Mt. Hood's Latest Eruption and Glacier Advances

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Introduction.

It gives me great pleasure to dedicate this article to the memory of Francois E. Matthes, who by his boundless interest in recent glacier fluctuations stimulated the Mazama Research Committee to undertake this study. In a letter to Kenneth Phillips dated July 28, 1946, he pointed out the need for obtaining data on the age of stunted trees on the modern moraines, especially of Eliot Glacier, in an attempt to learn whether they were formed by glacier advances as recent as those of the European glaciers which pushed forward to a remarkable degree in the 1600's, 1700's, and 1800's, to a maximum that Dr. Matthes felt had not been exceeded since the latter part of the Pleistocene, about 10,000 years ago. As a result of that letter, it was my good fortune to be invited by Kenneth Phillips, another man of boundless enthusiasm for glacier study, to begin work later that same summer, and it is to Kenneth that I am most indebted, for his untiring effort in the field, in cutting trees for sections, boring trees for sample cores, mostly in slow-growing mountain hemlocks whose wood often seems hard as iron, and in digging pits in the soil. Without his efforts this story could not have been written. I am anxious also to acknowledge the aid of a few others who have especially helped to bring this study to the present stage of completion: Mr. Fred Semler for the use of sanding equipment, forester Jim Langdon for special courtesy, Research Committee members Ralph Mason, Howard Richards, and Harry Clark for collecting soil samples, and my wife, Elizabeth, for help in the field and with the preparation of this manuscript. Some field expenses since 1946 have been paid by the Hardesty Trust Fund. Two articles on this work, one (Lawrence: Mazama, 1946) describing the technique employed, the other (Matthes: Mazama, 1946) explaining the importance of the study, have already appeared.

The Latest Eruption of Mt. Hood

As is the case in many scientific studies, one starts out to study one thing, and discovers something else of interest which was entirely unsuspected at the start. In this case we started out to investigate recent glacier fluctuation, and discovered as we went along that Mt. Hood had erupted, probably from the main crater in the vicinity of the present fumaroles (see Phillips: Mazama, 1936), emitting volcanic ash which settled to a maximum depth of at least six inches at timberline, as recently as about 1800, well within the lives of most of the trees growing there, so that had Lewis and Clark visited the site of Portland a few years earlier they might have seen a volcano cloud hanging over Mt. Hood and the snow mantle blackened with ash, as visualized in figure 1.

The intact layer of ash when examined closely is found to consist of fine-grained powdery, cement-gray particles densely packed together and containing occasional gritty particles as large as sand grains or, at some stations, even small lapilli as much as a half inch across. Viewed under the microscope, the particles are usually minute, some so small that they vibrate under the constant battering of the molecular activity of the surrounding fluid (Brownian movement). Most look like fractured fragments of colorless glass; the edges are usually very sharp and jagged and some particles look like miniature obsidian arrowheads, with that identical sort of fracture surface but made of the clearest rock crystal, and much smaller than a fine needle point. Only very occasionally are dark colored particles present. Samples collected from the south side of the mountain have so far seemed to contain coarser particles than those found elsewhere.

Fortunately for this study, we discovered the recent ash blanket at Tilly Jane Camp, a place on the northeast side of the mountain where it may be very readily demonstrated, and we knew of its presence early enough in the study (fall, 1946) so that its presence or absence could be turned into a useful tool in dating the recent glacier moraines. That discovery in the fall of 1946, of very recent ash, which was surely deposited between 1760 and 1810, and most likely about 1800, lying on top of a layer of forest duff, (see fig. 3) and hiding the root swell of the old trees, expanded our outlook and made us devise new techniques for dating the time of its fall, and we have been testing ideas about its source and distribution

