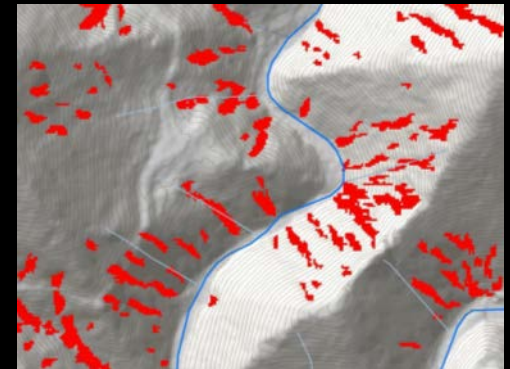


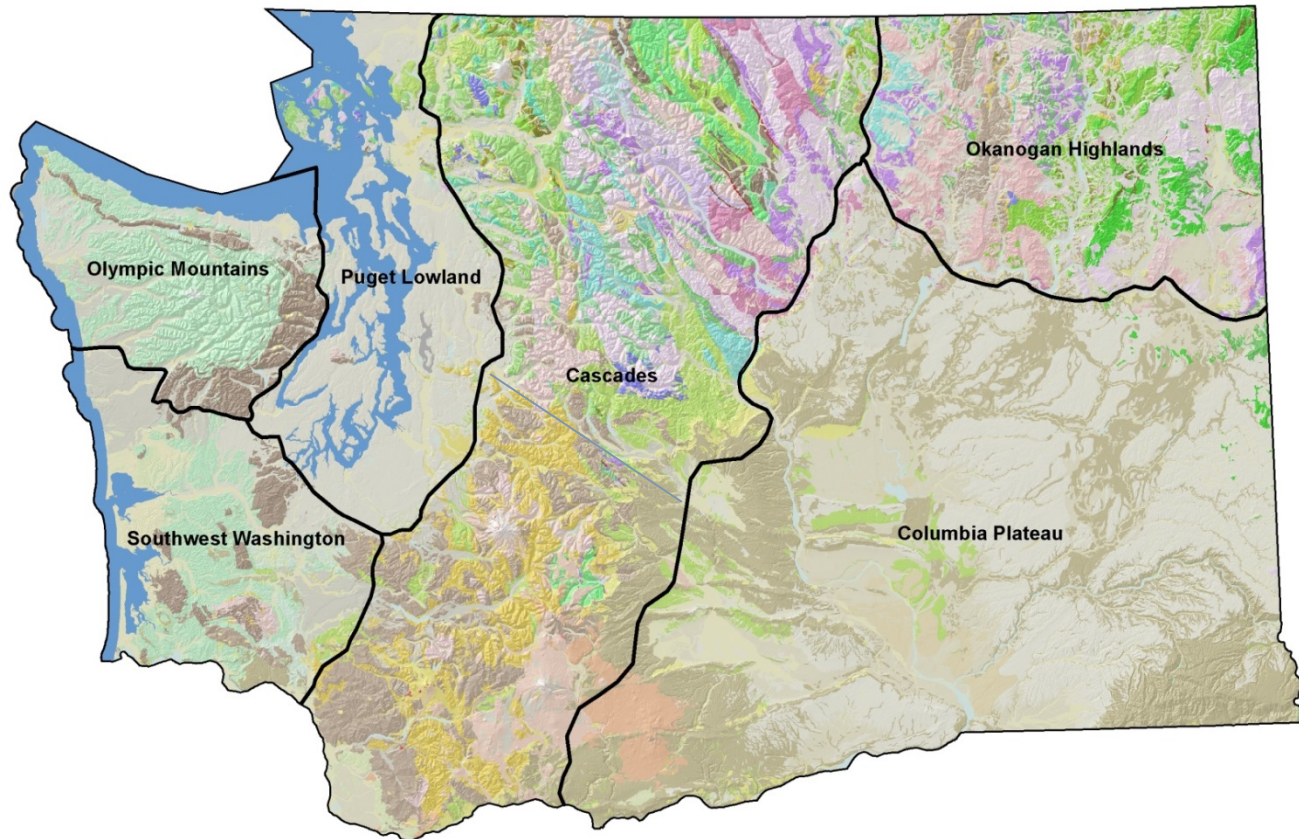
OVERVIEW: LANDSLIDE HAZARDS IN WASHINGTON STATE - STATUS OF INVENTORY AND DETECTION TOOLS



