

Loon Lake is a 294-acre (119 ha)^[1] lake in **Douglas County** in the **Oregon Coast Range** of the United States, 15 miles (24 km) east-southeast of **Reedsport, Oregon**, at an elevation of 392 feet (119 m).^[2] The lake is about 2 miles (3 km) long with a maximum width of about 0.4 miles (0.6 km), and is over 100 feet (30 m) deep in some places.

The lake is "a classic example of a landslide lake",^[1] dammed by a slide of **sandstone** blocks which fell into the Lake Creek valley about 1,400 years ago. The lake was discovered in 1852 and named for the **loons** found on its waters.

CARBON 14 TEST DATES LOON LAKE

Ewart M. Baldwin, professor of geology at the University of Oregon, reports that a sample of wood taken from a standing tree in Loon Lake, Douglas County, and sent to Dr. Willard Libby for age determination by the carbon 14 method, was found to be 1,460 years, plus or minus 80. The sample was sent to Dr. Libby by Miss Harriet Ward, resident on the shore of the lake, who recognized that a dating of the outer part of the tree would give the date the lake was formed. According to Dr. Baldwin, Loon Lake was caused by a landslide in which a large mass of Tye sandstone slipped down from the western slope of the valley of Lake Creek, forming a dam behind which the water was quickly impounded.

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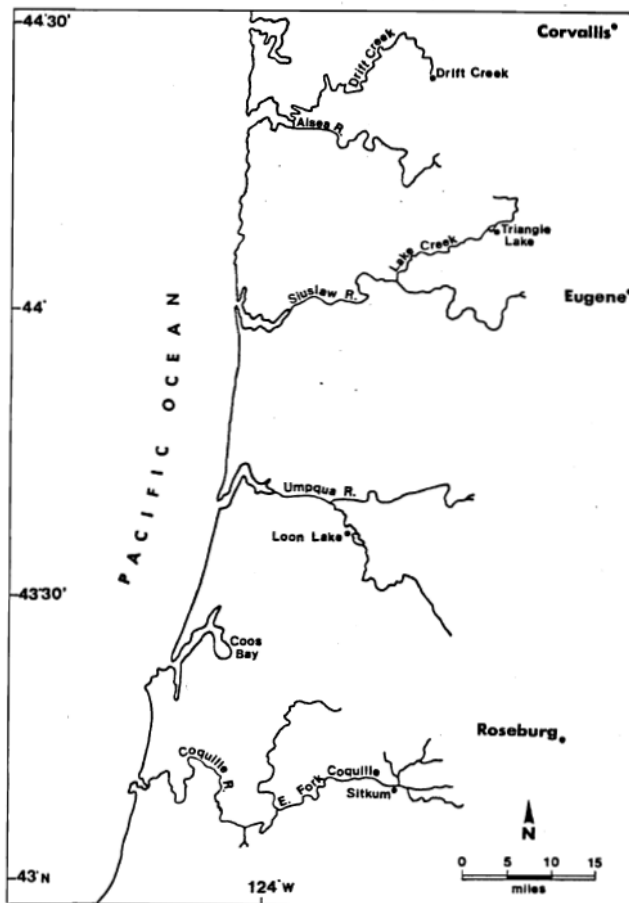


Figure 14. Location of major landslide-dammed lakes in the Coast Range, as discussed in the text; at Sitkum, Loon Lake, Triangle Lake, and Drift Creek.

TABLE 1. LANDSLIDE-DAM LAKES IN THE OREGON COAST RANGE

Name	Latitude (N)	Longitude (W)	Chronology
Ancient Lake Sittkum [†]	43.143°	123.866°	?
Ayers Lake	44.458°	123.785°	Drift Creek slide: Dec. 6, 1975
Bradish Lake	44.605°	123.701°	?
Camp Creek (temporary lake)	43.607°	123.778°	Camp Creek slide: winter, 1956
Esmond Lake	43.871°	123.598°	?
Gould (Elk) Lake	43.535°	123.943°	?
Loon Lake [†]	43.585°	123.837°	>1400 yr B.P.
Lost Lake	43.285°	123.606°	?
Triangle Lake [†]	44.172°	123.571°	>42,000 yr B.P.
Wasson Lake	43.747°	123.793°	?
Yellow Lake	43.799°	123.554°	?

