STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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Serial Lidar Landslide Inventory Map (2009–2023), Ecola State Park Study Area, Oregon

2025

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Ecola State Park Landslide Risk Analysis, Clatsop County, Oregon

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PLATE 5

Introduction

Oregon's state parks are treasures that make Oregon an ideal place to live and explore. Ecola State Park (Ecola) is located on the northern Oregon Coast in Clatsop County between the cities of Seaside and Cannon Beach. Landslide hazards have plagued Ecola since its designation in 1932.

The purpose of this project is to evaluate the current and future landslide susceptibility and risk within and surrounding Ecola to assist the Oregon Parks and Recreation Department (OPRD) in making decisions to reduce landslide risk, with an emphasis on roadways. Landslide susceptibility is the relative likelihood of the landslide hazard occurring in a certain portion of the study area. Landslide risk is the possibility of damage or losses to assets (people, infrastructure, and the environment) by the hazard. To accomplish this goal, several tasks were performed:

- A new lidar topography dataset was collected in 2023.
- The distribution of landslides was mapped throughout the park.
- A new/updated geologic map of the park was created.
- Existing and future landslide susceptibility was analyzed.
- Recommendations for future risk reduction were provided.

Landslide susceptibility and risk were analyzed using several methods, including:

- Landslide inventory: an inventory of contemporary and historic landslide activity was created by examining the 2023 topographic lidar dataset.
- Serial lidar change analysis: landslide activity was identified by examining changes in the topography during a window of time using lidar datasets (2023 and 2009).
- Serial orthophoto change analysis: landslide activity was identified by examining changes in the vegetation and other visual details using multiple orthorectified aerial images spanning 1939 to 2022.
- Geologic mapping: geologic mapping data from the region was collected, corroborated and further investigated with several field days during this study, and combined to build a robust geologic map that can be used in the development of a landslide susceptibility map and provide additional understanding of landslide mechanisms.

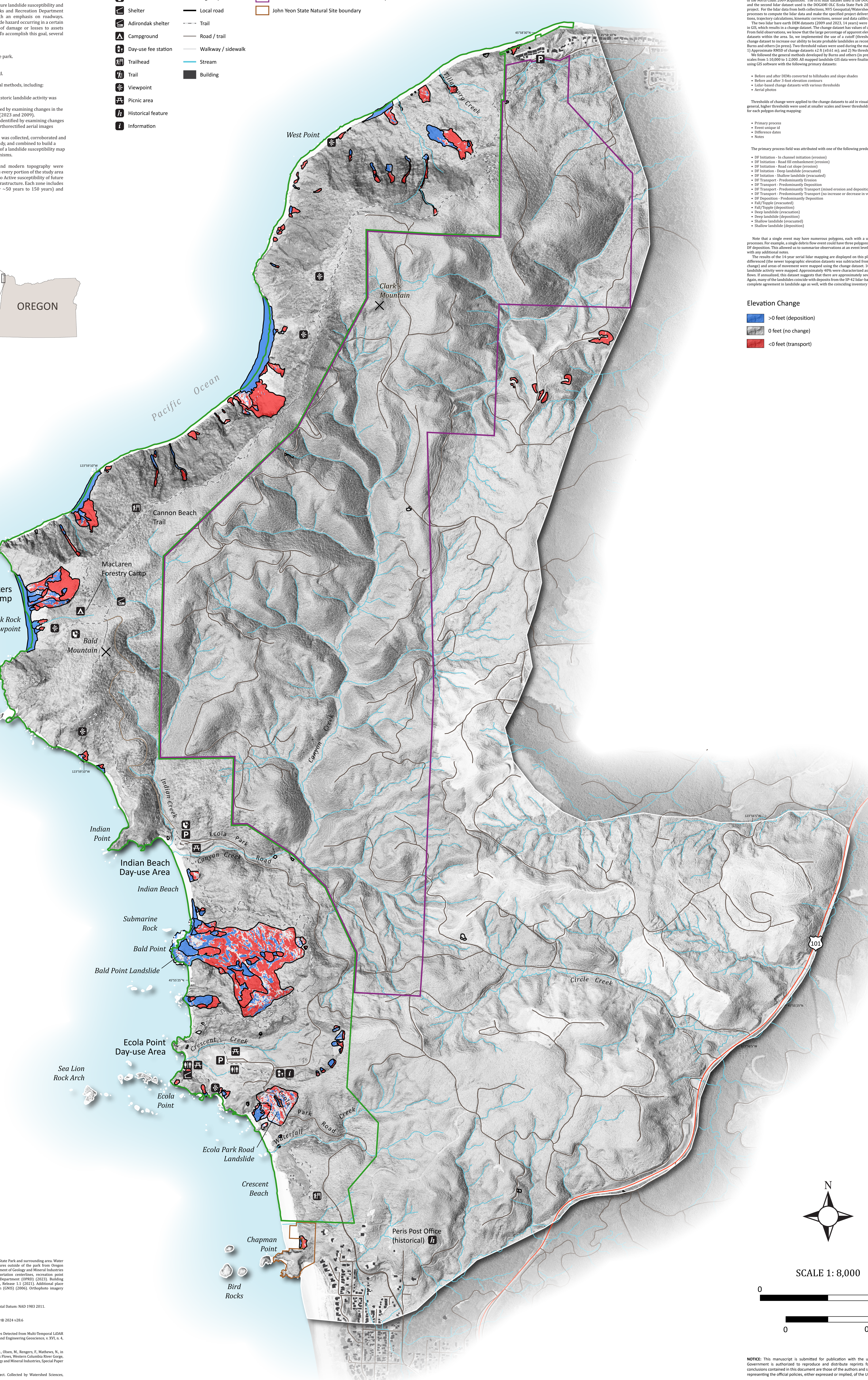
Finally, landslide inventories, geologic mapping data, and modern topography were combined to create a susceptibility and risk map that classifies every portion of the study area into one of the seven susceptibility zones, from None to Low to Active susceptibility of future landslide activity and risk of damage and losses to existing infrastructure. Each zone includes an estimate of past landslide-recurrence activity (e.g., every ~50 years to 150 years) and recommendations for future development to reduce risk.