David K. Norman, LHG, LEG
State Geologist

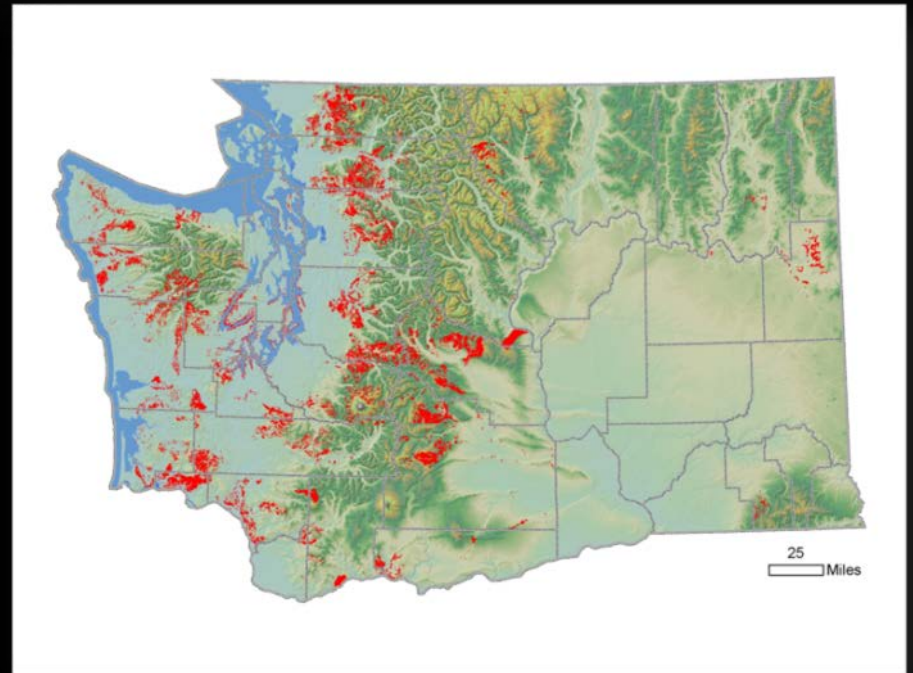
Washington Geological Survey
Division of Geology and Earth Resources
Washington Department of Natural Resources

WASHINGTON LANDSLIDE PROVINCES



DNR LANDSLIDE (LS) INVENTORY

- DNR has collected ~51,000 LS into a single GIS database
- Includes both shallow rapid landslides (SRLS ~30,000) and deep-seated landslides (DSLS ~11,000)
- No significant updates since 2009
- Available on Geology Portal



PRIMARY METHOD OF LS DATA COLLECTION



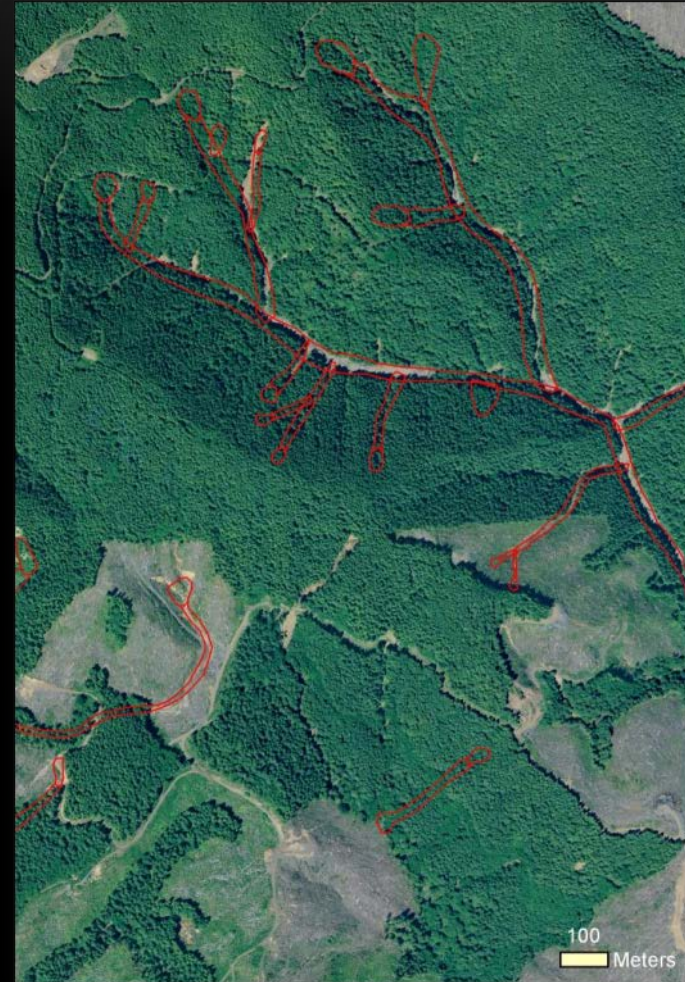
Remote sensing

- Oblique aerial images
- USGS topographic maps
- Aerial imagery
- 10- and 30-m DEM
- lidar DEM (Digital Elevation Model)



LANDSLIDE MAPPING TECHNIQUES

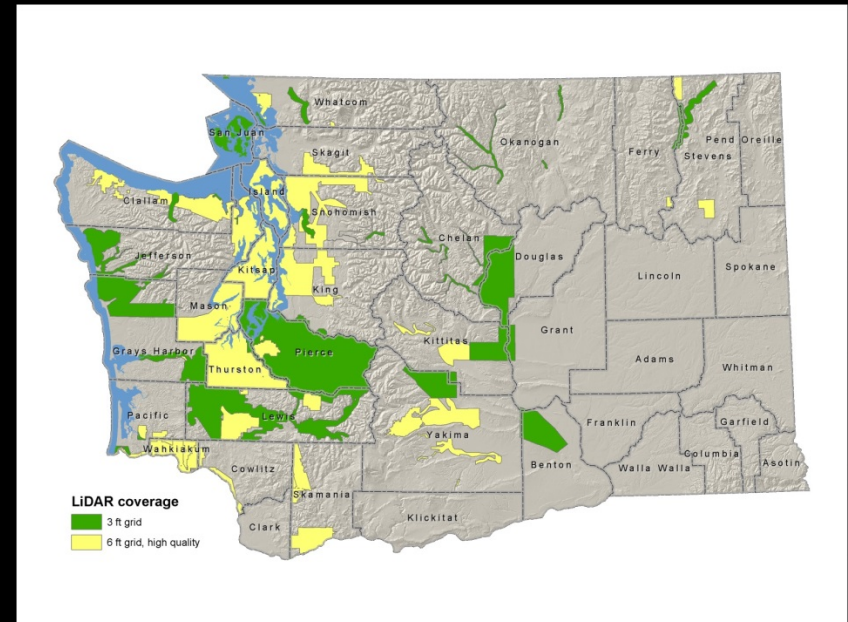
- Field validated
- Systematic: interpretation from several different years of air photos, DEM, and limited field validation
- Geologic Mapping
- Reconnaissance: interpretation from one set of air photos vertical or oblique