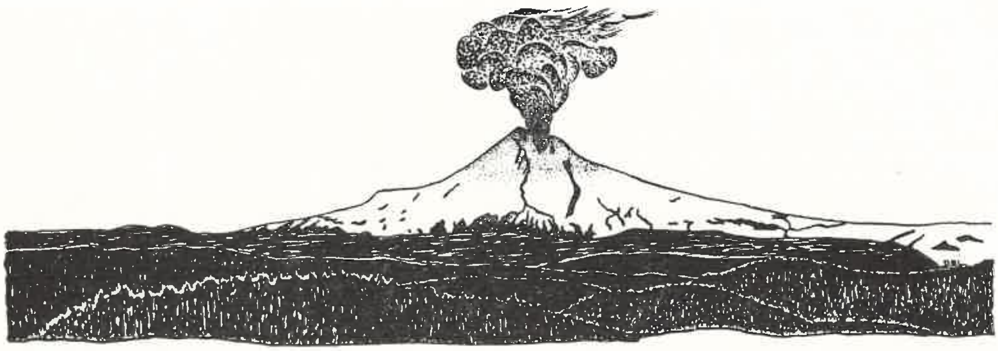

Fig. 1—Mt. Hood in eruption about 1800 A. D. as it may have looked from the site of Portland's Washington Park.

through the 1947 and 1948 field seasons. Though there are many features about the ash blanket that still remain uncertain, I feel sure enough of some of the observations to have prepared the map of figure 2 which presents in a very preliminary and tentative way, the depth and distribution of the new ash sheet about the mountain. When it became obvious that the ash must have fallen about 1800 A. D. we began to suspect at once that it might have come from the Mt. St. Helens eruption of 1802 which had already been demonstrated by our Research Committee work (Lawrence: Mazama, 1939). No ash was found however, at Lost Lake which lies on a direct line between Mt. Hood and Mt. St. Helens, and should therefore have a layer of ash even more than six inches deep if St. Helens was the source. The rapid diminution of ash depth northeastward from Tilly Jane Camp seems to prove the point equally well. Much more time must be devoted to the search for ash on the northwest and southeast sides of the mountain near timberline. Only the northeast and southwest quadrants can be considered fairly adequately sampled. The search for undisturbed ash is not a simple one, for in all well-drained open areas pocket gophers have industriously mixed the ash with underlying coarser material so that it no longer constitutes a distinct layer. It is most likely to be well preserved under dense stands of mountain hemlock where rodents do not work, and where the dense fall of needles, beginning immediately after the ash deposit, has prevented soil erosion. The region to the southeast of the mountain in the vicinity of the Loop Highway crossing of White River, and at Bennett Pass, is particularly baffling and is in need of much further study, yet at Hood River Meadows only about a mile to the east of Bennett Pass, the picture is crystal clear. At the Meadows, the ash layer, four and a half inches thick, lies buried below an equal thickness of brown fibrous peat. Below the ash is another layer of peat a foot thick which in turn overlies old yellowish volcanic ash and this seems to offer good evidence that several hundred years must have elapsed between our recent eruption of Mt. Hood about 1800 and the next preceding ash eruption. Other evidence from trees points toward the same long time lapse (at least 500 years) since an earlier eruption of ash. The prediction of just when we might expect the next eruption of Mt. Hood is beyond the present ability of the Mazama Research Committee.

Another interesting feature of Mt. Hood, the "ghost forest" which stands mainly just east of the terminus of White River Glacier, has often caused speculation; it was studied by the Mazama Research Committee (Phillips and Lawrence) as long ago as 1940. No conclusions were presented then, but now

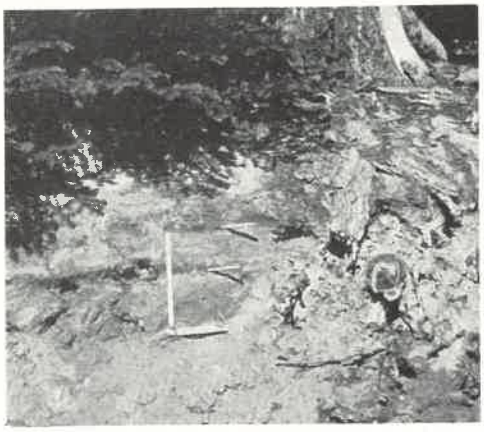

Fig. 3—Profile view of the five-inch recent volcanic ash deposit and old buried soil layer at Tilly Jane Camp. Vertical part of folding ruler is one foot. Pencils mark limits of ash layer.

