
Methodology

Post-disaster response time
1minute rings



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Results

LiDAR driven data

- Mass structural building damage of buildings constructed prior to 1976 would be highly probable, resulting in portions of road would be inaccessible.

- Though portions of road were obstructed due to building collapse
  - -582 buildings in study area were inaccessible
  - -2317 buildings in study area were accessible though all of them varied in emergency response times associated to them

- While the peak horizontal acceleration could not be fully assessed, visual inspection of the Digital Surface models and Feature Heights, reclassified to only displaying heights of high tree canopy and density along with the assessment of slope steepness allows us to isolate potentially damaged roads that have minimal human inhabitants and buildings

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Limitations and Uncertainty

- Gaging slope and landslides

- Datasets for soil saturation analysis and precipitation are sparse or expensive

- Historical landslide data is far too incomplete to fairly assess it’s impact or even run a kernel density

Conclusion

- Emergency response agencies need to prepare for natural disasters more intensely by evaluating multiple scenarios, probabilities and their consequences to estimate how the environment they are located in is affected spatially
- Emergency response agencies can use geospatial analysis to identify areas which will be inaccessible post disaster and need to establish pre-plans for routes of ingress to these areas
- As probability and predictability increase within the emergency response industry, so does the application of LiDAR, GIS and digital terrain analysis; it is always better to be prepared.

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