LANDSLIDE DETECTION TECHNIQUES

- Mapping deep seated landslides (DSLS) and shallow rapid landslides (SRLS) require very different techniques
- DSLS are best observed with Lidar
- SRLS that have occurred are best observed with aerial imagery immediately after the event; landforms susceptible to SRLS are best derived from Lidar

Where we have
acceptable
Lidar



Example One

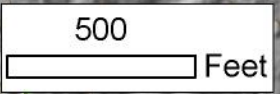
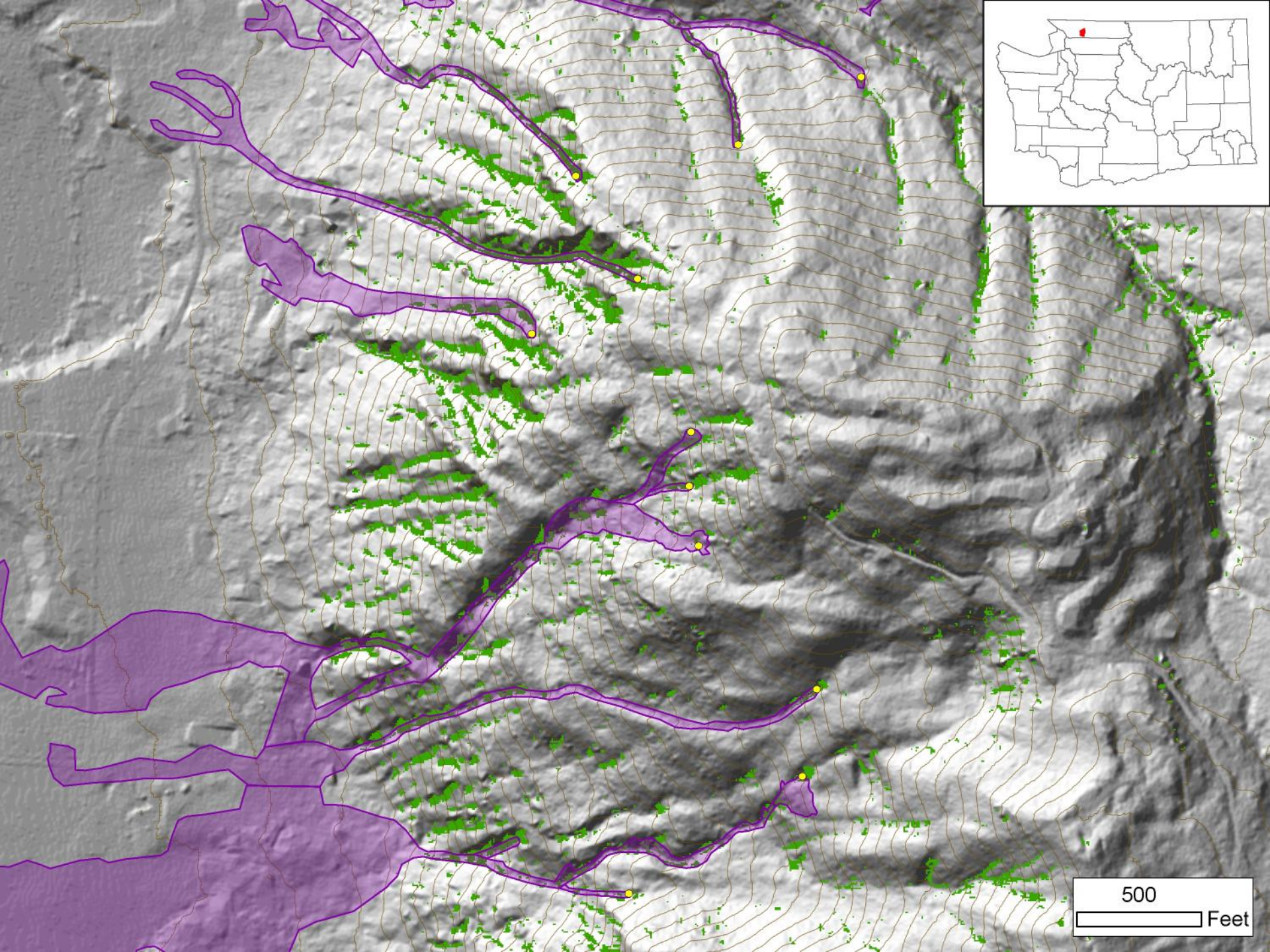
SHALLOW RAPID LANDSLIDES