D. B. Lawrence photo, August 17, 1947

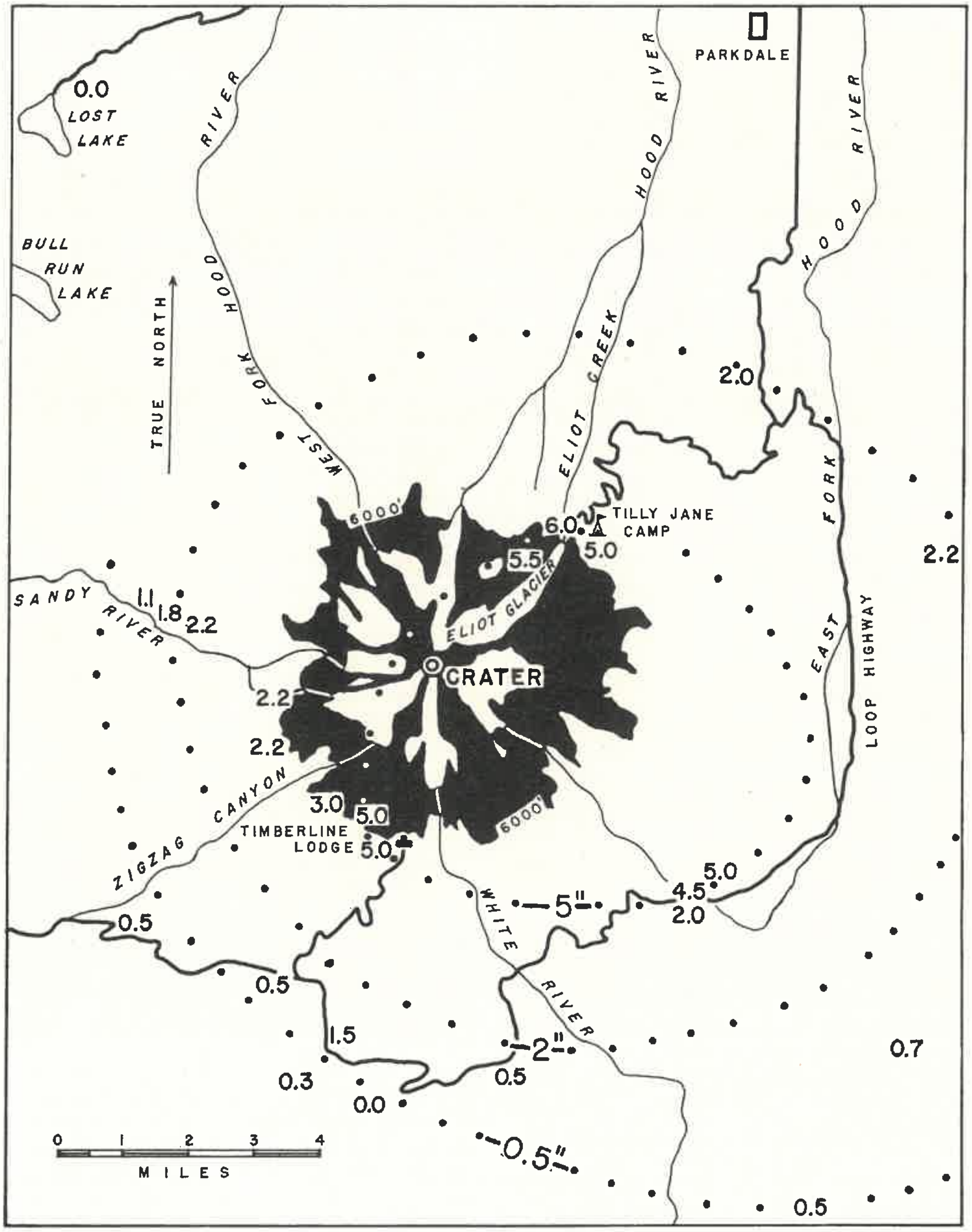

Fig. 2—Map showing tentative isopachs (lines of equal depth) of the volcanic ash which fell about 1800 A. D. (dotted lines) and depths in inches where actually measured; areas of the mountain lying above the 6,000-foot contour are shown in black except for glaciers.

