Eliot Glacier: Net Mass Balance

By Nicholas A. Dodge

In 1925, the Mazama Research Committee became interested in the glaciers of Mount Hood, especially, the Eliot Glacier. Occasional articles in *Mazama* described the committee's efforts to learn what the glacier was doing, but it was not until the 1960s that a systematic procedure was established to measure the net mass balance. Net mass balance is referred to as the net change in water equivalent during a water year, which ends in September. Water equivalent, which is measured as meters of water lost or gained over the entire surface area of the glacier, provides information about what the weather has been (dry, hot, cold, wet). It can also forecast future water supplies in the Hood River Valley.

A second important parameter measured in glacier studies is called the Accumulation Area Ratio (AAR), which is defined as the percentage of glacier surface covered by snow from the preceding winter.

This report summarizes the field work since 1971 and consolidates data from 1960 on. The tentative curve established for the net mass balance in 1971 (Dodge, 1971) has been strengthened by the new data (Figure 1), with the exception of the 1981 and 1982 data. These deviate significantly from the rest of the data, and cannot be considered seriously. There were changes in the field teams, and it is likely that their lack of experience caused the problem.

Two sets of data summarize the recent research on Eliot Glacier. There were no "ground" measurements taken between 1960 and 1968. The net mass balance was derived from aerial photography by relating the ELA (Equilibrium Line Altitude, or firn line) to the net mass balance. The procedure was explained in the 1971 *Mazama* article and charted in Figures 3 and 4 from that report (not shown here). For the period 1969-83, the net mass balance was measured directly on the glacier and is considered to be more accurate than data from the period 1960-8.

An October, 1968 photo shows an Eliot Glacier study team with Ed Davis preparing to drill a one-inch diameter hole in the ice. Nick Dodge is holding the 10-foot aluminum ablation stake. Amount of ice melt was later noted as the stake worked its way out. Vivian Staender, seated, is taking notes. Photo by Gil Staender.

	ELA Feet	Net Bal. m.	AAR		ELA Feet	Net Bal m.	AAR
1960	7750	+0.10	.540	1973	8900	−1.82	.142
1963	7750	+0.10	.543	1974	7400	+1.58	.770
1964	7600	+0.80	.688	1975	7600	+1.72	.738
1965	7650	+0.60	.674	1976	---	+1.16	.717
1966	7800	−0.15	.527	1977	9600+	−1.14	.050
1967	8700	−2.00	.314	1978	7600	+1.02	.800
1968	8900	−2.30	---	1979	8000	−0.62	.480
1969	7600	+0.70	.644	1980	7900	+0.59	.570
1970	7600	−0.27	.560	1981	8100	+0.32	.359
1971	7800	+0.70	.700	1982	7200	+4.15	.798
1972	7600	+0.83	.680	1983	7400	+0.85	.750