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500
Feet

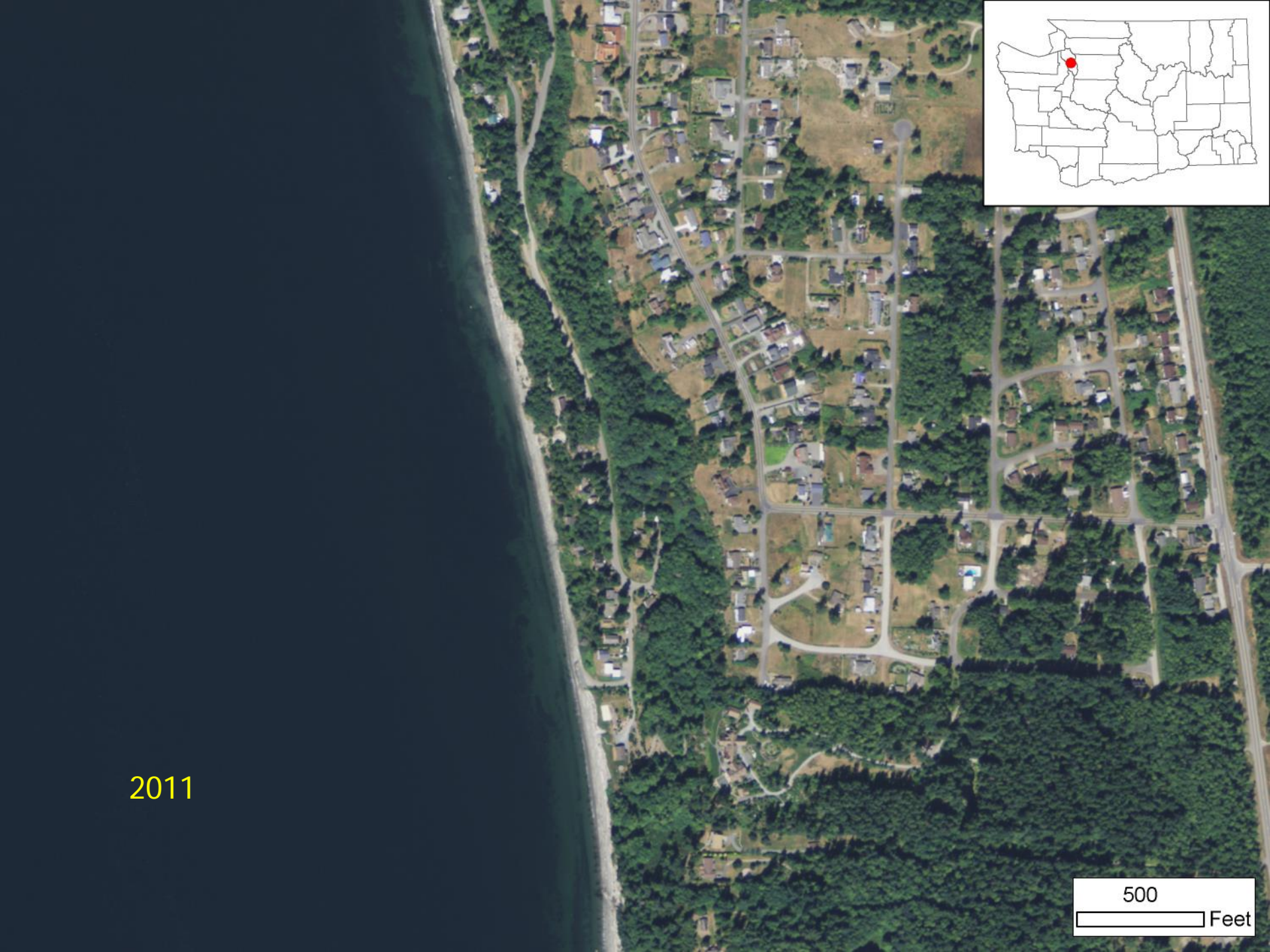


Example Two

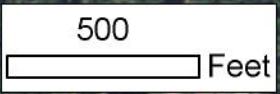
DEEP-SEATED LANDSLIDES

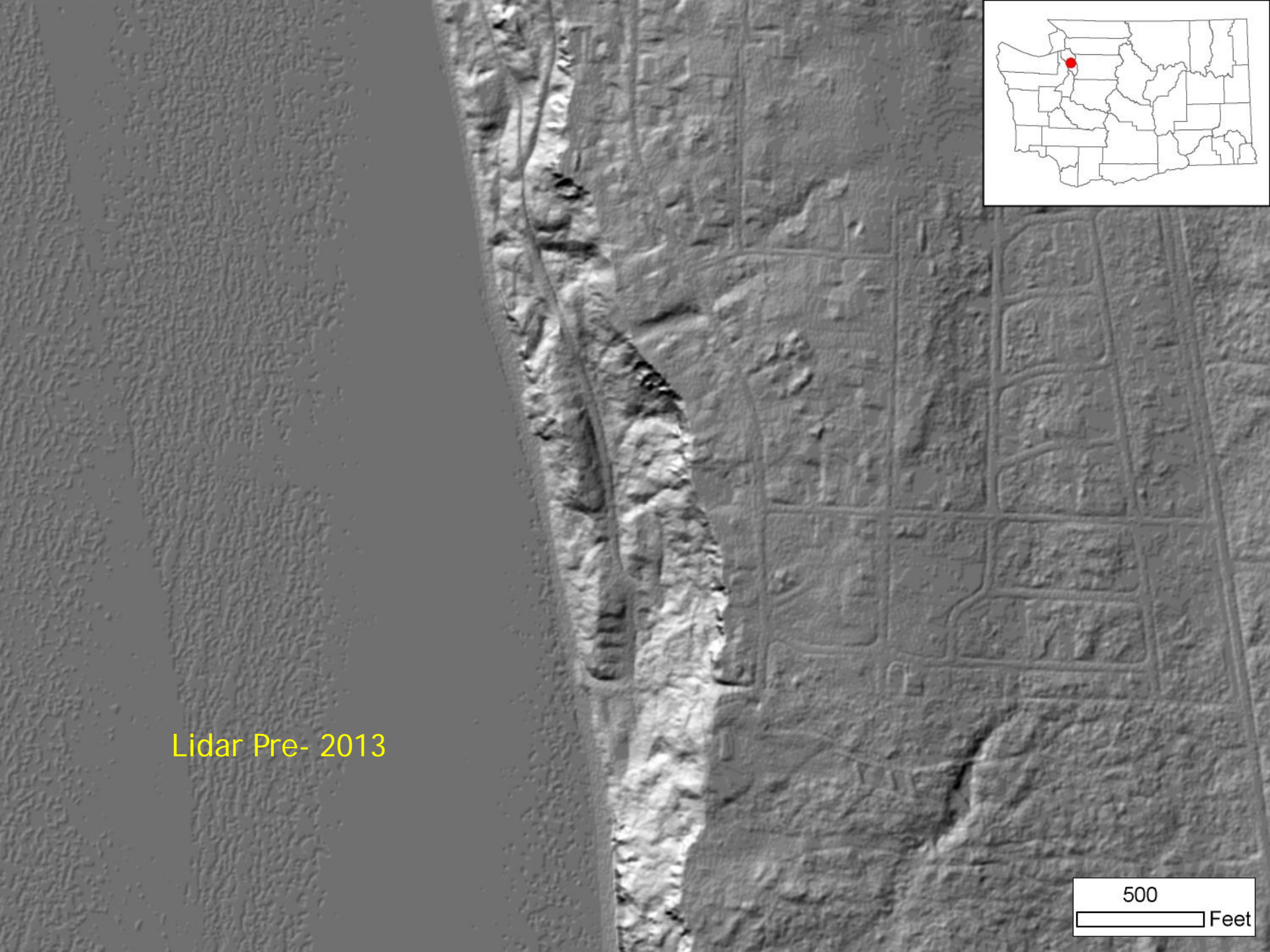


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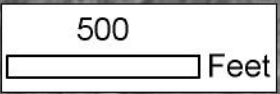


2011





Lidar Pre- 2013





Qgdm(e)

Qgo(f)

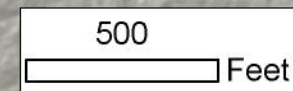
Qls

Qgt(v)

wtr

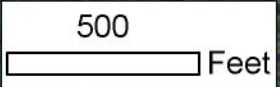
Published geology map
1:24,000 scale

Qgdm(e)