the results seem to fit in so closely with that presented above, that it surely deserves mention here. This ghost forest consists of the silvery bleached remains (see fig. 4) of what was once an upward extension of the timberline forest. It can be readily observed in summer off to the east from your seat on the chair lift that operates between Timberline Lodge and the Silcox Ski Hut. Before our investigation some people had thought that these forest remains extended to a higher elevation on the mountain (7,300 ft.) than trees could possibly grow under the climatic conditions that exist today, but we found this supposition to be entirely untrue, for a new generation of timberline trees was beginning to grow, sheltered at first, to be sure, in the lee (to the

Fig. 4—Ghost tree on ridge east of White River Glacier at an altitude of about 6,800 feet. View southwest, Timberline Lodge at left.

D. B. Lawrence photo, July 7, 1940

Fig. 5—Old white-bark pine, a relict survivor in the ghost forest at 7,000 feet altitude on ridge east of White River Glacier. Began growth about 1600 A. D. View northeast, K. N. Phillips as a scale; note ghost trees in background.

D. B. Lawrence photo, July 7, 1940

east) of rocks, as high up on the mountains as the dead snags could be found. The question to be answered therefore was: what agent killed the trees and when. Surely fire was not the answer, for no signs of charring were found. The possibility of a very windy, severe winter with a very light snow cover could still have been the cause; that possibility has not been ruled out, but the very local distribution of the ghost forest, immediately below the main crater of the mountain, seems to point to a volcanic cause. A very important discovery on that trip was a living old white-bark pine (see fig. 5), a relict survivor of the older generation now long since dead and bleached. This tree began growth well before 1670 and its growth rings had been very tiny for almost 100 years preceding the early 1800's; then about 1808 its growth rate suddenly increased with a new lease of life until the 1890's when growth again slowed down. This pattern of growth when considered in the light of adjacent dead neighbors which are obviously contemporaries, would indicate that shortly before 1808 the competition offered by this tree's neighbors had suddenly been removed. This tree would have undoubtedly been injured at that time and logically would have taken several years to gain a new rapid growth rate. It is my guess that the ghost forest died about 1800 as a result of volcanic activity connected with the volcanic ash deposit. Perhaps it may have been hot water from snow melted in the crater, that killed the trees, or a sudden blast of steam projected horizontally and downward as happened in one of the eruptions of Lassen Peak. In any case, trees of the new generation that now stand between the ghost trees began growth at least several years before 1870. More work needs to be done here, now that we know about the 1800 ash eruption.

Recent Advances of Eliot Glacier

Although as pointed out above, the recent volcanic activity of Mt. Hood has served as a useful tool in studying the glacier history, it has also complicated the interpretation of that history. On non-volcanic mountains the advances and recessions of glaciers are assumed to reflect climatic fluctuations purely and simply, but just how the violent earth trembling and emission of heat from the crater during eruption, and the presence of a volcanic ash blanket on the snow and ice following the eruption would affect the recession and advance of the ice streams on a volcanic peak, provides interesting material for conjecture. Research in Iceland, the Aleutians, and Central Chile should answer some of our questions.

Visitors who viewed the snout of Eliot Glacier in the 1890's or early 1900's and then have returned recently are shocked at the recession that has taken place. From 1901 when the first careful observation was made by H. F. Reid, to 1946, that recession amounted to very nearly 600 feet; the vertical shrinkage has also been very great (see especially Phillips: Mazama, 1938 and 1943). If a visitor could have seen the glacier in 1740 he would have observed it advancing into old forest whose trees had been growing