[†]Large lake with upstream alluviated valley greater than 4 km in length (Baldwin, 1936; Thrall et al., 1980; Lane, 1987).

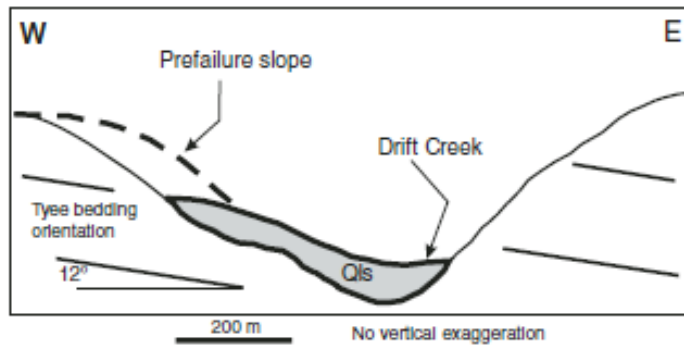


Figure 4. Schematic cross section of Drift Creek landslide (Dec. 6, 1975). Modified after Lane (1987). Qls refers to Quaternary landslide deposit.

Relations between geology and mass movement features in a part of the East Fork Coquille River watershed, southern Coast Range, Oregon

Lane, 1988, M.S. Thesis, OSU

Various types of mass movement features are found in the drainage basin of the East Fork Coquille River in the southern Oregon Coast Range. The distribution and forms of mass movement features in the area are related to geologic factors and the resultant topography. The Jurassic Otter Point Formation, a melange of low-grade metamorphic and marine sedimentary rocks, is present in scattered outcrops in the southwest portion of the study area but is not extensive. The Tertiary Roseburg Formation consists primarily of bedded siltstone and is compressed into a series of west to northwest-striking folds. The overlying Lookingglass, Flournoy, and Tye Formations consist of rhythmically bedded sandstone and siltstone units with an east to northeasterly dip of 5-15° decreasing upward in the stratigraphic section. The units form cuesta ridges with up to 2000 feet of relief. Signature redacted for privacy. The distribution of mass movements is demonstrably related to the bedrock geology and the study area topography. Debris avalanches are more common on the steep slopes underlain by Flournoy Formation and Tye Formation sandstones, on the obsequent slope of cuesta ridges, and on north-facing slopes. Soil creep occurs throughout the study area and may be the primary mass movement form in siltstone terrane, though soil creep was not studied in detail. Slump-earthflows, rockfalls, and rock slumps also occur in the study area though less extensively than

debris avalanches. Stratigraphy and bedrock attitude contributed to the pre-historic occurrence of a major landslide involving Flounoy and Tyee Formation bedrock. The Sitkum landslide dammed the East Fork Coquille River, forming a substantial lake which is now filled with sediments. The form and size of the Sitkum landslide is similar to other landslides which have dammed drainages in the Coast Range, including Loon Lake, Triangle Lake, and Drift Creek. **Comparisons with the Loon Lake landslide**, which has a known radiocarbon date, provide estimated dates of 3125 years B.P. for the Sitkum landslide and 10,300 years for the Triangle Lake landslide.

LANDSLIDE LAKES

Mass movement activity in the Oregon Coast Range is characterized by debris avalanches/torrents (Swanston and Swanson, 1977; Gresswell et al, 1979), by block glide failures (Graham, 1986) and by large bedrock landslides which effectively obstruct stream drainages and result in the formation of lakes. Landslide-dammed lakes typically occur in areas of the Coast Range underlain by resistant sandstone bedrock, such as the Flounoy and Tyee Formations. The bedrock contributes to the formation of landslide lakes by producing rugged, high relief terrains, and by forming deposits of very coarse debris when failure does occur. Lower overall clay content of the siltstone/mudstone interbeds, and typical dips of 100 to 20° of the Flounoy and Tyee units, also contribute to the opportunity for significant failures. Thus there is in the Coast Range greater potential for large, relatively rapid slides that impound drainages. In contrast, in the Cascades alteration of volcanic bedrock typically leads to development of slow moving earthflows which are easily eroded by streams, though local base level may be raised.

