Prehistoric buried forests of Mount Hood

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ABSTRACT

Mount Hood has experienced three major eruptive periods over the last 2,000 years. Lahars, pyroclastic flows, and fluvial reworking produced enough clastic debris during each period to overwhelm and bury the coniferous forests covering valley floors and the lower slopes of the mountain. Erosion has exposed these buried forests, most of which are in a good state of preservation, in at least six locations: (1) on the south side of Illumination Ridge north of Paradise Park (the Stadter buried forest), (2) near Twin Bridges campground on the Zigzag River (two separate forests are found here), (3) in the upper White River canyon near Timberline Lodge, (4) all along the Sandy River from Old Maid Flat to the community of Brightwood, (5) in the bed of the Zigzag River near Tollgate Wayside, and (6) along the lower Sandy River downstream from Marmot Dam.

INTRODUCTION

During the last 2,000 years, there have been three major eruptive periods at Mount Hood (Crandell, 1980; Cameron and Pringle, 1986, 1987). In order of decreasing age, they are the Timberline eruptive period, which lasted from about 1,800 to 1,400 years before the present (ybp); the Zigzag eruptive period, from 600 to 400 ybp; and the Old Maid eruptive period, which lasted from about 1760 A.D. to 1810 A.D. (Cameron and Pringle, 1987). During all three periods, the eruptive center was located high on the southwest flank of the mountain near the composite dacite dome known as Crater Rock. This location, bounded as it is by Steele Cliff on the east, the summit ridge to the north, and the upper portions of Illumination Ridge on the northwest, limited distribution of the eruptive products (excluding tephra) to the drainages of the Sandy, Zigzag, and White Rivers.

The eruptive style during all of the eruptive periods was virtually identical. Viscous dacitic lava reached the surface through the post-glacial vent and piled up to form a composite dome. The steep slopes in the vicinity of the vent helped initiate repeated collapse of the still-hot dome rock onto the lower slopes of the mountain, burying the existing topography and forming the smooth debris fan that gives the southwest side of the mountain its distinctive shape. When these slopes were covered with snow, the avalanches of hot rock created snow-melt water that mixed with loose debris to form lahars capable of traveling many miles along rivers leading from the mountain. Deposits from these lahars can be found at the confluence of the Sandy and Columbia Rivers near Troutdale, over 56 mi from the mountain, and in Tygh Valley along the White River, a flow path of over 47 mi (Cameron and Pringle, 1987). When the rock was hot and gas-rich enough, pyroclastic flows that traveled at least 5.6 mi down the White River and 8 mi along the Zigzag River were produced (Cameron and Pringle, 1987).

On the steep upper slopes of the mountain, clastic flows can attain impressive velocities (a pyroclastic flow erupted about 1800 A.D. into the White River canyon had a calculated velocity of 85 mi/hr [Cameron and Pringle, 1987]). In these locations, any tree encountered by a flow would be pushed over in a downstream

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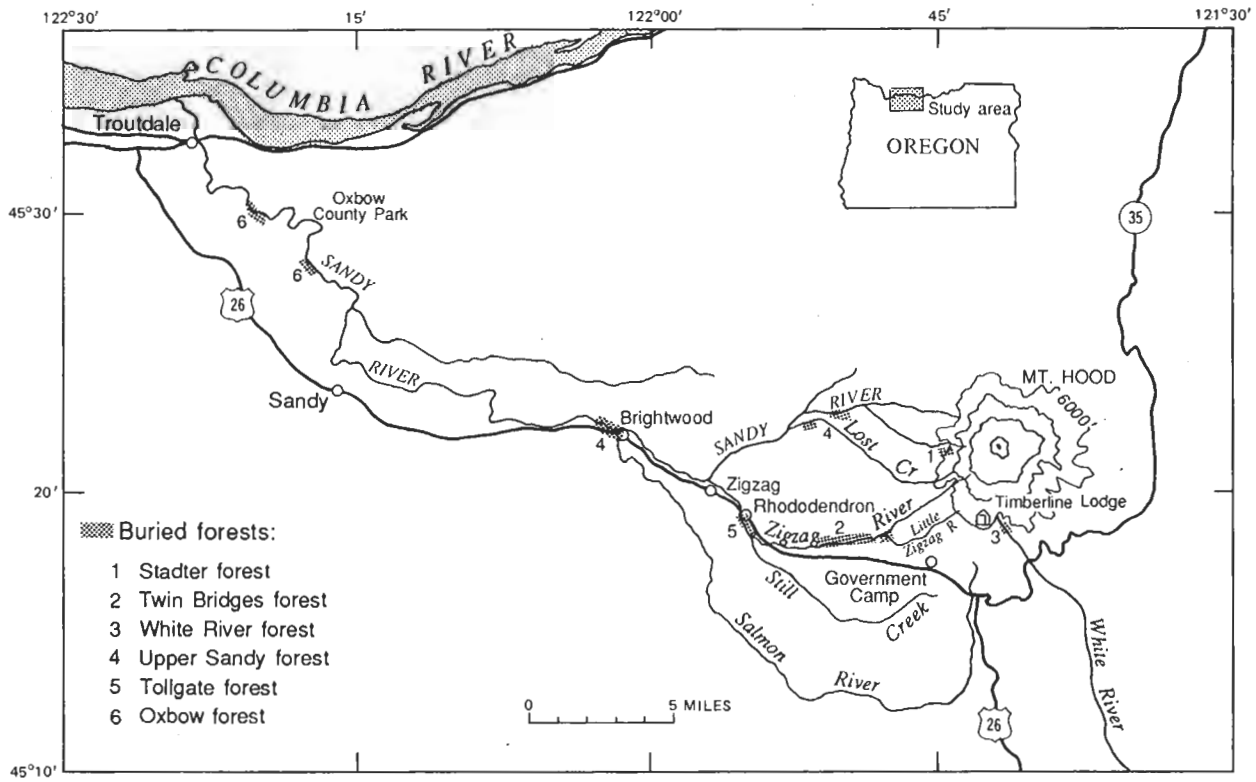

