The California Landslide Inventory Database

Chris Wills, California Geological Survey

This talk:
• Landslide hazard maps
• Landslide mapping at CGS
• What we would like to know about every landslide
• Landslide database fields
• Uses for a statewide landslide database
• Need for additional data
Types of Landslide Maps

1. **Landslide-inventory maps**, the most basic landslide maps, portray the location of existing landslides.

2. **Landslide-hazard maps** show where landslides are more likely. There are two general types of landslide-hazard maps, each of which provides a different level of information and detail:
   
   a. **Landslide-susceptibility maps** describe the relative likelihood of future landsliding based solely on the intrinsic properties of a locale or site. Prior failure (from a landslide inventory), rock or soil strength, and steepness of slope are the three site factors that most determine susceptibility.

   b. **Landslide-potential maps** describe the likelihood of landsliding based on susceptibility, jointly with the occurrence of a triggering event (opportunity).

3. **Landslide-risk maps** describe landslide potential jointly with the expected losses to life and property if a failure was to occur.

4. **Landslide-zone maps** depict areas with a higher probability of landsliding, within which specific actions are mandated by California law prior to any development.
Milestones in landslide mapping at CGS:

- **1971** - The state requires safety and seismic safety elements in local general plans – CGS works with local government to develop hazard maps, including landslide maps.
- **1973** - The state requires consideration of landslide hazards in forestry (logging) – CGS works with other state agencies to map landslides in forested areas.
- **1982** - Storms trigger debris flows in the Bay Area. The state establishes the Landslide Hazard Identification Program.
- **1989** - The Loma Prieta earthquake triggers landslides in the Santa Cruz Mountains. The state enacts the Seismic Hazard Zoning act.
A progression of landslide inventory maps
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From the beginning, there has been an attempt to record more than just “a landslide occurred here”.

Most maps show type of slide, and some show the author’s confidence that it is a slide, more recently most show relative activity.

Since the early 1990’s CGS has recorded basic information about landslides in a GIS database. Fields include:

- Type
- Activity
- Confidence
- Author/interpreter
- Depth
- Geologic unit & lithology
- and many other fields (details later)

Seismic hazards program and Forest and Watershed Geology program used slightly different database structures.
Types of Landslides

Rock slide  Earth flow

Debris slide  Debris flow  Rock fall
Types of Landslides

Big slow-moving landslides that damage property

Rock slide                  Earth flow

Small fast-moving landslides that kill people

Debris slide        Debris flow        Rock fall
Activity is an interpretation of the recency of movement based on how erosionally degraded the landslide appears. Ideally, we would like to know when each landslide moved. That information is rarely available.
### Feature Names:
- LS_DEPOSIT_POLY
- LS_DEPOSIT_LINE
- LS_DEPOSIT_POINT

### Feature Descriptions:
Landslide deposit features. Features are polygons, lines or points. Line features are for long narrow landslides less than 150 feet wide. Points exist for features covering less than a quarter acre.

### Attribute Descriptions:

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<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Type</th>
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<td>LS_ID (PK)</td>
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<tr>
<td>MVMT_DATE_DAY</td>
<td>The day of the latest movement. For landslides that are moving continuously, the day used is the last date it moved. Valid values 01-31</td>
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<tr>
<td>TRIGGERING_EVENT</td>
<td>Comments on event that triggered the most recent phase of movement.</td>
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<tr>
<td>SUPERSEDED</td>
<td>Flag to indicate if this feature has been retired. Valid values are null or Y. Attribute value updates are not considered substantial enough to retire a feature. If there is a substantial change required for a landslide deposit boundary (&gt; 50% of the perimeter needs to be modified) then the original feature is copied to create a new feature with a new ls_id and the new polygon is edited to reflect current mapping. The original feature is then flagged as superseded (&quot;Y&quot; in this field).</td>
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</table>
Landslide Hazard Zones maps result in detailed investigations and plans for mitigation prior to development.
Landslide Susceptibility Map

Steep slopes + weak rocks = bad things happen
Wills, C., Perez, F., and Branum, D., 2014, New method for estimating landslide losses from major winter storms in California and application to the ARkStorm Scenario. Natural Hazards Review. 10.1061/(ASCE)NH.1527-6996.0000142.

developed a prototype landslide loss estimation system based on HAZUS, the earthquake, wind, and flood loss estimation program developed for FEMA.

The data collected regarding landslides and landslide damage in past storms have been sparse and inconsistent. Few previous studies have mapped landslides triggered by individual storms, and even fewer have tallied the amount of damage from landslides. The variation in loss with different storm intensities allows for estimates of loss for any given storm intensity, up to the highest recorded intensity.

Landslide susceptibility versus loss ratio by census tract for damage recorded by the City of Los Angeles following the 1978 storms: horizontal bars represent mean loss ratios for three general classes of landslide susceptibility.

Comparison of county-averaged rainfall with ratio of actual landslide damage to landslide damage projected by using the loss ratios from the 1978 storm in Los Angeles for the 1982 storm in the San Francisco Bay Area. The relation between county averaged peak two-day rainfall and the ratio between actual and projected losses allows for estimation of landslide losses for counties based on peak 2-day rainfall.
Conclusion

• The California Landslide Database contains most of the landslides mapped by CGS over the past 50 years – over 100,000 features.

• Attributes included with each landslide database record include the source of the feature, along with basic information such as type, activity, confidence, depth…

• Some more recent records include data on the geologic setting of the landslide, dates of movement, and triggering event.

• A more complete database helps us and others make better landslide hazard and landslide zone maps.

• Landslide inventory maps by others can be incorporated in the CGS database, just send GIS files to chris.wills@conservation.ca.gov