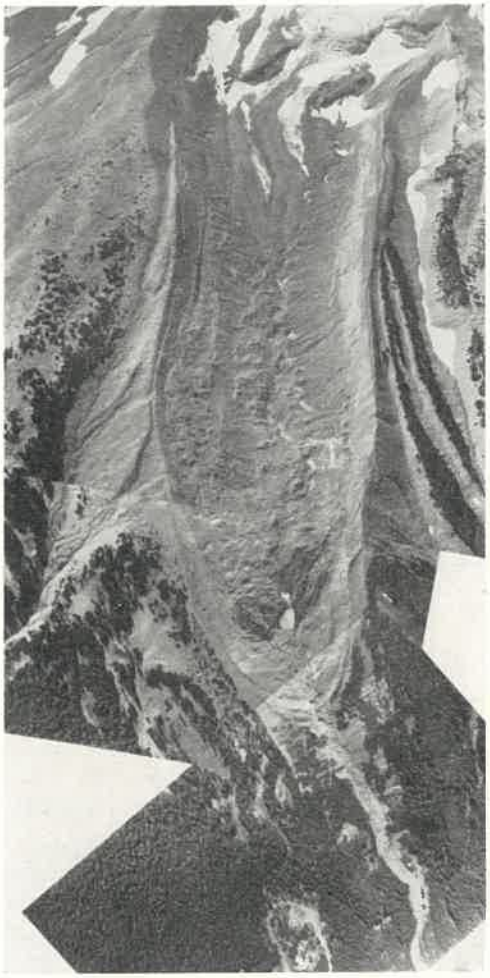

Fig. 6—Photomosaic of Eliot Glacier.

Upper photo by Ray Atkeson

Others by A. J. Gilardi, September 27, 1946

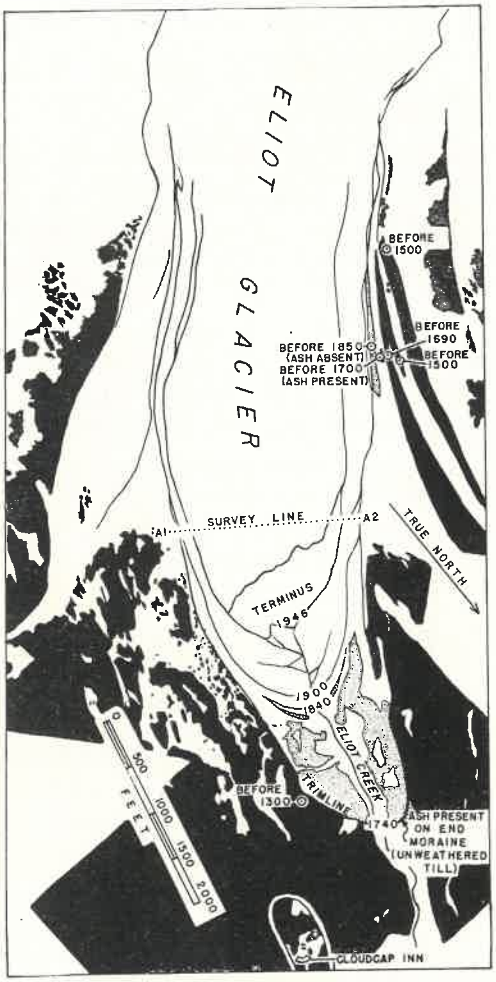

Fig. 7—Map traced from figure 6, showing recent history of Eliot Glacier. Old forest shown in black, young forest stippled. Approximate dates based on ring counts of trees on recessional moraines, are shown; maximum recent advance was about 1740 A. D. Tilly Jane Camp is 4,000 feet east of Cloud Cap Inn.

there since at least 1300 A. D. The history of this maximum recent advance and of the subsequent recession and one of the lesser readvances, has been worked out from a study of tree rings from a large enough number of cores and sections so that the results can be considered fairly reliable. The area studied can be seen photographically in figure 6 and diagrammatically in figure 7. As the glacier receded from its position of maximum advance, it left a sharp boundary at the forest edge marking off strikingly the denuded land it had occupied, from the mature forest beyond. Glaciologist R. P. Sharp has given this important feature the useful name "trimline" which I have adopted here. It is strikingly visible even today as may be seen in figure 8. A closeup study of the trimline reveals a number of old trees that were evidently in contact wtih the ice at the time of maximum advance (see fig. 9). One of these that was sectioned had a bad scar on the ice side which resulted no doubt from actual contact pressure; that scar was formed about 1740 and constitutes the main evidence for such an exact dating, but other evidence agrees closely, for a tree on a small moraine that was left at the edge of the trimline began to grow there as early as 1760 indicating definitely that the ice had begun its recession by that time. On the floor of Eliot Creek Canyon at an altitude of about 5,500 feet, about 2,140 feet down slope from the position of the base of the terminus in

