



2025

Ecola State Park Landslide Risk Analysis, Clatsop County, Oregon
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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 in 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 (2009, 1929, and 2001).
- **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.

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

The map shows the Elmer Feldenheimer State Natural Site, which is shaded in light green. The Pacific Ocean is to the west and south. The Oregon Coast Trail is shown as a dashed line. The Ecola State Park Road is a solid black line. Various day-use areas are marked: Hikers' Camp, Indian Beach Day-use Area, Ecola Point Day-use Area, and Crescent Beach. The John Yeon State Natural Site is shown to the south, shaded in light pink. The legend indicates that the solid black line is the Ecola State Park Road, the dashed line is the Oregon Coast Trail, the light green area is the State Park, the light pink area is Oregon, and the blue area is the Pacific Ocean.

- Ecola State Park
 — Oregon Coast
 State Park
 Oregon
 Pacific Ocean

	Modern restroom		Summit		Building
	Pit restroom		Highway		Ecola State Park boundary
	Shelter		Trail		Elmer Feldenheimer State National Site boundary
	Adirondack shelter		Road / trail		John Yeon State Natural Site boundary
	Campground		Walkway / sidewalk		
	Day-use fee station		Stream		
	Trailhead		40-foot contour		
	Trail		200-foot contour		
	Viewpoint				
	Picnic area				
	Historical feature				
	Information				

-
- X Summit
 — Highway
 — Trail
 — Road / trail
 — Walkway / sidewalk
 — Stream
 — 40-foot contour
 — 200-foot contour
- Building
 Ecota State Park boundary
 Elmer Feldenheimer State Natural Site boundary
 John Yeon State Natural Site boundary

The Geology of Ecola State Park

The geology of Ecola and the surrounding region has been studied and mapped by Schlicker and others (1961), North and Byrne (1965), Schlicker and others (1972), Niem and others (1973, 1990, 1994), Niem (1975), Carson and Hankel (1975), Neel (1976), Niem and Niem (1985), and Witter and others (2009). Many of these publications also discussed landslide hazards. New detailed geologic mapping in the region by Niem and others (unpublished data, 2024) updates the geologic framework for the area and serves as a basis for landslide analysis in this study.