Landslide lakes in the Coast Range vary in size, probably depending on the volume of the slide debris, the height of the dam, and valley geometry. The lifetime of a lake is related to the capacity of the impounded stream to incise or remove the dam, and the rate of sediment deposition from the drainage basin contributing to the lake. Most landslide lakes are quite small and are located near the heads of drainages, such as Elk and Wasson Lakes in the Scottsburg quadrangle (Baldwin, 1958). However, three of the larger sites--Loon Lake, Triangle Lake, and Drift Creek Slide--are comparable to the Sitkum landslide area and are considered in this study (Figure 14).

Loon Lake is located in the Scottsburg 7.5-minute USGS quad range, about 30 miles north of Sitkum, and was formed by a landslide 1460 ± 80 years B.P. (radiocarbon date on wood from standing, drowned trees, from Baldwin, 1981). The slide consists of Tyee Formation sandstone which failed on an east-aspect slope and moved approximately 0.5 mile down-slope to dam the drainage of Mill Creek (Figures 15 and 16). Undisturbed bedrock nearby has an attitude of N 15 E and dips 12 southeast. The failure occurred on the bedrock dip slope.

The dam formed by the landslide debris at Loon Lake is about 235 feet high and originally impounded a lake of about 6 miles in length and 2.6 square miles in surface area (based on area of sediment deposition). Sediment has filled most of the impoundment, reducing Loon Lake to its present surface area of 218 acres (0.34 square miles). The lake outlet flows over coarse landslide debris, consisting of boulder to car-size sandstone blocks, so that incision of the dam has been minor, probably less than 50 feet. The rate of sediment production by the watershed (92 square miles in area) compared to the rate of dam incision over the past 1460 years indicates the lake will be filled long before the landslide dam is removed completely.

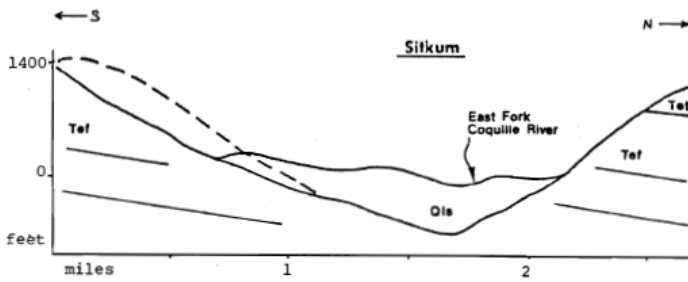
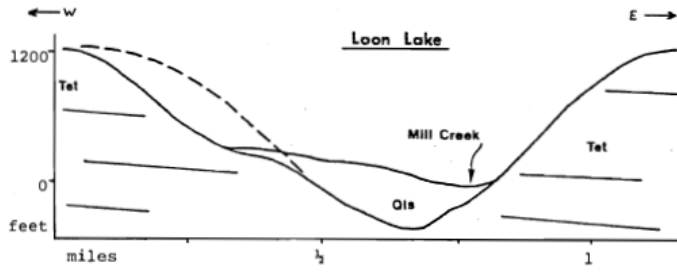


Figure 15. Valley profiles of the Loon Lake and Sitkum landslide sites, both viewed in a downstream direction. The large arrows indicate the location of the streams at the crest of the landslide dams. Qls= landslide debris, Tef= Flourney Fm., Tet= Tyee Fm. The apparent dip of the bedrock is indicated. The dashed lines approximate the former hillslope prior to failure, and indicate the valley wall from which the landslide moved.

