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DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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Maps Showing Three Levels of SICCM Landslide Modeling Results for the Lutsinger Creek Watershed, Central Coast Range, Oregon

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The Scarp Identification and Contour Connection Method (SICCM): A Tool for Use in Semi-Automatic Landslide Mapping

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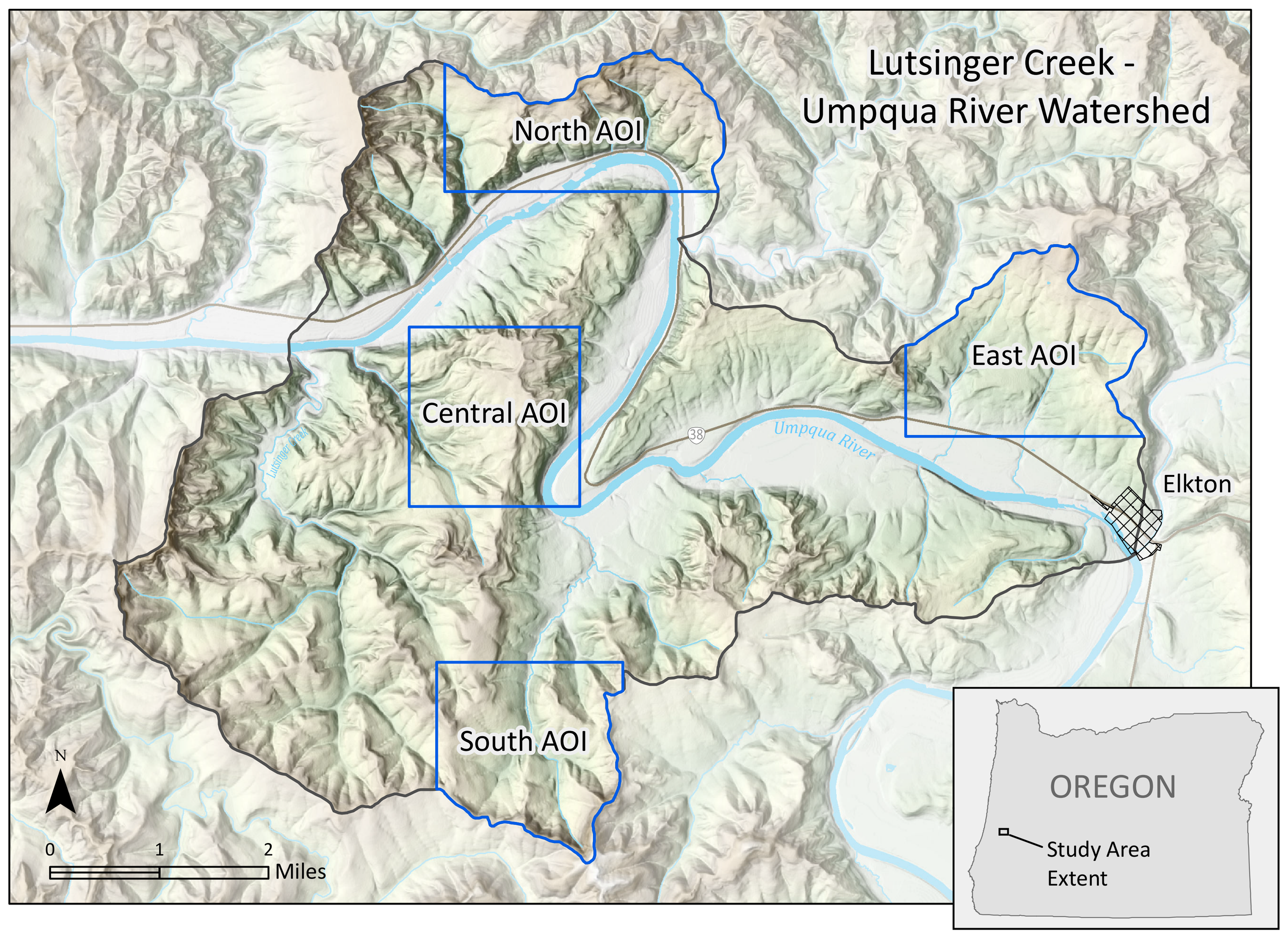
PLATE 1