Fig. 8—View northeast from west moraine of Eliot Glacier showing east moraine with trimline (dotted) formed by advance of Eliot Glacier about 1740 A. D. Young forest below, old forest above and beyond. Cloud Cap Inn visible on knoll at the left.

D. B. Lawrence photo, August 18, 1946

Fig. 9—Closeup view northward down the trimline on east moraine ridge of Eliot Glacier showing some old trees injured about 1740 by pressure of advancing ice.

K. N. Phillips photo, August 16, 1947

1946 and 600 feet lower in altitude, an end moraine exists, which is exactly in line with the lower end of the trimline shown in figure 8. The oldest of several trees cut on this moraine began to grow about 1770 indicating again definitely that the ice was then already in recession. A six inch layer of volcanic ash is very definitely present on top of the moraine and there is no sign of any soil layer between the unweathered till of the moraine and the volcanic ash. This demonstrates definitely that the volcanic ash fell after about 1740, and yet not too many years after that, even if no other evidence were available.

In order to have advanced to this extended position Eliot Glacier must have been well nourished and convex on the upper surface so that the ice would have towered above the lateral moraines instead of sagging between them as today (see fig. 10). It must also have well filled Eliot Canyon and should have easily been visible from the site of Cloud Cap Inn (see fig. 11). The date of maximum recent advance of Eliot Glacier and the time when recession must have begun, can be pretty categorically stated to be the early or middle 1700's. The dates of formation of the recessional moraines cannot be quite so definitely stated. About all that can be said regarding the striking moraine shown in closeup view in figure 12 and also in figures 6 and 7, is the fact that trees had begun to grow on it by the late 1840's. Although it is labeled 1840 on the map of figure 7, the ice may have receded from it by the very early 1800's. We still do not know enough about the time lapse between a moraine just freed of ice and the establishment of tree seedlings. The moraine labeled 1900 on the map of figure 7 is not dated on the basis of vegetation at all, but purely on old photographs, and may mark a readvance as early as the 1880's.

Fig. 10—View northeast down double crested west moraine; Eliot Glacier lies to the right, slumped beneath its load of debris. In 1740 the ice must have stood high above this moraine ridge.

D. B. Lawrence photo, August 16, 1947

Fig. 11—Mt. Hood, Eliot Glacier, and Eliot Creek Canyon; view southwestward from Cloud Cap Inn. Present glacier terminus is beneath snowbank at left center. In 1740 ice must have filled all of the canyon visible here, and the terminus lay beyond lower right corner.

D. B. Lawrence photo, August 18, 1946

Fig. 12—Central region of figure 11 showing small patch of young forest on west moraine of 1840.

K. N. Phillips photo, August, 1947

Fig. 13—Mountain hemlock seventeen years old and young willow on surface debris of Eliot Glacier at survey line A1-A2 (see fig. 7), moving along down the mountain at a rate of four feet per year. One foot ruler.

D. B. Lawrence photo, August 14, 1947

In walking across the glacier surface along the survey line shown in figure 7, it was interesting to see a number of small trees and shrubs as was noted by Phillips (Mazama, 1943) and as may be seen in figure 13. The oldest of these that I have found were a white-bark pine that began growth in 1915 and a mountain hemlock that germinated in 1930. All have been moving along with the glacier at a rate of about four feet per year, and all are doomed to destruction by the slumping that occurs at the edge of the terminus. I believe now that trees of this sort do not take any part in the permanent vegetation that develops following recession of the ice.

