STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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Serial Orthophoto-Based Landslide Inventory Map (1939–2022), 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 4

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.

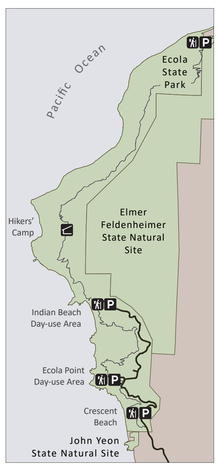
Finally, landslide inventories, geologic mapping data, and modern topography were combined to create a susceptibility and risk map that classifies every portion of the study area into one of the seven susceptibility zones, from None to Low to Active susceptibility of future landslide activity and risk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

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



Orthophoto-based Landslide Inventory Mapping Data and Methods

The lidar change analysis is accurate spatially, but it is limited to only 14 years (2009 to 2023). Orthophoto-based landslide inventory mapping is less accurate spatially but can provide data over a longer time frame (Burns, 2007). We used historic serial orthophotos to create an additional landslide inventory dataset which spans the period from 1939 to 2022 (U.S. Department of Agriculture). The following orthophotos were used:

1939 - Southwest portion of the study area only
1967 - Entire coastal strip of the study area only
1975 - Southwest portion of the study area only
1995 - Entire study area (NAIP)
2000 - Entire study area (NAIP)
2005 - Entire study area (NAIP)
2009 - Entire study area (NAIP)
2011 - Entire study area (NAIP)
2012 - Entire study area (NAIP)
2014 - Entire study area (NAIP)
2016 - Entire study area (NAIP)
2018 - Entire study area (NAIP)
2020 - Entire study area (NAIP)
2022 - Entire study area (NAIP)

We estimate the total timeframe of landslide inventory captured by this analysis to be approximately 83 years (~1939 to 2022). After each landslide was mapped, two fields were attributed for each polygon: landslide type and date range.

The results of the 87-year serial orthophoto mapping are displayed on this plate. We identified a total of 72 landslides which moved between 1939 and 2022 (see Table 1). If annualized, this dataset suggests that there is approximately one landslide/year within the study area. Many of these historic 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.

Table 1. Summary of the serial orthophoto landslide mapping. Note the two highest percentages of the total are time frames with extreme storm events: December 1964 and February 1996.

Orthophoto Time Frame	Number of Inventoried Landslides During the Timeframe	Percent of Total
Pre 1939	3	4%
1939–1967	15	21%
1967–1975	0	0%
1975–1995	14	19%
1995–2000	17	24%
2000–2005	4	6%
2005–2009	2	3%
2009–2011	1	1%
2011–2012	0	0%
2012–2014	5	7%
2014–2016	0	0%
2016–2018	0	0%
2018–2020	3	4%
2020–2022	11	15%
Total	72	4%

Orthophoto Time Frame Legend

- pre 1939–1967
- 1995–2000
- 2000–2011
- 2012–2020
- 2020–2022

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., 2007, Comparison of remote sensing data-sets for the establishment of a landslide mapping protocol in Oregon. AEG Special Publication 23: Vail, Colo., Conference Presentations, 1st North American Landslide Conference.

U.S. Army Corps of Engineers (USACE), 1939, 1967, 1975: Aerial photographs of the Oregon Coast.

U.S. Department of Agriculture (USDA), NAIP Digital Ortho Photo Images. Oregon Statewide Imagery Program (OSIP), geohub.oregon.gov/datasets.

Digital Cartography:
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SCALE 1: 8,000

0 0.5 Miles

0 0.5 Kilometers