STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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Lidar-Based Regional Landslide Inventory Map (SP-42), 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 3

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.

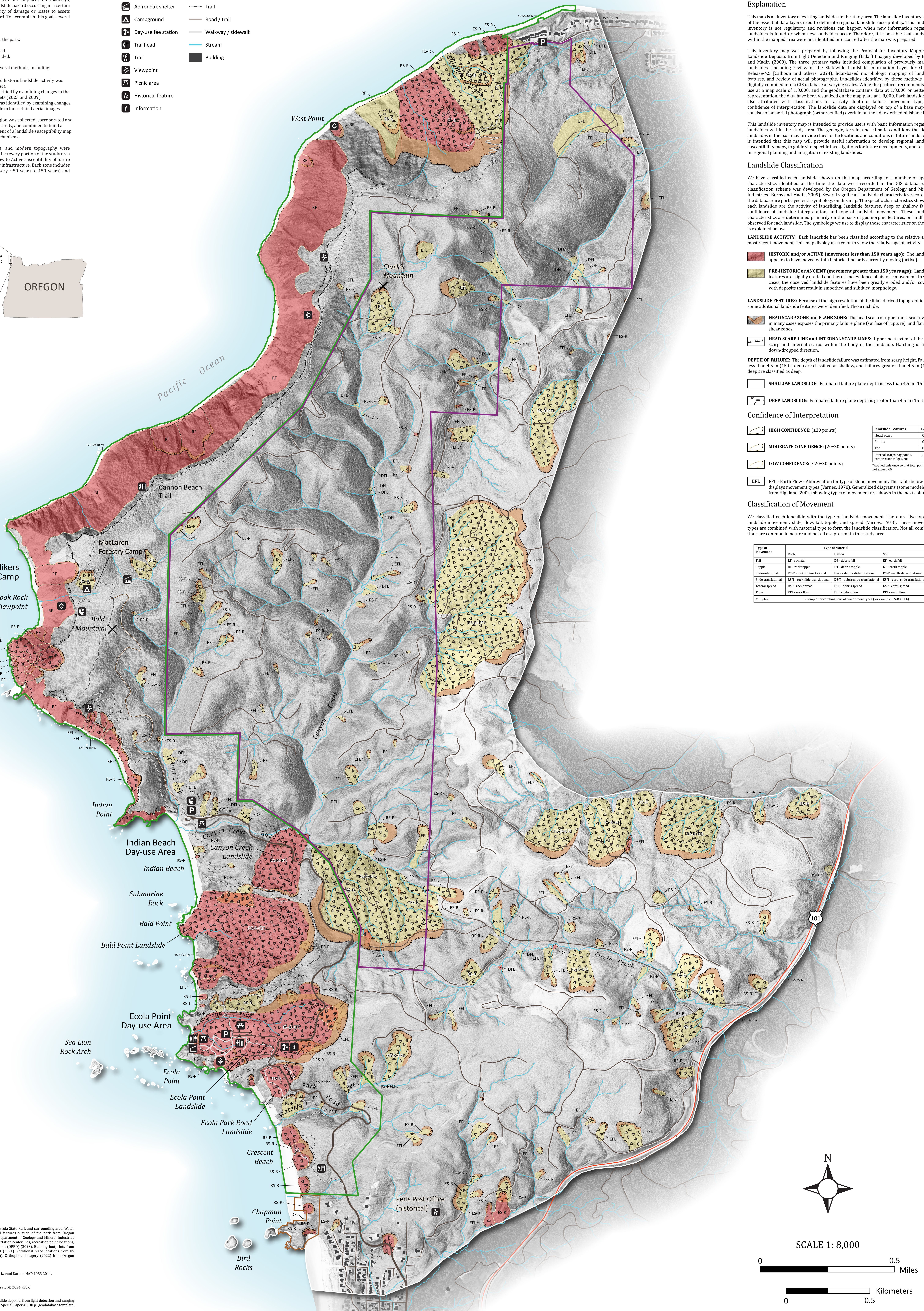
Finally, landslide inventories, geologic mapping data, and modern topography were combined to create a susceptibility and risk map that classifies every portion of the study area into one of the seven susceptibility zones, from None to Low to Active susceptibility of future landslide activity and risk 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

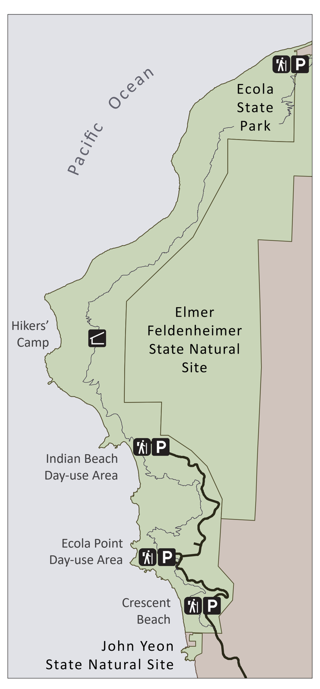
- City
- Highway
- Project Area
- State Park
- Oregon
- Pacific Ocean

General Legend

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



Park Boundary Map



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

Landslide Inventory Introduction

Our lidar-based landslide inventory resulted in the identification of 270 discrete mass movements that have likely occurred in the study area at some point in the past. Of these, 91 are inside Ecola State Park. About 50% were characterized as having moved within the last 150 years, or historic, the other half demonstrated subdued features leading to their characterization as having moved more than 150 years ago, or prehistoric.

