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Inventory of Landslide Deposits from Light Detection and Ranging (Lidar) Imagery of the Portland Metropolitan Region, Oregon and Washington

2012

IMS-53
INTERPRETIVE MAP SERIES

Inventory of Landslide Deposits from Light Detection and Ranging (Lidar) Imagery of the Portland Metropolitan Region, Oregon and Washington

by William J. Burns, Ian P. Madin,
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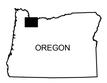
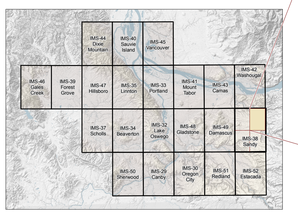
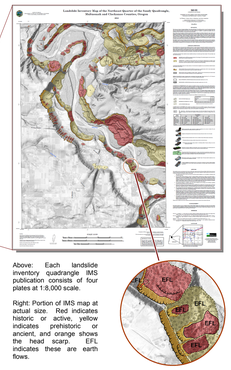


LOCATION MAP AND INDEX TO INTERPRETIVE MAP SERIES PUBLICATIONS

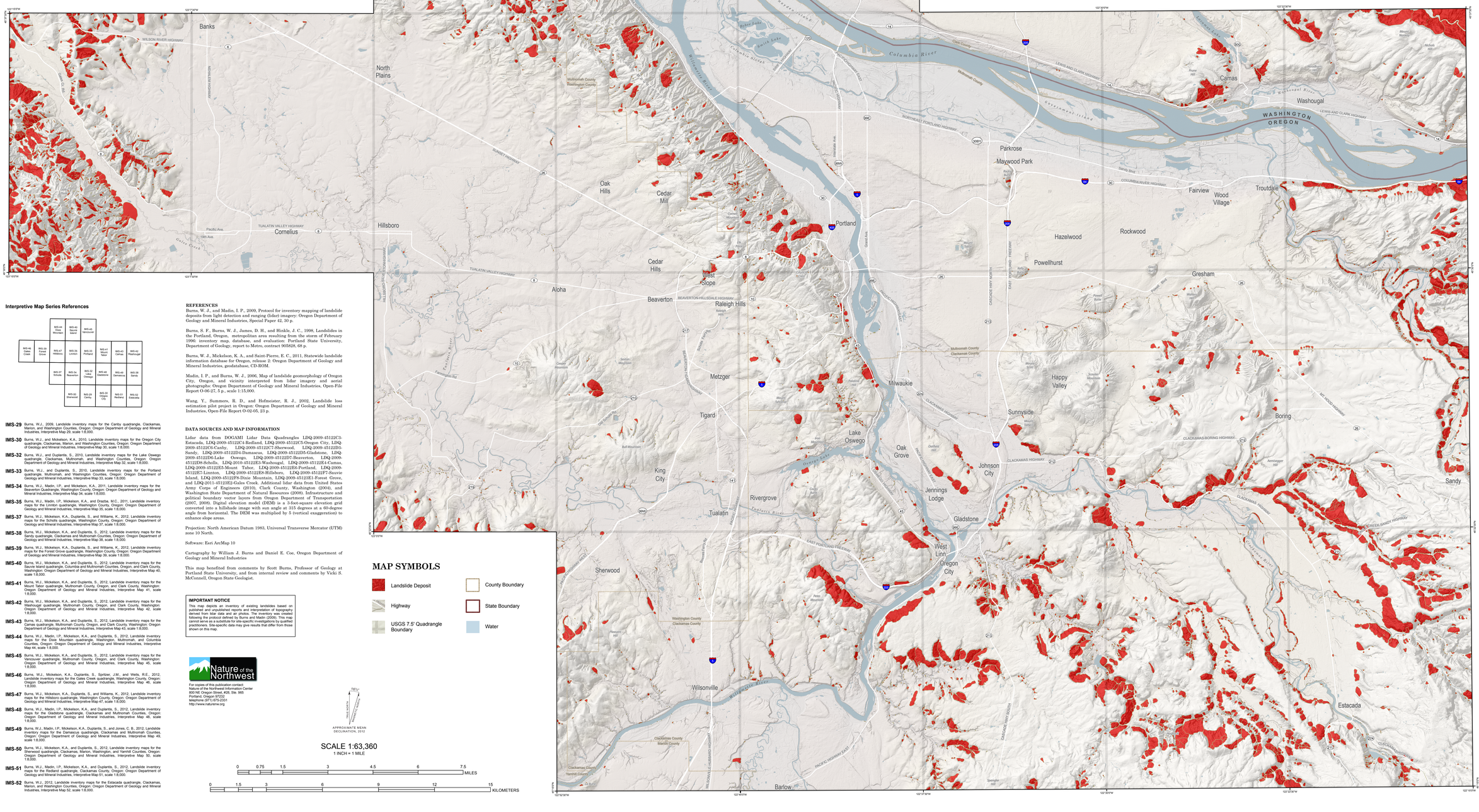


U.S. Geological Survey 7.5-minute quadrangles, DOGAMI Interpretive Map Series (IMS) publications are labeled; see full IMS references below.



Above: Each landslide inventory quadrangle IMS publication consists of four plates at 1:8,000 scale.

Right: Portion of IMS map at actual size. Red indicates historic or active, yellow indicates prehistoric or ancient, and orange shows the head scarp. EFL indicates these are earth flows.



Interpretive Map Series References

IMS-29 Burns, W.J., 2009, Landslide inventory maps for the Canby quadrangle, Clackamas, Marion, and Washington Counties, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 29, scale 1:8,000.

IMS-30 Burns, W.J., and Mickelson, K.A., 2010, Landslide inventory maps for the Oregon City quadrangle, Clackamas, Marion, and Washington Counties, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 30, scale 1:8,000.

IMS-32 Burns, W.J., and Duplantis, S., 2010, Landslide inventory maps for the Lake Oswego quadrangle, Clackamas, Multnomah, and Washington Counties, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 32, scale 1:8,000.