In conclusion, it is of great interest to note that the date of maximum recent advance of Eliot Glacier coincides very closely with that of Ladd Glacier to the west, and even more important, with the time of the maximum advance in Glacier Bay, Alaska, as worked out by W. S. Cooper (Ecology, 1939) thirteen years ago. Perhaps then, we can safely assume after all, that the volcanic activity of about 1800 on Mt. Hood had no serious complicating influence on the effects of the climatic factors that produced the strong *advance* which culminated in the early 1700's. How it may have influenced the *recession* especially on the southwest quarter of the mountain is another matter, indeed.

We still do not know the history of the striking tree-covered moraines shown in figures 6 and 7, to the west of the more recent ones. Probably they were formed too long ago to be dated by tree rings. We do know that they were formed by advances prior to the advance of the early 1700's, for trees were already growing on them by the beginning of the 1500's.

Some New Ideas on the Stadter Buried Forest

One final thought seems worth presenting here, though it stands at the moment just as an hypothesis developed from studying the fine set of Forest Service aerial photos of the mountain provided last year with Mazama funds, and my notes made on the west and southwest sides of the mountain during the second week of this past September.

During the search for volcanic ash at the place where Timberline Trail crosses the Muddy Fork of the Sandy River, we found a number of gigantic dead snags of Douglas fir trees four feet in diameter, which had been killed by burial in an outwash deposit 10 to 15 feet thick. Some of these tree trunks that were probably hollow when buried, have already decayed down into the outwash leaving tree-wells such as those so common on the north side of Mt. St. Helens near Spirit Lake (see Lawrence: Mazama, 1938, 1939). Others are still sound and protrude as much as 60 feet above the outwash surface; it is my guess that they died little more than a century ago. A young forest of a new generation of pioneer species has grown up between the snags. Immediately to the north of the Muddy Fork, and standing on higher ground, is a forest of very large living trees that are obviously contemporaries of the dead snags. As one follows the Timberline Trail southeastward over the extensive outwash deposit paralleling the Sandy River, one continues to find dead snags, tree-wells, and young lodgepole pine forest. The aerial photos show this to extend up the Sandy River for three miles, to the canyon at the base of the mountain. The main point of interest to be brought out here is the fact that the Stadter Buried Forest is higher up in this same canyon at an altitude of only 6,200 feet (Hodge: Mazama, 1931). It was the opinion of Dr. Hodge at the time he wrote his article, that those forest remnants could not have grown there at that altitude under the present climatic conditions, and that a warmer climatic phase would have to be assumed to explain their presence. Close examination of the aerial photos however, reveals the living timberline forest extending up to an altitude even higher on the next ridge to the north beyond Reid Glacier. It is my guess that the Stadter Buried Forest was buried at the same time as the snags along the Sandy River below, and by the same agency, which I believe to have been a volcanically induced flood, and not a glacier advance. I furthermore suspect that this happened immediately before the deposition of the recent ash layer that has been discussed earlier, and occurred in the initial stages of that same eruption. If one carefully examines the aerial photographs, one finds that the whole region which opens out below the main crater of the mountain and extends from Steel Cliff and its southward continuation, all the way westward around to Illumination Ridge, is one great smooth, denuded and scour-streaked fan, gouged at its lower extremities by steep V-shaped canyons. It is to be remembered that at the time of the 1800 eruption which we have been considering, the glaciers were extended beyond their present limits, and undoubtedly the snow mass in the main crater was very great, compared to the amount present there today. Rapid melting of that snow which would logically have accompanied an eruption from the main vent, must certainly have swept down the mountain with great violence, as did a similar flood during the historic eruption of Lassen Peak. (Pictorial history of the Lassen Volcano, by B. F. Loomis. Anderson, California. 1926).

If further research shows these suppositions to be correct, the Stadter Buried Forest and the ghost forest described above, will have grown contemporaneously, and many features of this sector of the mountain will be far more easily explained than has been the case heretofore. A few weeks of intensive field work should suffice for testing these ideas and it is to be hoped that that may be accomplished next summer.

Francis Kies (1946)

Looking up Coe Creek canyon at Mt. Hood