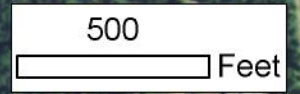


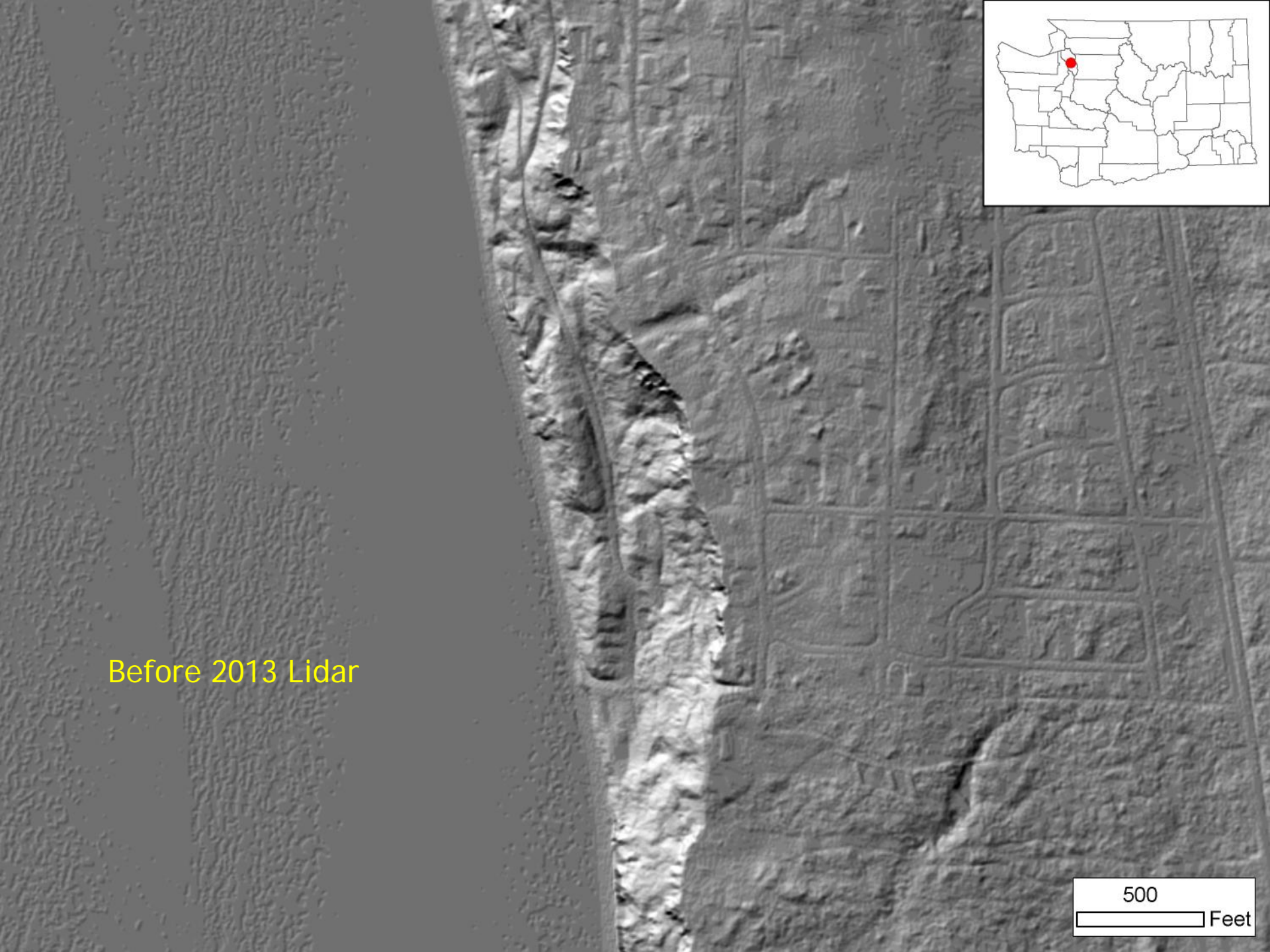
Before 2013
landslide



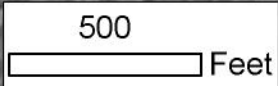


After 2013
landslide



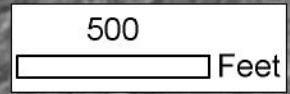


Before 2013 Lidar



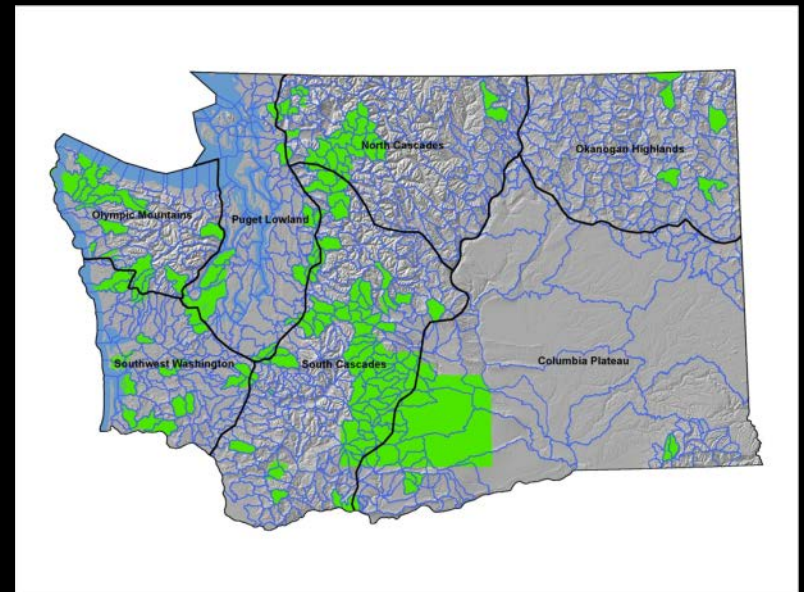


Lidar flown
shortly after
2013 landslide



SYSTEMATIC LANDSLIDE HAZARD MAPS

- Watershed Analysis (WA)
Mass Wasting Module
 - 54 projects, 1994-2002
- Landslide Hazard Zonation (LHZ)
 - 63 projects, 2003-2009
- Forested watersheds only
- 825 watershed (WAUs), 754 are forested

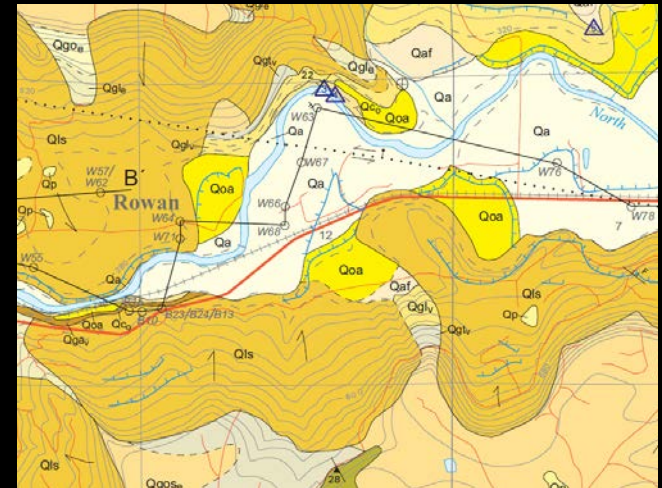
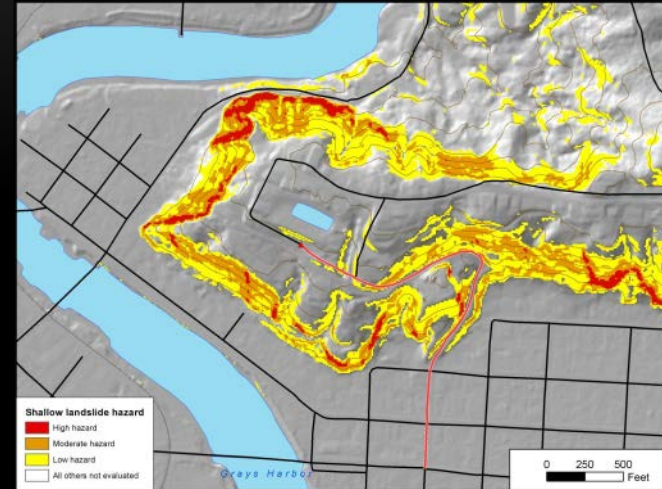