At the forefemur in Oregon stems from the position on an active plate margin between the overriding on the north and the subducting on the south. The CZS is commonly referred to as the Cascadia Subduction Zone (CZS), where the Juan De Fuca Plate subducts beneath Oregon and the Pacific Northwest (Madin, 2009). The CZS can produce magnitude earthquakes, and the last one occurred on January 26, 1700 (Atwater and others, 2005). The CZS is the most rupture of the US, and caused widespread destruction throughout the Pacific Northwest. Over a thousand landslides are attributed to the CZS, many from the existing landslides along the CZS to be triggered and move in the next CZS major earthquake (Madin, 2009). In general, the geology of Ecola consists of three primary bedrock units: the Oligocene Siuslaw River Formation (Bd), lower Miocene Astoria Formation (Tc, Tac1), and lower Miocene Columbia River Basalt (Crb). The bedrock formations include Late Pleistocene and Holocene coastal alluvial terrace deposits (Qpt, QH1, QH2, QH3, QH4, QH5, QH6, QH7, QH8, QH9, QH10, QH11, QH12, QH13, QH14, QH15, QH16, QH17, QH18, QH19, QH20, QH21, QH22, QH23, QH24, QH25, QH26, QH27, QH28, QH29, QH30, QH31, QH32, QH33, QH34, QH35, QH36, QH37, QH38, QH39, QH40, QH41, QH42, QH43, QH44, QH45, QH46, QH47, QH48, QH49, QH50, QH51, QH52, QH53, QH54, QH55, QH56, QH57, QH58, QH59, QH60, QH61, QH62, QH63, QH64, QH65, QH66, QH67, QH68, QH69, QH70, QH71, QH72, QH73, QH74, QH75, QH76, QH77, QH78, QH79, QH80, QH81, QH82, QH83, QH84, QH85, QH86, QH87, QH88, QH89, QH90, QH91, QH92, QH93, QH94, QH95, QH96, QH97, QH98, QH99, QH100, QH101, QH102, QH103, QH104, QH105, QH106, QH107, QH108, QH109, QH110, QH111, QH112, QH113, QH114, QH115, QH116, QH117, QH118, QH119, QH120, QH121, QH122, QH123, QH124, QH125, QH126, QH127, QH128, QH129, QH130, QH131, QH132, QH133, QH134, QH135, QH136, QH137, QH138, QH139, QH140, QH141, QH142, QH143, QH144, QH145, QH146, QH147, QH148, QH149, QH150, QH151, QH152, QH153, QH154, QH155, QH156, QH157, QH158, QH159, QH160, QH161, QH162, QH163, QH164, QH165, QH166, QH167, QH168, QH169, QH170, QH171, QH172, QH173, QH174, QH175, QH176, QH177, QH178, QH179, QH180, QH181, QH182, QH183, QH184, QH185, QH186, QH187, QH188, QH189, QH190, QH191, QH192, QH193, QH194, QH195, QH196, QH197, QH198, QH199, QH200, QH201, QH202, QH203, QH204, QH205, QH206, QH207, QH208, QH209, QH210, QH211, QH212, QH213, QH214, QH215, QH216, QH217, QH218, QH219, QH220, QH221, QH222, QH223, QH224, QH225, QH226, QH227, QH228, QH229, QH230, QH231, QH232, QH233, QH234, QH235, QH236, QH237, QH238, QH239, QH240, QH241, QH242, QH243, QH244, QH245, QH246, QH247, QH248, QH249, QH250, QH251, QH252, QH253, QH254, QH255, QH256, QH257, QH258, QH259, QH260, QH261, QH262, QH263, QH264, QH265, QH266, QH267, QH268, QH269, QH270, QH271, QH272, QH273, QH274, QH275, QH276, QH277, QH278, QH279, QH280, QH281, QH282, QH283, QH284, QH285, QH286, QH287, QH288, QH289, QH290, QH291, QH292, QH293, QH294, QH295, QH296, QH297, QH298, QH299, QH300, QH301, QH302, QH303, QH304, QH305, QH306, QH307, QH308, QH309, QH310, QH311, QH312, QH313, QH314, QH315, QH316, QH317, QH318, QH319, QH320, QH321, QH322, QH323, QH324, QH325, QH326, QH327, QH328, QH329, QH330, QH331, QH332, QH333, QH334, QH335, QH336, QH337, QH338, QH339, QH340, QH341, QH342, QH343, QH344, QH345, QH346, QH347, QH348, QH349, QH350, QH351, QH352, QH353, QH354, QH355, QH356, QH357, QH358, QH359, QH360, QH361, QH362, QH363, QH364, QH365, QH366, QH367, QH368, QH369, QH370, QH371, QH372, QH373, QH374, QH375, QH376, QH377, QH378, QH379, QH380, QH381, QH382, QH383, QH384, QH385, QH386, QH387, QH388, QH389, QH390, QH391, QH392, QH393, QH394, QH395, QH396, QH397, QH398, QH399, QH400, QH401, QH402, QH403, QH404, QH405, QH406, QH407, QH408, QH409, QH410, QH411, QH412, QH413, QH414, QH415, QH416, QH417, QH418, QH419, QH420, QH421, QH422, QH423, QH424, QH425, QH426, QH427, QH428, QH429, QH430, QH431, QH432, QH433, QH434, QH435, QH436, QH437, QH438, QH439, QH440, QH441, QH442, QH443, QH444, QH445, QH446, QH447, QH448, QH449, QH450, QH451, QH452, QH453, QH454, QH455, QH456, QH457, QH458, QH459, QH460, QH461, QH462, QH463, QH464, QH465, QH466, QH467, QH468, QH469, QH470, QH471, QH472, QH473, QH474, QH475, QH476, QH477, QH478, QH479, QH480, QH481, QH482, QH483, QH484, QH485, QH486, QH487, QH488, QH489, QH490, QH491, QH492, QH493, QH494, QH495, QH496, QH497, QH498, QH499, QH500, QH501, QH502, QH503, QH504, QH505, QH506, QH507, QH508, QH509, QH510, QH511, QH512, QH513, QH514, QH515, QH516, QH517, QH518, QH519, QH520, QH521, QH522, QH523, QH524, QH525, QH526, QH527, QH528, QH529, QH530, QH531, QH532, QH533, QH534, QH535, QH536, QH537, QH538, QH539, QH540, QH541, QH542, QH543, QH544, QH545, QH546, QH547, QH548, QH549, QH550, QH551, QH552, QH553, QH554, QH555, QH556, QH557, QH558, QH559, QH560, QH561, QH562, QH563, QH564, QH565, QH566, QH567, QH568, QH569, QH570, QH571, QH572, QH573, QH574, QH575, QH576, QH577, QH578, QH579, QH580, QH581, QH582, QH583, QH584, QH585, QH586, QH587, QH588, QH589, QH590, QH591, QH592, QH593, QH594, QH595, QH596, QH597, QH598, QH599, QH600, QH601, QH602, QH603, QH604, QH605, QH606, QH607, QH608, QH609, QH610, QH611, QH612, QH613, QH614, QH615, QH616, QH617, QH618, QH619, QH620, QH621, QH622, QH623, QH624, QH625, QH626, QH627, QH628, QH629, QH630, QH631, QH632, QH633, QH634, QH635, QH636, QH637, QH638, QH639, QH640, QH641, QH642, QH643, QH644, QH645, QH646, QH647, QH648, QH649, QH650, QH651, QH652, QH653, QH654, QH655, QH656, QH657, QH65

The oldest glauconite in Ecola, cropping out only in the northern part of the park, is the Oligocene Smagger Cove Formation (**TSC**; Nene, 1976; Nien and Nien, 1985). This sequence of tuffaceous bioturbated claystone and tuffaceous mudstone/siltstone was deposited in a deepwater bathyal environment (Nien and Nien, 1985; Nien and Nien, 1987; Nien and Nien, 1988). The Astoria Formation (**TAC**; Tactl) is a widespread, scattered coastal lito-stratigraphic unit exposed in four sedimentary basins from Astoria to Newport, Oregon (Snavely and others, 1976) and inland southwest Washington (Wolfe and McKee, 1968). The Cannon Beach Member is the only part of the Astoria Formation that is exposed in the Cannon Beach area (Nien and Nien, 1985). The Cannon Beach Formation (**TBC**) is this sequence of well-laminated, dark gray, micromacroscale and carbonaceous mudstone (**Ta**) and fine-grained quartz-feldspathic turbidite sandstone (**Tactl**) was deposited in a deep-marine depositional environment (a deep-sea, burrowing organisms) on the upper continental shelf (Nien and Nien, 1985; Nien and Nien, 1987; Nien and Nien, 1988; Nien and Nien, 2024).