BACKGROUND

Climate, geology, and topography combine to render portions of the landscape prone to landslides. Rainfall, earthquakes, and human activity are primary triggers of landslides. Landslide deposits remain weak and are susceptible to reactivation. Areas that are prone to landslides can indicate where other landslides may occur. In Oregon, landslides are a significant hazard to the public, damaging infrastructure and assets, and can be life threatening. To reduce risk from existing and future landslides, a variety of measures are required, all of which benefit from an accurate and complete assessment of existing landslides.

LANDSLIDE INVENTORY MAPPING

A map of existing landslide deposits is called a landslide inventory. The DOGAMI SP-42 method (Burns and Madin, 2009) of creating landslide inventories is based on the use of lidar-derived, bare-earth digital elevation model imagery to assist experienced geologists in mapping landslide deposits, head scarps and flanks, and internal scarps. These features are attributed and combined to create an SP-42 landslide inventory. The process is labor intensive and time consuming. The amount of effort to produce an inventory can be a barrier to developing needed data in landslide prone regions.

SCARP IDENTIFICATION AND CONTOUR CONNECTION METHOD

The Scarp Identification and Contour Connection Method (SICCM) uses a set of Python scripts packaged in an ArcGIS toolbox to provide an efficient, semi-automatic framework to quickly scan large areas within a region and detect morphological features that indicate possible landslides (Leshchinsky and others, 2015). SICCM requires elevation base data, Esri ArcGIS software with Spatial Analyst® extension, and a practitioner with knowledge and experience identifying landslides in remotely sensed imagery. Levels of automation ranging from nearly fully automated to semi-automated offer opportunities during tool use for practitioners to analyze interim outputs and adjust parameters. SICCM creates approximated landslide head scarps, represented as lines, that are then used in creating polygons that approximate the locations and extents of landslide deposits. The Scarp Identification and Contour Connection Method (SICCM) is described in further detail by Bunn and others (2019). Their paper discusses the sensitivity of the algorithm to changes in input parameters, explores how geology influences the resulting landslide inventory results, and describes how the results may be used to discern geologic features and trends.

SICCM RESULTS COMPARED WITH SP-42 LANDSLIDE MAPPING

This plate shows SICCM modeled landslide deposit extents compared with SP-42-style landslide deposit extents that have been hand digitized by an experienced landslide geologist.

The study area, the Lutsinger watershed in the central Oregon Coast Range, is about 100 square kilometers. The area has moderate relief and rugged topography and has known, pervasive landslide deposits. When modeling an area, a SICCM practitioner can choose levels of model automation for scarp identification. Fully automated landslide polygons (orange below) represent results obtained by using SICCM default settings. Semi-automated landslide polygons (purple below) represent results obtained by adjusting parameters affecting scarp outputs. Manual landslide deposits (blue below) require an experienced geologist to digitize landslide scarps, and the scarps are then used in the Contour Connection Method portion of SICCM.

For comparison, manually digitized landslide deposit polygons (black outlines below), created using the SP-42 deposit method of mapping (without flank polygons or attributes), are overlain on SICCM modeled results. SICCM results achieved with the time-saving, semi-automated scarp identification level of modeling provide a reasonable starting point for SP-42 landslide inventory mapping. Manual scarp identification also provides a reasonable starting point for SP-42 mapping, but time savings are minimal.

LIMITATIONS AND USES

Because SICCM identifies landslides on the basis of scarplike morphological features, the SICCM method requires a defined head scarp connected to, or in the immediate vicinity of, a landslide deposit. Falls, topples, spreads, and debris flows, following the nomenclature of Cruden and Varnes (1996), cannot be mapped with SICCM.