Location Map

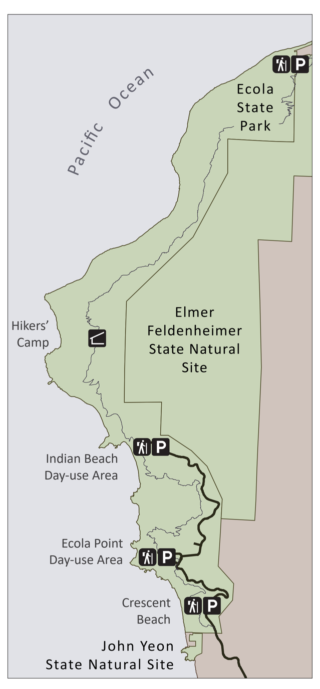
- City
- Highway
- Project Area
- State Park
- Oregon
- Pacific Ocean

General Legend

- Modern restroom
- Pit restroom
- Shelter
- Adirondak shelter
- Campground
- Day-use fee station
- Trailhead
- Trail
- Viewpoint
- Picnic area
- Historical feature
- Information
- Summit
- Highway
- Local road
- Trail
- Road / trail
- Walkway / sidewalk
- Stream
- Building
- Ecola State Park boundary
- Elmer Feldenheimer State National Site boundary
- John Yeon State Natural Site boundary



Park Boundary Map



- Ecola State Park Road
- Oregon Coast Trail
- State Park
- Oregon
- Pacific Ocean

Serial Lidar Landslide Inventory Map Data and Methods

In this study, two lidar point cloud datasets were used to develop a vertical difference raster to help quantify the movement of landslides over a recent 14-year period (2009–2023) in Ecola State Park. Both datasets were collected under the management of the Oregon Lidar Consortium (OLC) at DOGAMI. The lidar for both datasets were acquired by the same Oregon-based remote sensing firm, NV5 Geospatial, which was known as Watershed Sciences at the time of the North Coast 2009 acquisition. The first lidar dataset used is the DOGAMI OLC North Coast 2009 Lidar project, and the second lidar dataset used is the DOGAMI OLC Ecola State Park 2023 Lidar project, collected as part of this project. For the lidar data from both collections, NV5 Geospatial/Watershed Sciences utilized automated and manual processes to compute the lidar data and make the specified project deliverables. These include GPS control calculations, trajectory calculations, kinematic corrections, sensor and data calibration, and lidar point classification.

The two lidar bare earth DEM datasets (2009 and 2023, 14 years) were differenced (2009 subtracted from 2023) in GIS, which results in a change dataset. The change dataset has values of change throughout most of the study area. From field observations, we know that the large percentage of apparent elevation changes was error between the two datasets within the area. So, we implemented the use of a cutoff (threshold) value for removing noise within the change dataset to increase our ability to locate probable landslides as recommended by Burns and others (2010) and Burns and others (in press). Two threshold values were used during the mapping depending on the scale of mapping: 1) Approximate RMSD of change datasets ±2 ft (±0.61 m); and 2) No threshold.