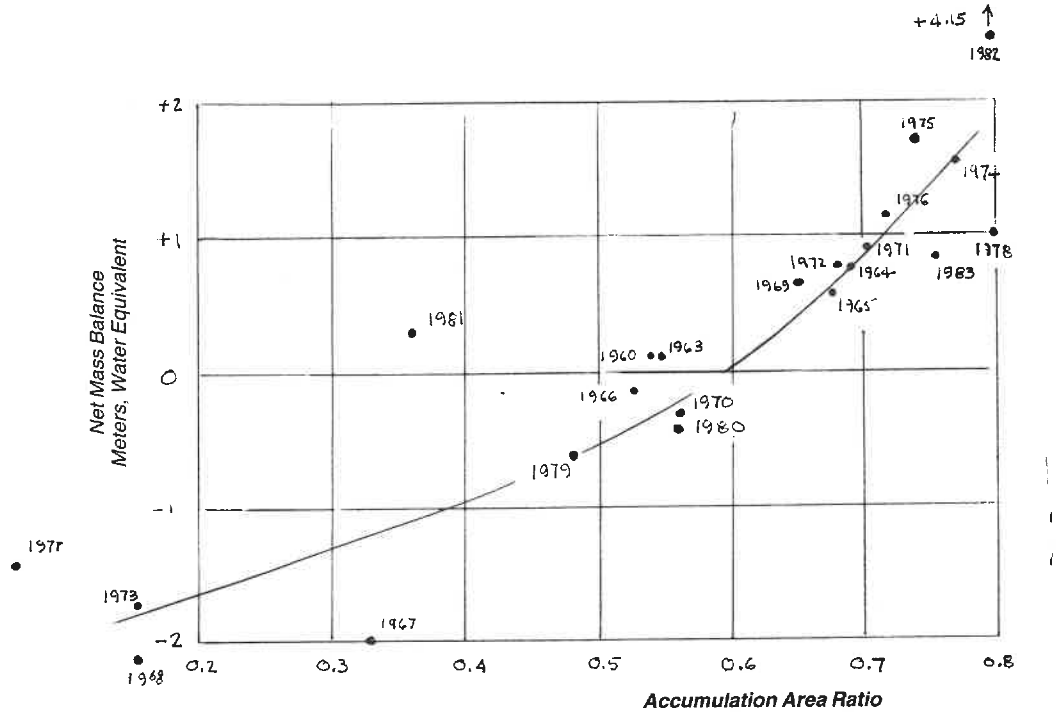


Figure 1. Relationship of Net Balance to AAR, 1960-1983, Eliot Glacier

As stated in the 1971 report, the AAR remains the single most appropriate parameter for measuring a glacier's health. While fluctuating from year to year over the past two decades, Eliot Glacier has gained less than 1.3 meters of water equivalent, excluding the questionable data mentioned previously. In terms of geologic history, two decades are too short a time to indicate a new trend. The glacier does release more water during drought years such as 1987 and holds back release when there is an abundance of precipitation. This is due to the fact that during high precipitation periods, the albedo is high, which means that more of the sun's energy is reflected away from more new snow on the surface, thereby reducing melting.

The fluctuations of Eliot Glacier are not always the same as those of other Pacific Northwest glaciers, even though there is a general correlation. The Pacific Ocean circulation pattern of moisture is variable enough that, while certain parts of the Pacific Northwest might be in a drought, other parts may be relatively wet (see Figure 2). In 13 of 23 years of record, correlation in net mass balance between Eliot Glacier and one control glacier is evident, but in only eight of 23 years did all three glaciers exhibit similar characteristics.

There are certain factors that govern the activity of glaciers. Inland glaciers exist at higher elevations than those close to the Pacific Ocean (Figure 3). The closer a glacier is to the moisture source, the greater is the exchange between input (precipitation) and output (runoff). At Mount Baker Lodge, Washington, where annual precipitation averages 2,790 millimeters, snow on the ground has been measured to a depth of 7.6 meters. East of the divide, temperatures are more extreme, and precipitation decreases sharply. At Stehekin, Washington, the average annual precipitation is 864 millimeters, while at Chelan, Washington, it is only 277 millimeters. North- and northeast-facing glaciers receive far less solar radiation than glaciers flowing south or southwest. Glaciers facing north are further protected, as snow is swept into their cirques by the southwest winds that bring precipitation from the Pacific Ocean. Within these variable parameters, it is still possible to predict in statistical terms the water supply from a local glacier. The data obtained on the Eliot Glacier also could be correlated with the runoff of Eliot Creek. Such a relationship, however, has yet to be established.

Requiem for Mazama Eliot Glacier Research

While the Mazamas have supported Eliot Glacier research for a period of almost 60 years, research has usually resulted from the efforts of a handful of people, and it appears that we have run out of them. Starting in 1925 with Earl Marshall, the program leadership progressed to Ken Phillips, Ralph Mason, Nick Dodge, and finally Carroll Davis. Over the years, more than 80 helpers were employed in various tasks such as carrying supplies and equipment, drilling holes in the ice, running profiles with transit and stadia, measuring amounts of annual snow accumulation, wandering about the crevasses, and even falling into a few. There was work, and there were the cameraderie and friendship that were perhaps as important as the science. Thanks to all of these people, and to the Executive Council, which supported the program for such a long time.