Twigg, Tobi, Twigg: Nield Creek (1973). The CBRG in an extensional tectonic environment: the tectonic basin and basinal andesite lava flows that cover more than 130,488 km² in parts of Oregon, Washington, and Idaho. These lava flows largely erupted from NNW-striking linear fissures that trended north-south and were formed by extensional tectonics. The CBRG was formed by extensional tectonics that flowed west through the Columbia transect lowland to the Miocene Pacific coast of Oregon and Washington (Wells and others, 2009; Camp and Wells, 2021). When some lava flows reached the eastern edge of the CBRG, they were forced to flow southward into the Columbia River valley. The CBRG was formed by extensional tectonics (Wells and others, 2009). Relatively dense lava flows invaded soft, water-saturated, and poorly consolidated deep-marine sediments of the Astoria Formation, forming a complex network of ridges, hills, dunes, and irregularly shaped intrusive bodies (Schlicker and others, 1961; Nield and others, 1973; Wells and others, 2009; Camp and Wells, 2021). The CBRG was formed by extensional tectonics. The marine sediment was accompanied by formation of basalt breccia and pebbly concretions, complex deformation (chevron folding) of the sediments, and local hydrothermal contact baking metamorphism.




Most of the larger deep landslides in Ecola originate within the Cannon Beach Member of the Astoria Formation (Tac, Tacl), an overall fine-grained lithology that is characterized by weak bedding planes, relatively low material strength, and deformation by several processes. Schlicker and others (1961) proposed that deformation caused by basalt intrusions may have weakened the sedimentary rock and made them more landslide prone. About one-third of the exposed Smuggler Cove Formation in Ecola is associated with overlying basalt landslides sourced from the West Point fault scarps.

Geologic units shown on this plate, following the work of Niem and others (unpublished data, 2024), are as follows:

QUATERNARY SURFICIAL DEPOSITS

- | | |
|-----|---|
| Qbs | beach sand and basalt gravel berm (Holocene) |
| Qbg | basalt beach gravel (Holocene) |
| Qds | dune sand (Holocene) |
| Qal | alluvium and estuarine deposits (Holocene) |
| Qft | coastal and fluvial terrace deposits (Holocene and Pleistocene) |
| Qot | coastal-fluvial terrace deposits (Upper Pleistocene) |

COLUMBIA RIVER BASALT GROUP

- Wanapum Basalt
- Frenchman Springs Member*
-  Basalt of Ginkgo, invasive sills and dikes (lower Miocene)
- Grande Ronde Basalt
- Normal-polarity (N2) magnetostratigraphic unit*
- Sentinel Bluffs Member
-  Sentinel Bluffs Member, invasive basalt sill (lower Miocene)
- Winter Water Member
-  Winter Water Member (lower Miocene)

ASTORIA FORMATION

Cannon Beach Member

Tac deep marine micromicaceous mudstone (lower Miocene)






Subdivided in Ecola State Park to show:

TacL micaceous and carbonaceous fine-grained quartzo-feldspathic turbidite sandstone (lower Miocene)

SMUGGLER COVE FORMATION

Tsc	tuffaceous and bioturbated clayey siltstone (Oligocene)
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Explanation of Geology Symbols

- | | |
|---|---|
|  | Inclined bedding: Showing strike and dip |
|  | Inclined generic (origin not known or not specified)
foliation—Showing strike and dip |
|  | Contact — long-dashed line where approximate, short-dashed where inferred, dotted where concealed. |
|  | Fault — long dashed line where approximate, short-dashed where inferred, dotted where concealed, queried where uncertain. |
|  | Normal fault — ball and bar on downthrown block. Long-dashed where approximate, short-dashed where inferred, dotted where concealed, queried where uncertain. |

References:

[illegible]

Source Data: Oregon Land 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 (ODGI) (2012) orthophoto. Park infrastructure GIS data (transportation centers, recreation points, recreation locations, transportation structures) from Oregon Parks and Recreation Department (OPRD) (2013). Building footprints from DGCAMI Statewide Building Footprints for Oregon (SBFO), Release 1.1 (2021). Additional place locations from US Geologic Survey, Geographic Names Information System (GNIS) (2006). Orthophoto images (2022) from Oregon Statewide Imagery Program (OSIP).

Projection:

Oregon Statewide Limb

Software:
Esri ArcGIS® ArcPro v3.3

Fluorescence

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