We followed the general methods developed by Burns and others (in press). Mapping was performed at a range of scales from 1:10,000 to 1:2,000. All mapped landslide GIS data were finalized at 1:2,000. All mapping was performed using GIS software with the following primary datasets:

- Before and after DEMs converted to hillshades and slope shades
- Before and after 3-foot elevation contours
- Lidar-based change datasets with various thresholds
- Aerial photos

Thresholds of change were applied to the change datasets to aid in visualizing the data at various spatial scales. In general, higher thresholds were used at smaller scales and lower thresholds at larger scales. We attributed four fields for each polygon during mapping:

- Primary process
- Event unique id
- Difference dates
- Notes

The primary process field was attributed with one of the following predetermined choices (DF=debris flow):

- DF Initiation - In channel initiation (erosion)
- DF Initiation - Road fill embankment (erosion)
- DF Initiation - Road cut slope (erosion)
- DF Initation - Deep landslide (evacuated)
- DF Initation - Shallow landslide (evacuated)
- DF Transport - Predominantly Erosion
- DF Transport - Predominantly Deposition
- DF Transport - Predominantly Transport (mixed erosion and deposition)
- DF Transport - Predominantly Transport (no increase or decrease in volume)
- DF Deposition - Predominantly Deposition
- Fall/Topple (evacuated)
- Fall/Topple (deposition)
- Deep landslide (evacuation)
- Deep landslide (deposition)
- Shallow landslide (evacuated)
- Shallow landslide (deposition)

Note that a single event may have numerous polygons, each with a unique ID, representing different primary processes. For example, a single debris flow event could have three polygons including DF initiation, DF transport, and DF deposition. This allowed us to summarize observations at an event level. Finally, a field called "notes" was filled in with any additional notes.

The results of the 14-year serial lidar mapping are displayed on this plate. The 2009 and 2023 lidar DEMs were differenced (the newer topographic elevation datasets was subtracted from the older revealing areas of topographic change) and areas of movement were mapped using the change dataset. 100 discrete areas considered to represent landslide activity were mapped. Approximately 40% were characterized as shallow, 50% as deep, and 10% as debris flows. If annualized, this dataset suggests that there are approximately seven landslides/year within the study area. Again, many of the landslides coincide with deposits from the SP-42 lidar-based landslide inventory. There was almost complete agreement in landslide age as well, with the coinciding inventory deposits all classified as historic.

Elevation Change

- >0 feet (deposition)
- 0 feet (no change)
- <0 feet (transport)

SCALE 1: 8,000

0 — 0.5 Miles

0 — 0.5 Kilometers

Source Data:
Oregon Lidar Consortium (OLC) one-meter digital elevation model for Ecola State Park and surrounding area. Water features from USGS National Hydrology Dataset (NHD) (2017). Road features outside of the park from Oregon Department of Transportation (ODOT) (2015) or digitized by Oregon Department of Geology and Mineral Industries (DOGAMI) from 2022 orthophotos. Park infrastructure GIS data (transportation centerlines, recreation point locations, transportation structures) from Oregon Parks and Recreation Department (OPRD) (2023). Building footprints from DOGAMI Statewide Building Footprints for Oregon (SBFO), Release 1.1 (2021). Additional place locations from US Geologic Survey, Geographic Names Information System (GNIS) (2006). Orthophoto imagery (2022) from Oregon Statewide Imagery Program (OSIP).

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

Software:
Esri ArcGIS® ArcPro v3.3.1, ArcGIS® ArcMap v10.7.1, and Adobe® Illustrator® 2024 v28.6

References:

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Burns, W.J., Calhoun, N.C., Roering, J., Sanders, M., Leshchinsky, B., DeSousa, D., Olsen, M., Rengers, F., Mathews, N., in press. Multitemporal Lidar Analysis of Pre and Post Eagle Creek Fire Debris Flows, Western Columbia River Gorge, Hood River and Multnomah Counties, Oregon, Oregon Department of Geology and Mineral Industries, Special Paper 55.

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Oregon Lidar Consortium (OLC), 2023. OLC Ecola State Park 2023 Lidar Project. Collected by NV5 Geospatial, Portland, Oregon in 2023.

Digital Cartography:
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