Completed LHZ and WA

SYSTEMATIC LANDSLIDE HAZARD MAPS

Other landslide hazard maps

- Cowlitz County
- Coastal landslide hazard mapping
- 1:24,000-scale geologic maps (DSLS only)
- Earthquake induced landslides for tsunami inundation area (SRLS only unless you have detailed borehole and stratigraphy)
 - Northridge CA 1994 M6.7 had more than 11,000 landslides
 - Wenchuan China, 2008 M8 had more than 60,000



SOME RECENT SIGNIFICANT LANDSLIDES OF WASHINGTON



SR530 slide - 2014



Whidbey Island, Ledgewood Landslide - 2013

Impacted about 30 homes





Nile 2009 Yakima County -

- 80 acre landslide
- ½ mile long x 1/4 mile wide
- 40 million cy
- 9 houses destroyed
- >\$20 million to replace Hwy 410
- River rerouted





Stevenson, Skamania County 2007

Franklin County May 13, 2006
Cost to repair and re-route road 170 --\$6 million
Lake beds consisting of sand, silt, clay



2009 Skagit Co.



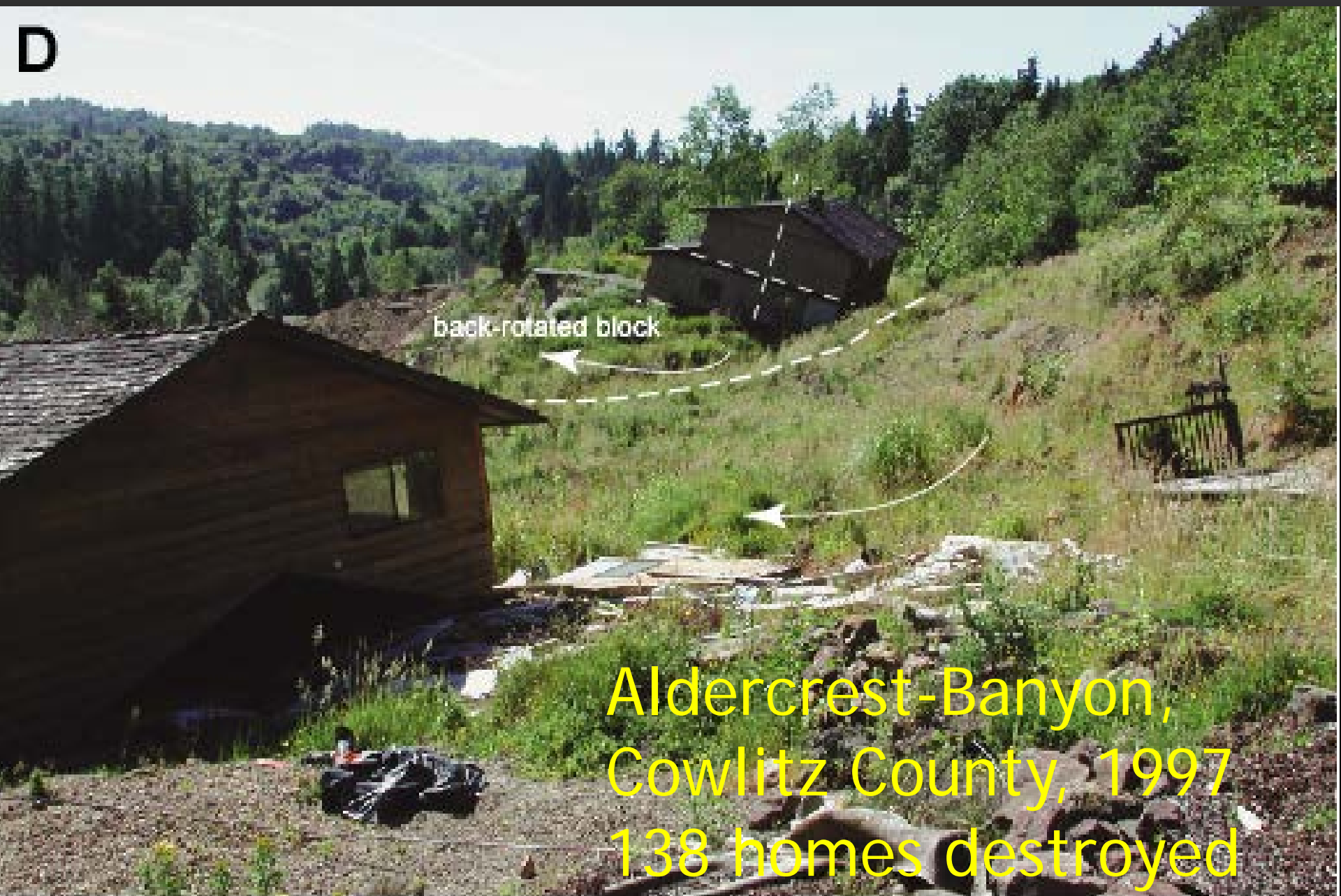
More than
1500
landslides
recorded

2009 SR 12 Lewis County



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Natural Resources

D



back-rotated block

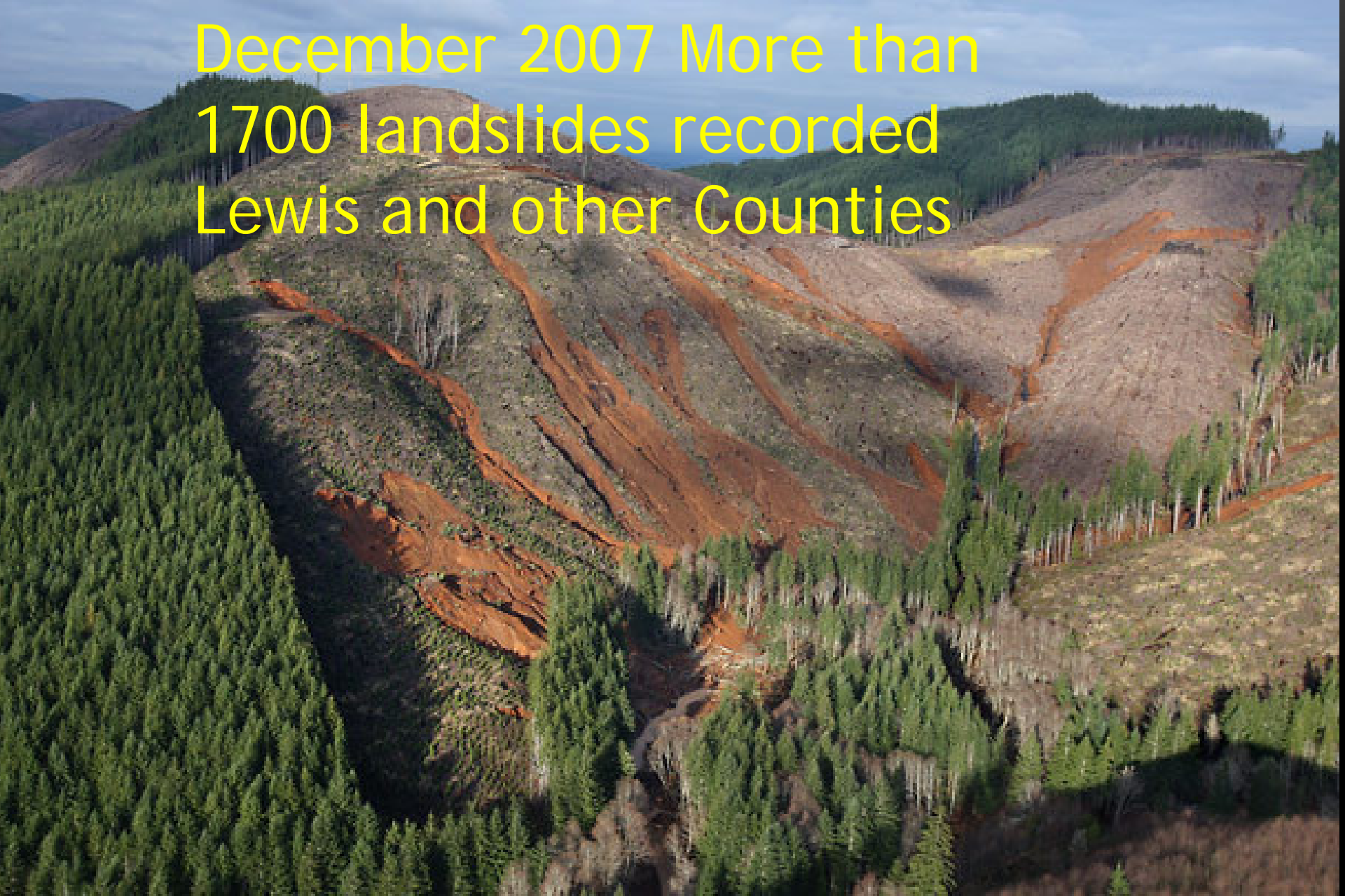
Aldercrest-Banyon,
Cowlitz County, 1997
138 homes destroyed

CARLYON BEACH LANDSLIDE

In February 1999, movement began on a dormant landslide near Olympia eventually forcing more than thirty families from their homes.