IMS-33 Burns, W.J., and Duplantis, S., 2010, Landslide inventory maps for the Portland quadrangle, Multnomah, and Washington Counties, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 33, scale 1:8,000.

IMS-34 Burns, W.J., Madin, I.P., and Mickelson, K.A., 2011, Landslide inventory maps for the Beaverton Quadrangle, Washington County, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 34, scale 1:8,000.

IMS-35 Burns, W.J., Madin, I.P., Mickelson, K.A., and Drazba, M.C., 2011, Landslide inventory maps for the Linnton quadrangle, Washington County, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 35, scale 1:8,000.

IMS-37 Burns, W.J., Mickelson, K.A., Duplantis, S., and Williams, K., 2012, Landslide inventory maps for the Scholls quadrangle, Washington County, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 37, scale 1:8,000.

IMS-38 Burns, W.J., Mickelson, K.A., and Duplantis, S., 2012, Landslide inventory maps for the Sandy quadrangle, Clackamas and Multnomah Counties, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 38, scale 1:8,000.

IMS-39 Burns, W.J., Mickelson, K.A., Duplantis, S., and Williams, K., 2012, Landslide inventory maps for the Forest Grove quadrangle, Washington County, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 39, scale 1:8,000.

IMS-40 Burns, W.J., Mickelson, K.A., and Duplantis, S., 2012, Landslide inventory maps for the Sauvie Island quadrangle, Columbia and Multnomah Counties, Oregon, and Clark County, Washington: Oregon Department of Geology and Mineral Industries, Interpretive Map 40, scale 1:8,000.

IMS-41 Burns, W.J., Mickelson, K.A., and Duplantis, S., 2012, Landslide inventory maps for the Mount Tabor quadrangle, Multnomah County, Oregon, and Clark County, Washington: Oregon Department of Geology and Mineral Industries, Interpretive Map 41, scale 1:8,000.