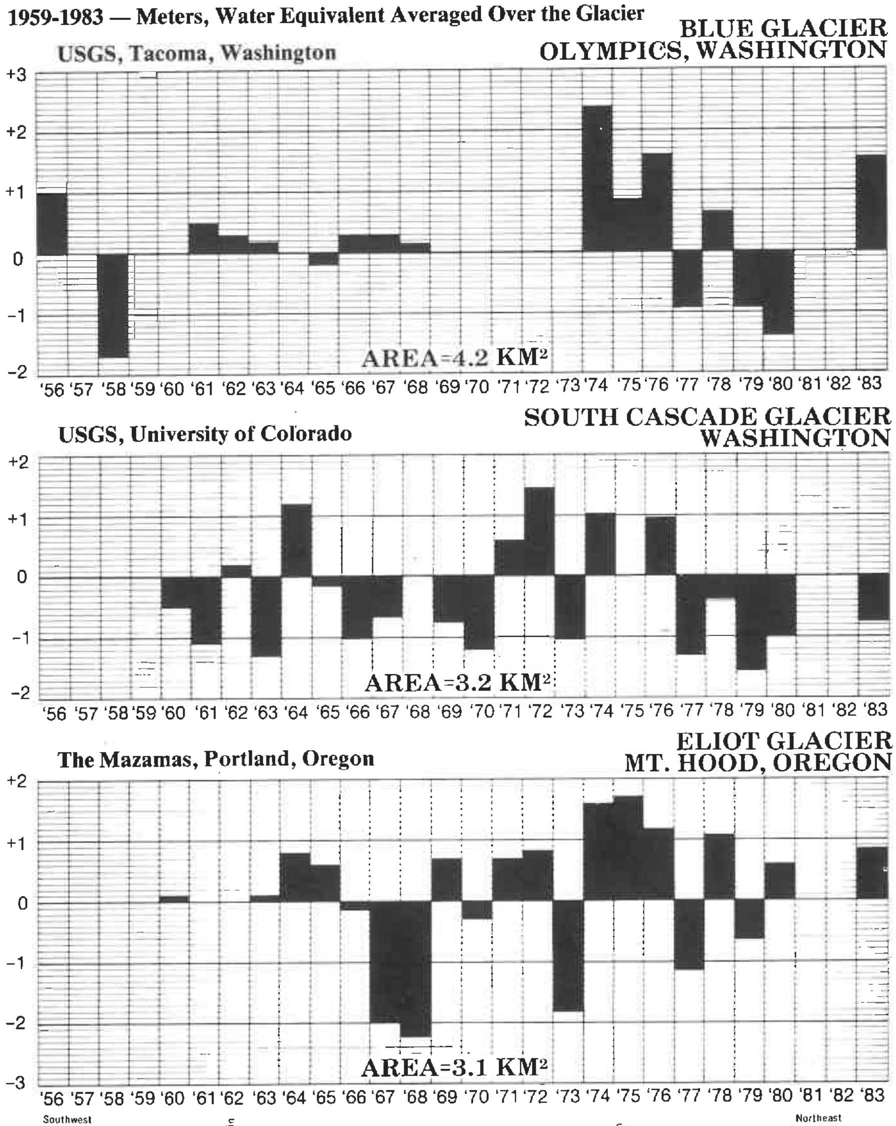
Editor's notes: Nick Dodge heads the Corps of Engineers Water Management Branch, which manages many of the region's large water-resources projects. Water runoff forecasts are critical to the operation of these projects. This article presents one very small portion of the types of data that are used to develop runoff forecasts. The data obtained and conclusions made in this article have been forwarded to World Center A for Glaciology, located at the University of Colorado, Boulder. The other two centers are located at London, England, and Moscow, USSR.

Reference cited: Dodge, Nicholas A., 1971, The Eliot Glacier: New Methods and some interpretations: *Mazama*, V. LIII, No. 13, p. 25.

This photo from the Mazama collection was taken by Paul Theiss in 1926, when a research group visited Eliot Glacier. The person sighting through the instrument is unidentified, however, it is probably Earl Marshall who began the measurement program in 1925.

Figure 2. Net Mass Balance Pacific Northwest Glaciers

1959-1983 — Meters, Water Equivalent Averaged Over the Glacier



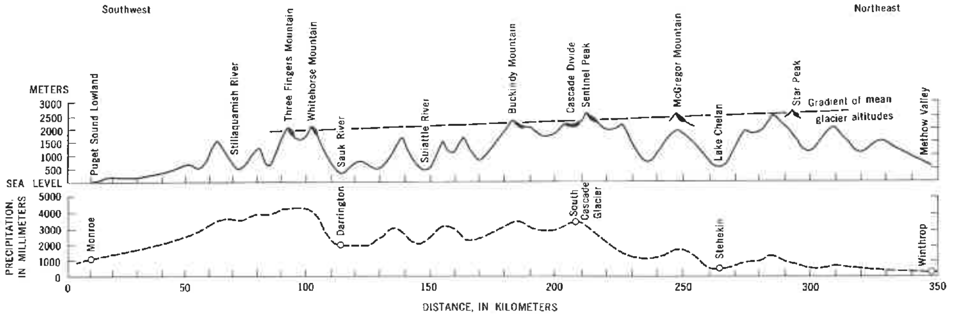


Figure 3. Southwest-northeast profile across the North Cascades showing topography, precipitation, and gradient of mean glacier altitudes. Short, heavier segments on topographic profile indicate glaciers. Precipitation is indicated by circles where measured and by dashed line where inferred from streamflow records.