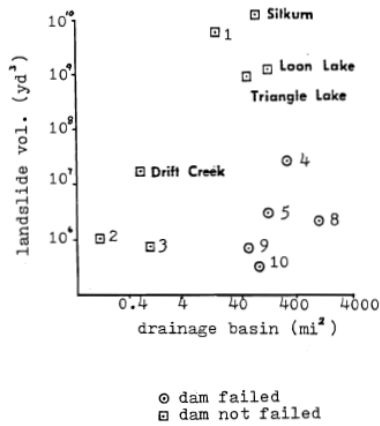


Figure 20. Distribution of landslide dams in relation to the landslide volume and the drainage basin area above the landslide dam. Dam sites 1 through 10 are from Swanson et al (1986), "Landslide Dams in Japan," and the site numbers correspond to Swanson et al's (1986) figure 7.

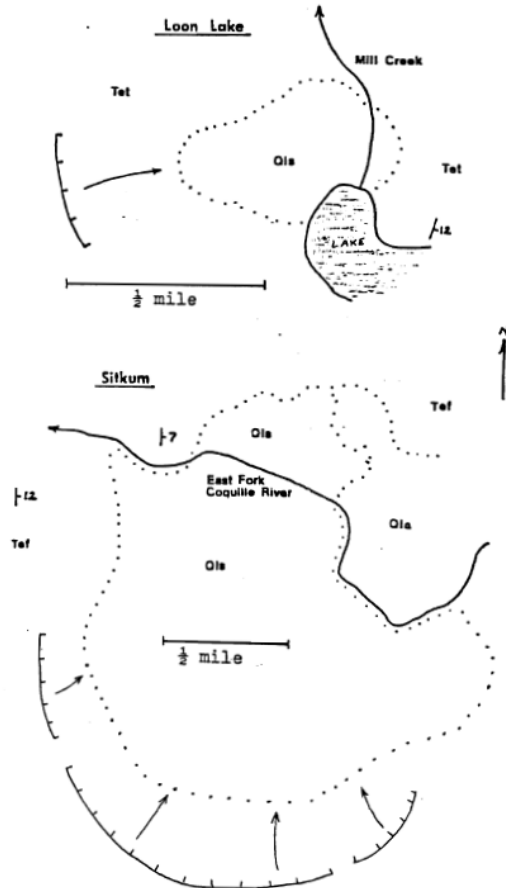


Figure 16. Sketch maps of Loon Lake and Sitkum landslides.

Triangle Lake, in the Blachly 7.5-minute USGS quadrangle, about 60 miles north of Sitkum, is dammed by landslide debris composed of Flounoy Formation sandstone and siltstone. The landslide dam, which is about 250 feet in height, was formed when bedrock failed on a northwest-aspect slope and moved about 0.5 mile downslope, blocking the drainage of Lake Creek (Figures 17 and 18). Undisturbed bedrock near the landslide dam has an attitude of N 50 degrees E, dipping 2 degrees northwest, so the Triangle Lake slide also occurred on the bedrock dip slope. Unlike the Sitkum and Loon Lake slides, however, the stream outlet from Triangle Lake flows on bedrock between the landslide dam and the hillslope on which failure occurred. The outlet, Lake Creek, apparently was entrenched in undisturbed bedrock of the hillslope after breaching the dam crest at the headward edge of the landslide debris. The original lake formed by the dam extended for 6 miles upstream and had an area of approximately 3200 acres (5.0 square miles). Most of the former basin is filled with sediment, leaving a 256 acre lake near the landslide dam. No radio-isotopic age determinations have been made for the Triangle Lake slide. However, an age estimate of 10,300 years B.P. is obtained for Triangle Lake by applying the sedimentation rates and known age of Loon Lake (see Appendix A).