IMS-42 Burns, W.J., Mickelson, K.A., and Duplantis, S., 2012, Landslide inventory maps for the Washougal quadrangle, Multnomah County, Oregon, and Clark County, Washington: Oregon Department of Geology and Mineral Industries, Interpretive Map 42, scale 1:8,000.

IMS-43 Burns, W.J., Mickelson, K.A., and Duplantis, S., 2012, Landslide inventory maps for the Camas quadrangle, Multnomah County, Oregon, and Clark County, Washington: Oregon Department of Geology and Mineral Industries, Interpretive Map 43, scale 1:8,000.

IMS-44 Burns, W.J., Madin, I.P., Mickelson, K.A., and Duplantis, S., 2012, Landslide inventory maps for the Dixie Mountain quadrangle, Washington, Multnomah, and Columbia Counties, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 44, scale 1:8,000.

IMS-45 Burns, W.J., Mickelson, K.A., and Duplantis, S., 2012, Landslide inventory maps for the Vancouver quadrangle, Multnomah County, Oregon, and Clark County, Washington: Oregon Department of Geology and Mineral Industries, Interpretive Map 45, scale 1:8,000.

IMS-46 Burns, W.J., Mickelson, K.A., Duplantis, S., Spritzer, J.M., and Wells, R.E., 2012, Landslide inventory maps for the Gales Creek quadrangle, Washington County, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 46, scale 1:8,000.

IMS-47 Burns, W.J., Mickelson, K.A., Duplantis, S., and Williams, K., 2012, Landslide inventory maps for the Hillsboro quadrangle, Washington County, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 47, scale 1:8,000.

IMS-48 Burns, W.J., Madin, I.P., Mickelson, K.A., and Duplantis, S., 2012, Landslide inventory maps for the Gladstone quadrangle, Clackamas and Multnomah Counties, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 48, scale 1:8,000.

IMS-49 Burns, W.J., Madin, I.P., Mickelson, K.A., Duplantis, S., and Jones, C. B., 2012, Landslide inventory maps for the Damascus quadrangle, Clackamas and Multnomah Counties, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 49, scale 1:8,000.

IMS-50 Burns, W.J., Mickelson, K.A., and Duplantis, S., 2012, Landslide inventory maps for the Sherwood quadrangle, Clackamas, Marion, Washington, and Yamhill Counties, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 50, scale 1:8,000.

IMS-51 Burns, W.J., Madin, I.P., Mickelson, K.A., and Duplantis, S., 2012, Landslide inventory maps for the Redland quadrangle, Clackamas County, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 51, scale 1:8,000.

IMS-52 Burns, W.J., 2012, Landslide inventory maps for the Estacada quadrangle, Clackamas, Marion, and Washington Counties, Oregon: Oregon Department of Geology and Mineral Industries, Interpretive Map 52, scale 1:8,000.

REFERENCES

Burns, W. J., and Madin, I. P., 2009, Protocol for inventory mapping of landslide deposits from light detection and ranging (lidar) imagery: Oregon Department of Geology and Mineral Industries, Special Paper 42, 30 p.

Burns, S. F., Burns, W. J., James, D. H., and Hinkle, J. C., 1998, Landslides in the Portland, Oregon, metropolitan area resulting from the storm of February 1996: inventory map, database, and evaluation: Portland State University, Department of Geology, report to Metro, contract 905828, 68 p.

Burns, W. J., Mickelson, K. A., and Saint-Pierre, E. C., 2011, Statewide landslide information database for Oregon, release 2: Oregon Department of Geology and Mineral Industries, geodatabase, CD-ROM.

Madin, I. P., and Burns, W. J., 2006, Map of landslide geomorphology of Oregon City, Oregon, and vicinity interpreted from lidar imagery and aerial photographs: Oregon Department of Geology and Mineral Industries, Open-File Report O-06-27, 5 p., scale 1:15,000.

Wang, Y., Summers, R. D., and Hofmeister, R. J., 2002, Landslide loss estimation pilot project in Oregon: Oregon Department of Geology and Mineral Industries, Open-File Report O-02-05, 23 p.