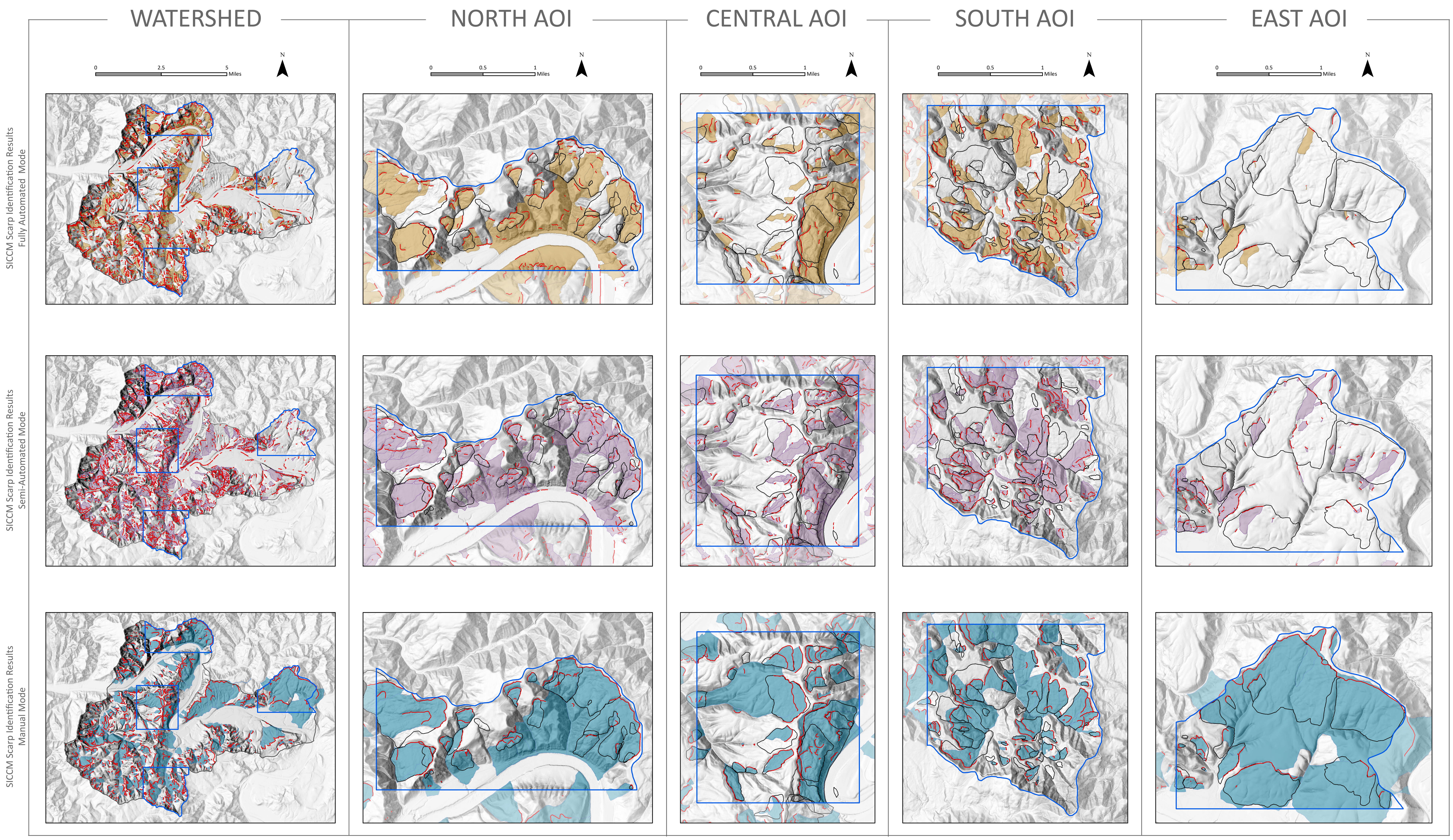
The SICCM process is intended to automate the discovery of landslide-like features at watershed to regional scales. SICCM can expedite landslide inventory mapping, but the SICCM process does not replace a geologist trained in landslide mapping. In Oregon, the public practice of geology must be performed by a licensed geologist or certified engineering geologist as regulated by the Oregon State Board of Geologist Examiners. A landslide inventory that strictly follows the SP-42 protocol is considered of sufficient quality to be used within the context of policy and regulatory purposes.

