Project Summary

With the formation of the new landslide hazards program at the Washington Geological Survey (WGS), landslide mapping efforts in Washington State have shifted from inventories in managed forest lands to assessments of where people live, work, and recreate. Due to this change of scope and the recent collection of high-resolution lidar, the WGS published the Protocol for Landslide Inventory Mapping from Lidar Data in Washington State (Slaughter and others, 2017) in April 2017. The objective of the inventory protocol is to establish a standard method for the production of a GIS-based landslide inventory. The protocol includes techniques, decision-making criteria, and classification rules for integrating landslide information into the interpretation of landforms and contains an ESRI file geodatabase template with pull-down menus (domains) for ease and consistent data entry. The mapping procedures are similar to the landslide inventory protocol developed by the Oregon Department of Geology and Mineral Industries (Burns and Main, 2005) and vary slightly due to programmatic needs and regional differences.

The data attributes gathered from detailed landslide inventory mapping following this protocol are used to help generate regional landslide susceptibility maps.

Attribute Collection Methods

A primary goal of the protocol is consistency in landslide mapping from lidar. Below we illustrate here we collect some landslide metrics outlined in the protocol.

| Attribute | Description
|-----------|-------------------------------------------------|
| 1A | Photographs
| 1B | Map showing the average horizontal distance between all identified landslide scarps, including the headscarp. The horizontal distance should always be measured from the top of the headscarp to the toe of the landslide deposit. The sum of the horizontal distances is divided by the number of scarps to estimate the average scarp distance in feet. Adapted from Burns and Madin, 2009.
| 1C | Photograph of headscarp elevation measured and profile graph of headscarp elevation measured.
| 1D | Photograph of slope gradient.
| 1E | Photograph of slope map.
| 2 | Components of digitizing a landslide deposit and associated landform features: Digitizing the landslide: (A) headscarp, (B) footslip, (C) slope, and (D) scarps. (yellow), and (E) black.

Benefits of the Protocol

- Create a standardized method for the creation of a landslide inventory in a GIS to ensure that any and all data is inventoried in a consistent manner.
- Follows the well-established landslide inventory protocol developed and currently used in Oregon.

What's in the Publication

- Match geodatabase with step-by-step instructions with accompanying spreadsheets describing all fields and domains.
- An example of a mapped landslide with attributes.

Why do we need high-quality lidar?

Western Washington has very dense, temperate forest (17), so to collect sufficient ground return lidar data at a 0.4-foot resolution is collected during a field condition. Figure 8A shows an orthophoto (A) and two lidar mirel images from the same area (B and C) with differing lidar quality near Burlington, Washington. Areas that lack sufficient ground return pixels clearly reveal the Earth’s curves and are called “knob,” or CEV, and appear similar to a sharpened, minimal raster as in (B). Note the significant detail missing between lidar products and IC, including the crosstalk channels and forest roads that are apparent in IC.

Why we never digitize a landslide with a helicopter

Landslide susceptibility maps use the most reliable method to accurately delineate landslide deposits. A slope map digitized using a helicopter flown airborne photogrammetry has been flown in Washington using three different camera orientations represented by shaded relief views (9A, 9B, 9C) of shaded relief views (9A, 9B, 9C) of a slope map. Surface features such as kame-center morphology, the extent of the toe and mark scarp, and relative age are difficult to discern in (9B) as compared to (9C). In the absence of resources, the WGS creates attributed landslide landform features.

The Geodatabase

The landslide inventory database is structured such that specific feature classes are intended for different mapping techniques—each feature class contains attributes relevant to that particular mapping technique. For instance, when mapping landslide deposits in a GIS using lidar and orthophotos, the inventory class intended for remote mapping contains only attributes that can be populated from remote sensed data. However, for on-the-ground mapping, a separate feature class contains attributes associated with data typically collected from field observations. The inventory class for ground mapping (field, check, sample) can be linked to a mapped landslide deposit using the same primary key values associated with the feature.