DATA SOURCES AND MAP INFORMATION

Lidar data from DOGAMI Lidar Data Quadrangles LDQ-2009-45122C3-Estacada, LDQ-2009-45122C4-Redland, LDQ-2009-45122C5-Oregon City, LDQ-2009-45122C6-Canby, LDQ-2009-45122C7-Sherwood, LDQ-2009-45122D3-Sandy, LDQ-2009-45122D4-Damascus, LDQ-2009-45122D5-Gladstone, LDQ-2009-45122D6-Lake Oswego, LDQ-2009-45122D7-Beaverton, LDQ-2009-45122D8-Scholls, LDQ-2010-45122E3-Washougal, LDQ-2009-45122E4-Camas, LDQ-2009-45122E5-Mount Tabor, LDQ-2009-45122E6-Portland, LDQ-2009-45122E7-Linnton, LDQ-2009-45122E8-Hillsboro, LDQ-2009-45122F7-Sauvie Island, LDQ-2009-45122F8-Dixie Mountain, LDQ-2009-45123E1-Forest Grove, and LDQ-2011-45123E2-Gales Creek. Additional lidar data from United States Army Corps of Engineers (2010), Clark County, Washington (2004), and Washington State Department of Natural Resources (2008). Infrastructure and political boundary vector layers from Oregon Department of Transportation (2007, 2008). Digital elevation model (DEM) is a 5-feet-square elevation grid converted into a hillshade image with sun angle at 315 degrees at a 60-degree angle from horizontal. The DEM was multiplied by 5 (vertical exaggeration) to enhance slope areas.

Projection: North American Datum 1983, Universal Transverse Mercator (UTM) zone 10 North.

Software: Esri ArcMap 10

Cartography by William J. Burns and Daniel E. Coe, Oregon Department of Geology and Mineral Industries

This map benefited from comments by Scott Burns, Professor of Geology at Portland State University, and from internal review and comments by Vicki S. McConnell, Oregon State Geologist.

IMPORTANT NOTICE

This map depicts an inventory of existing landslides based on published and unpublished reports and interpretation of topography derived from lidar data and air photos. The inventory was created following the protocol defined by Burns and Madin (2009). This map cannot serve as a substitute for site-specific investigations by qualified practitioners. Site-specific data may give results that differ from those shown on this map.

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MAP SYMBOLS

- Landslide Deposit
- Highway
- USGS 7.5' Quadrangle Boundary
- County Boundary
- State Boundary
- Water

APPROXIMATE MEAN DECLINATION, 2012

SCALE 1:63,360
1 INCH = 1 MILE

0 0.75 1.5 3 4.5 6 7.5 MILES

0 1.5 3 6 9 12 15 KILOMETERS

BACKGROUND

Landslides in Oregon cause ten to hundreds of millions of dollars in direct losses annually and have caused a number of fatalities (Wang and others, 2002). The Statewide Landslide Information Database for Oregon, release 2 (SLIDO-2, Burns and others, 2011) contains records of approximately 1,200 historic landslides in the greater Portland metropolitan region, of which 705 occurred during severe storms in the winter of 1996-1997 (Burns and others, 1998). Over 100 homes were moderately to completely damaged by landslides in just those two years. As the population of the region grows, greater losses are likely to result.

To reduce the risk from future landslides, a variety of mitigation measures are required, all of which must start with an accurate and complete assessment of existing landslide hazards. Locating existing landslides is a crucial first step in understanding the hazard. To meet this need, the Oregon Department of Geology and Mineral Industries (DOGAMI) developed a method to create landslide inventories using detailed topographic information derived from lidar (Burns and Madin, 2009). DOGAMI maps using lidar because these data, collected with an airborne laser scanner, provide very detailed and accurate images of the ground surface, even under dense vegetation.