SICCM results, if used for the public practice of geology, should be carefully reviewed and edited by a licensed geologist or by a certified engineering geologist. Applications such as developing inventory maps for authoritative decisions in planning, zoning, and development restrictions require detailed review such that the resulting inventory is of quality equal to a SP-42 landslide inventory. However, SICCM results may be used to provide preliminary landslide information for nonregulatory purposes. Some examples of nonregulatory uses include maps that 1) assist in the manual landslide mapping process, 2) support broad planning efforts that do not relate to zoning, development, or other authoritative decisions, such as understanding the relative scale of landslide hazards in a region, and (3) provide data layers for teaching or research purposes.

NOTICE

ABOUT THIS PUBLICATION

Landslides are a chronic hazard to people and infrastructure in Oregon. A landslide inventory, a collection of existing landslide deposits in an area, provides baseline data necessary for risk reduction and mitigation efforts. The purpose of this study is to explain how to incorporate the Scarp Identification and Contour Connection Method (SICCM), a semi-automatic process, into a landslide inventory mapping method. This plate displays modeling results of the SICCM method using three levels of automation, compared to hand-digitized landslide polygons mapped using the DOGAMI SP-42 method (Burns and Madin, 2009). The example study area is the Lutsinger Creek watershed. This publication includes a text report, appendix with step-by-step instructions for using the SICCM tool, example Lutsinger Creek watershed geodatabase GIS files, and associated metadata. The SICCM Toolbox for Esri® ArcGIS® is available from Oregon State University, College of Forestry.



Area of Interest (AOI)
Study Area
SP-42 Landslide Outlines
Scarps

SICCM Scarp Identification Automation Level

Fully Automated Mode Landslides
Semi-Automated Mode Landslides
Manual Mode Landslides

Source Data:
Lidar data from DOGAMI Lidar Data Quadrangles 43123E5-Kellogg, 43123E6-Old Blue, 43123E7-Loon Lake, 43123F5-Elkton, 43123F6-Devil's Graveyard, and 43123F7-Scottsburg. Roads and the Elkton City limits from Oregon Department of Transportation, 2013. Streams, rivers, and waterbodies are from the National Hydrology Dataset, 2013.

Projection:
Oregon Statewide Lambert Conformal Conic, Unit: International Feet, Horizontal Datum: NAD 1983 2011.

Software:
Esri® ArcMap® 10.6.0, SICCM Toolbox for ArcGIS

Cartography:
Jon J. Franczyk

References:
Bunn, M. D., Leshchinsky, B. A., Olsen, M. J., Booth, A., 2019, A simplified, object-based framework for efficient landslide inventorying using LIDAR digital elevation model derivatives: Remote Sensing, v. 11, no. 3, 303. https://www.mdpi.com/2072-4292/11/3/303/htm

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., geodatabase, template.

Cruden, D. M., and Varnes, D. J., 1996, Landslide types and processes, *in* Turner, A. K., and Schuster, R. L., eds., Landslides, investigation and mitigation: National Research Council, Washington, D.C., Transportation Research Board Special Report 247, p. 36–75.

Leshchinsky, B. A., Olsen, M. J., and Tanyu, B. F., 2015, Contour Connection Method for automated identification and classification of landslide deposits: Computers & Geosciences, v. 74, 27–38.

SICCM Toolbox for ArcGIS:
The toolbox is available from Oregon State University, College of Forestry: http://geotech.forestry.oregonstate.edu/CCM.html