Explanation

This map is an inventory of existing landslides in the study area. The landslide inventory is one of the essential data layers used to delineate regional landslide susceptibility. This landslide inventory is not regulatory, and revisions can happen when new information regarding landslides is found or when new landslides occur. Therefore, it is possible that landslides within the mapped area were not identified or occurred after the map was prepared.

This inventory map was prepared by following the Protocol for Inventory Mapping of Landslide Deposits from Light Detection and Ranging (Lidar) Imagery developed by Burns and Madin (2009). The three primary tasks included compilation of previously mapped landslides (including review of the Statewide Landslide Information Layer for Oregon Release-4.5 [Calhoun and others, 2024), lidar-based morphologic mapping of landslide features, and review of aerial photographs. Landslides identified by these methods were digitally compiled into a GIS database at varying scales. While the protocol recommends data use at a map scale of 1:8,000, and the geodatabase contains data at 1:8,000 or better, for representation, the data have been visualized on the map plate at 1:8,000. Each landslide was also attributed with classifications for activity, depth of failure, movement type, and confidence of interpretation. The landslide data are displayed on top of a base map that consists of an aerial photograph (orthorectified) overlaid on the lidar-derived hillshade image.

This landslide inventory map is intended to provide users with basic information regarding landslides within the study area. The geologic, terrain, and climatic conditions that led to landslides in the past may provide clues to the locations and conditions of future landslides.It is intended that this map will provide useful 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.

Landslide Classification

We have classified each landslide shown on this map according to a number of specific characteristics identified at the time the data were recorded in the GIS database. The classification scheme was developed by the Oregon Department of Geology and Mineral Industries (Burns and Madin, 2009). Several significant landslide characteristics recorded in the database are portrayed with symbology on this map. The specific characteristics shown for each landslide are the activity of landsliding, landslide features, deep or shallow failure, confidence of landslide interpretation, and type of landslide movement. These landslide characteristics are determined primarily on the basis of geomorphic features, or landforms, observed for each landslide. The symbology we use to display these characteristics on the map is explained below.

LANDSLIDE ACTIVITY: Each landslide has been classified according to the relative age of most recent movement. This map display uses color to show the relative age of activity.

HISTORIC and/or ACTIVE (movement less than 150 years ago): The landslide appears to have moved within historic time or is currently moving (active).

PRE-HISTORIC or ANCIENT (movement greater than 150 years ago): Landslide features are slightly eroded and there is no evidence of historic movement. In some cases, the observed landslide features have been greatly eroded and/or covered with deposits that result in smoothed and subdued morphology.

LANDSLIDE FEATURES: Because of the high resolution of the lidar-derived topographic data, some additional landslide features were identified. These include:

HEAD SCARP ZONE and FLANK ZONE: The head scarp or upper most scarp, which in many cases exposes the primary failure plane (surface of rupture), and flanks or shear zones.

HEAD SCARP LINE and INTERNAL SCARP LINES: Uppermost extent of the head scarp and internal scarps within the body of the landslide. Hatching is in the down-dropped direction.

DEPTH OF FAILURE: The depth of landslide failure was estimated from scarp height. Failures less than 4.5 m (15 ft) deep are classified as shallow, and failures greater than 4.5 m (15 ft) deep are classified as deep.

SHALLOW LANDSLIDE: Estimated failure plane depth is less than 4.5 m (15 ft).

DEEP LANDSLIDE: Estimated failure plane depth is greater than 4.5 m (15 ft).

Confidence of Interpretation

HIGH CONFIDENCE: (≥30 points)

MODERATE CONFIDENCE: (20−30 points)

LOW CONFIDENCE: (≤20−30 points)

landslide Features	Points
Head scarp	0–10
Flanks	0–10
Toe	0–10
Internal scarps, sag ponds, compression ridges, etc.	0–10*

*Applied only once so that total points do not exceed 40.

EFL EFL - Earth Flow - Abbreviation for type of slope movement. The table below displays movement types (Varnes, 1978). Generalized diagrams (some modeled from Highland, 2004) showing types of movement are shown in the next column.

Classification of Movement

We classified each landslide with the type of landslide movement. There are five types of landslide movement: slide, flow, fall, topple, and spread (Varnes, 1978). These movement types are combined with material type to form the landslide classification. Not all combinations are common in nature and not all are present in this study area.

Type of Movement	Type of Material		
	Rock	**Debris**	**Soil**
Fall	**RF** - rock fall	**DF** - debris fall	**EF** - earth fall
Topple	**RT** - rock topple	**DT** - debris topple	**ET** - earth topple
Slide-rotational	**RS-R** - rock slide-rotational	**DS-R** - debris slide-rotational	**ES-R** - earth slide-rotational
Slide-translational	**RS-T** - rock slide-translational	**DS-T** - debris slide-translational	**ES-T** - earth slide-translational
Lateral spread	**RSP** - rock spread	**DSP** - debris spread	**ESP** - earth spread
Flow	**RFL** - rock flow	**DFL** - debris flow	**EFL** - earth flow
Complex	**C** - complex or combinations of two or more types (for example, ES-R + EFL)		

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:
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. https://pubs.oregon.gov/dogami/sp/p-SP-42.htm

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Highland, L., compiler, 2004, Landslide types and processes: U.S. Geological Survey Fact Sheet 2004-3072 (ver. 1.1), 4 p.

Varnes, D.J., 1978, Slope movement types and processes, in Schuster, R.L., and Krizek, R.J., eds., Landslides — analysis and control: Washington, D.C., Transportation Research Board Special Report 176, p. 11– 33.

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SCALE 1: 8,000

0 — 0.5 Miles

0 — 0.5 Kilometers