This map provides an overview of the results of a multi-year landslide inventory mapping project carried out by DOGAMI in the Portland metropolitan area and serves as an index map for associated quadrangle-based landslide inventory maps. The purpose of the mapping project was to create the best currently possible maps of existing landslides in order to provide base data for comprehensive landslide hazard assessments. The project resulted in a detailed geographic information system (GIS) geodatabase of existing landslide deposits and features mapped on high-resolution bare-earth lidar imagery that became available for the Portland urban area in 2006 and 2007. From the geodatabase 22 individual hillshade inventory maps at a scale of 1:8,000 were created. Each inventory map publication includes a digital database of landslide shape, location, and attributes. Each inventory map consists of four plates; each plate covers one quarter of a USGS 7.5-minute quadrangle. See the index map in the upper left of this plate and IMS references list in the lower left for specific inventory maps.

This project was carried out between 2006 and 2012 as part of a collaborative DOGAMI–U.S. Geological Survey (USGS) regional urban geologic mapping project. The project was funded by DOGAMI and through USGS Cooperative Agreements G10AC00133 (Portland Landslide Compilation, FY10-12), G11AC20312 (Portland Surficial Geology, FY11-12), and 07CRGR0009 (Landslide Hazard Program, FY07-08) from the United States Geological Survey. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the USGS.

LANDSLIDE INVENTORY MAPPING

A landslide inventory is one of the essential data layers used to delineate regional landslide hazard. The 22 individual maps were each prepared by following the procedures described in DOGAMI Special Paper 42, Protocol for Inventory Mapping of Landslide Deposits from Light Detection and Ranging (Lidar) Imagery (Burns and Madin, 2009). The three primary tasks in the procedure included compilation of previously mapped landslides (including review of DOGAMI SLIDO-2 [Burns and others, 2011]), lidar-based morphologic mapping of landslide features, and review of aerial photographs. Limited field checking was also performed within each quadrangle. Landslides identified by these methods were digitally compiled into a GIS geodatabase at varying scales. The geodatabases contain multiple GIS datasets including deposit polygon, head scarp polygon, and flank polygon, as well as other scarp lines. Each landslide is also attributed with 29 fields including type of movement, confidence of interpretation, age, slope, estimated depth, area, volume, and others as described in DOGAMI Special Paper 42 (Burns and Madin, 2009). The landslide data are displayed on top of a base map that consists of a lidar-derived hillshade image. The recommended map scale for these data is 1:8,000, as is used for display the data on the quarter-quadrangle plates in each map publication.

RESULTS

Landslide deposits cover approximately 83 square miles, or about 7%, of the study area. This map shows 7,081 landslides, 3,321 of which are large, deep landslides with failure surfaces estimated to have a mean depth of approximately 40 feet below the surface. Of the other landslides, 2,376 are shallow, with mean estimated failure surface of approximately 10 feet deep, 1,311 are debris flow fans, and the remaining are other types or of unknown depth. The referenced IMS maps provide detailed information on deposit type. Individual quadrangle landslide inventory maps (see IMS references; lower left) and associated GIS data are available as CD-ROM publications from DOGAMI.

The geologic, terrain, and climatic conditions that led to landslides in the past are good predictors of future landslides; thus the inventory maps provide critical information to develop regional landslide susceptibility maps, to guide site-specific investigations for future developments, and to assist in regional planning and mitigation of existing landslides.

LIMITATIONS

The landslide inventory data shown on this map were developed by using the protocol of Burns and Madin (2009) and the best available data. Limitations of the protocol are detailed in Burns and Madin (2009). This map is designed for regional applications and should not be used as an alternative to site-specific studies in critical areas. This map shows only landslides newly mapped for the quadrangle-based inventories (see IMS maps; lower left); it does not show historic landslide data points from SLIDO-2 (Burns and others, 2011), including those that occurred during the 1996-1997 winter. Those data are easily accessible on the DOGAMI SLIDO-2 viewer at http://www.oregongeology.org/sub/slido/index.htm. Please contact DOGAMI if errors and/or omissions are found so that they can be corrected in future versions of this map. It is possible that small landslides within the mapped area were not identified. This landslide inventory has no regulatory standing.