December 2007 More than
1700 landslides recorded
Lewis and other Counties



ROLLING BAY, BAINBRIDGE ISLAND, 1997

Tragedy struck on January 19th, 1997. Within three seconds, 2,000 tons of rock, trees, and soil crushed the home, killing all four family members.



MARBLEMOUNT , SKAGIT COUNTY, 1985 - 4 DEATHS





April 10,
2014-
Temporarily
Blocked the
Cedar River



EARTHQUAKE-INDUCED LANDSLIDES

NISQUALLY EARTHQUAKE, 2001



U.S. 101 Landslide



Cedar River Landslide



Capital Lake Landslide



Salmon Beach Landslide

FINDING DATA AND PUBLICATIONS

- Geology Website
<http://www.dnr.wa.gov/geology>
- DNR FP and Geology Databases
- Geology Portal
- <http://www.dnr.wa.gov/geologyportal>

INTERACTIVE MAPS

Using our interactive maps, you can create, save, and print custom maps, find out more information about map features, and download map data for use in a geographic information system (GIS). In addition to a variety of geoscience layers that can be turned on and off, each interactive map has many base layers to choose from, so you can customize your map in any number of ways. Please note that because of the volume of data available through these interactive maps, data loading and identification operations may not be instantaneous; we thank you for your patience.



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