The Drift Creek slide (T. 13 S., R. 9 W., Sec. 9 of the Tidewater 15-minute quadrangle) is 24 miles northwest of Triangle Lake. It is by far the smallest of the sites discussed here, but is included because it is the only one of these lakes to have formed since settlement by Europeans in the area. The landslide consists of Flounoy Formation siltstones and sandstones which failed on an east aspect slope near the headwaters of Drift Creek in December, 1975,

during a period of high precipitation (Thrall et al, 1980). The lake formed by the landslide dam is approximately 10 acres in size. The lake outlet flows across the toe of the slide, which has not been deeply incised apparently because of the small discharge of the stream (Figures 17, 18 and 19). The slide, which failed during a known period of less than 36 hours, possibly within minutes, has a volume of approximately 1.7×10^7 cubic yards, and a surface area of about 50 acres. In contrast with the Sitkum and Loon Lake sites the Drift Creek slide deposit is more finely textured, with sandstone boulders of only a few feet in maximum diameter. A portion of the initial slide flowed down the stream channel after reaching the hillslope base and damming the stream. The upper third of the slide area failed by block glide. It now consists of several large competent blocks of siltstone bedrock, and a head scarp that is about 200 feet in height (Thrall et al, 1980).

Similarities between the Drift Creek, Triangle Lake, Loon Lake, and Sitkum slides include: failure of bedrock on a dip slope, involvement of Tyee Formation and/or Flourney Formation bedrock, and the creation of relatively long-lived dams. In addition, all appear to have failed rapidly since the outlet streams flow through the slide debris and not against the opposite valley wall. Slow failure, such as is typical of an earthflow, would have pushed the stream ahead of the landslide mass as it moved across the valley floor. In this case the channel would flow between the slide debris and the opposite valley wall.

Swanson et al (1986) studied landslide dams in Japan and classified them on the basis of either rapid (more than 1.5 meters/day) or slow (less than 1.5 meters/day) landslide movement and landslide channel interaction. A channel constriction ratio of landslide toe speed to channel width gives an expression of channel response to the landslide. An annual constriction ratio of greater than 100 seems necessary to form a lake behind a landslide dam (Swanson et al, 1986). Figure 20 shows data from Swanson et al (1986) combined with data for Sitkum, Loon Lake, Triangle Lake, and Drift Creek, comparing landslide volume with drainage basin area. The figure relates the occurrence of dam failure to the interaction of landslide volume and fluvial erosion potential. For example, a land slide of small volume would likely produce a short-lived lake if the contributing drainage basin is large enough to produce streamflow that can remove the dam. However, many other factors influence the lifespan of a landslide dam, such as the coarseness of the landslide debris and the steepness of the downstream slope on the dam surface.

The occurrence of landslide-dammed lakes in the central and southern Coast Range results from a particular geologic setting and the hydrologic influence of high precipitation. Any additional causative factor has not been determined. Adams (1981) studied landslide-dammed lakes in New Zealand whose formation was triggered by historic earthquakes. He also examined prehistoric landslide dammed lakes which he interpreted as probably being formed by earthquakes. He based conclusions with regard to the prehistoric events on similar landslide morphology, synchronous age, and areal distribution of the "earthquake-dammed" lakes.

The Oregon Coast Range, being on the North American continental margin, is an area of active structural deformation and uplift. Earthquakes in the Coast Range are rare, however, at least in historical time, so this mechanism may not be applicable to the landslide dammed lakes in the Coast Range. In addition, a synchronous age for the major landslide sites has not been determined, and the Drift Creek slide is known to not have been triggered by an earthquake. However, studies by Heaton and Hartzell (1987) indicate that seismicity along the North American and Juan de Fuca plate margin may be characterized by long periods of quiet broken by short periods of large subduction earthquake activity. They present evidence that the

Cascadia subduction zone, off the coasts of Oregon and Washington, may store elastic energy for intervals of several hundred years between occurrences of rapid plate motion. Since historical records in the Pacific Northwest are available for only the past 150 years, it is possible that subduction of the Juan de Fuca plate along the Cascadia subduction zone may trigger landslides in the Oregon Coast Range.