Figure 1. General location map to the known buried forests of Mount Hood.

direction or snapped off and carried away by the flow. Farther from the vent where slopes are more gentle and velocities are lower or in the mouths of tributary valleys where backwater flooding occurred, the flows would move passively among tree trunks, bury their roots and lower trunks, and eventually kill the trees.

Deposits left behind by these flows are generally coarse grained and massive. Near the mountain, boulders up to 6 ft across can be found suspended in a matrix of sand and gravel. With increasing distance from the source, the size of the largest clast drops steadily. At Brightwood, roughly 18 mi from the vent area, Old Maid-age deposits are composed of coarse sand and gravel with an occasional cobble up to 10 in. in diameter. Near Oxbow County Park, approximately 44 mi from the source, deposits from the same flow are composed of sand to coarse sand with some gravel lenses. At the town of Troutdale, at least 50 mi from the mountain, only thick, cross-bedded deposits of medium sand are found.

Preservation of the buried trees is, for the most part, a function of water. If there is sufficient water to keep the buried wood moist but not saturated, the wood will decay rapidly, and the tree may cease to be recognizable after only a few decades (for Douglas fir, 50 to 75 years; for western red cedar, 75 to 125 years [Franklin and others, 1981]). In drier environments or where the wood is constantly water-saturated, decay is greatly slowed, and trees may last for hundreds of years. Therefore, most of the buried forests are found high on the mountain in relatively dry environmental zones or directly adjacent to rivers where the trees were constantly below the local water table.

THE BURIED FORESTS

Six prehistoric buried forests have been discovered at Mount Hood to date (Figure 1). (Any reader who knows of others not mentioned in this article is asked to contact the authors.) The forests range in location from less than 2½ mi from the vent area at an elevation of 5,850 ft to over 44 mi away at an elevation of less than 50 ft. In time they range from over 1,700 ybp to less than 200 ybp. Only one forest has been named, and that one only unofficially (the Stadter buried forest [Hodge, 1931]). For convenience, the forests will be referred to here as (1) the Stadter buried forest, located at the 5,850-ft level below the terminus of Zigzag Glacier; (2) the Twin Bridges buried forest, upstream from the site of the old Twin Bridges Campground on the Zigzag River; (3) the White River buried forest, easily seen from the "Buried Forest Overlook" just east of Timberline Lodge along the Timberline Trail; (4) the Upper Sandy buried forest, found along the upper Sandy River from the Ramona Falls trail to the town of Brightwood below the confluence with the Zigzag River; (5) the Tollgate buried forest, along the Zigzag River just upstream from Tollgate Wayside; and (6) the Oxbow buried forest, along the lower Sandy River from just downstream of Oxbow County Park to near Indian John Island. Of the six, only the Stadter and Oxbow forests require more than a short walk to be seen.

Stadter buried forest

The Stadter buried forest is the only one with a previously published detailed history (Hodge, 1931). First seen in 1926 by Fred W. Stadter, a Portland judge, and investigated a few years later by members of the Mazamas climbing club, the Stadter buried forest is located on the south side of Illumination Ridge at the 5,850-ft level. Hodge originally reported the elevation as 6,200 ft, which almost made the authors miss the forest during a search for it in the summer of 1988. The 5,850-ft figure was checked by altimeter, and the altimeter was checked against the benchmark on the steps of Timberline Lodge, both at the start and end of the hike. It is perhaps the original mistake in elevation that led to the original interpretation by Hodge that this forest existed higher on the mountain than trees now live (modern timberline is around 6,000 ft). He deduced that warm fogs and rains produced by volcanic activity near Crater Rock created a micro-environment capable of supporting a forest and also kept the glaciers at bay. When volcanic activity ceased, the glaciers advanced and overran the forest.

This forest is reached only after a hike of at least 7 mi (Figure 2). To get there, follow the Timberline Trail (also marked as the Pacific Crest Trail or Trail No. 2000) west from Timberline Lodge to Paradise Park. From the north end of the Park, take off cross-country, angling uphill and northward to the edge of the deep canyon that drains Zigzag Glacier. The forest is exposed across the canyon above the local tree line as a line of logs sticking out of the canyon wall about 5 ft below the top of the wall on the upstream end and about 40 ft below the top at the downstream end (the horizon containing the logs dips at a steeper angle than does the top of the ridge). To actually reach the logs of the forest takes considerably more effort. At least 500 ft of elevation must be gained before the canyon is shallow enough to be crossed safely, allowing access to the top of the ridge on the other side. Most of the trees protrude from the nearly vertical face of the canyon wall, but near the upstream end of the exposure where the log horizon comes close to intersecting the ridge top, they can be seen close up.

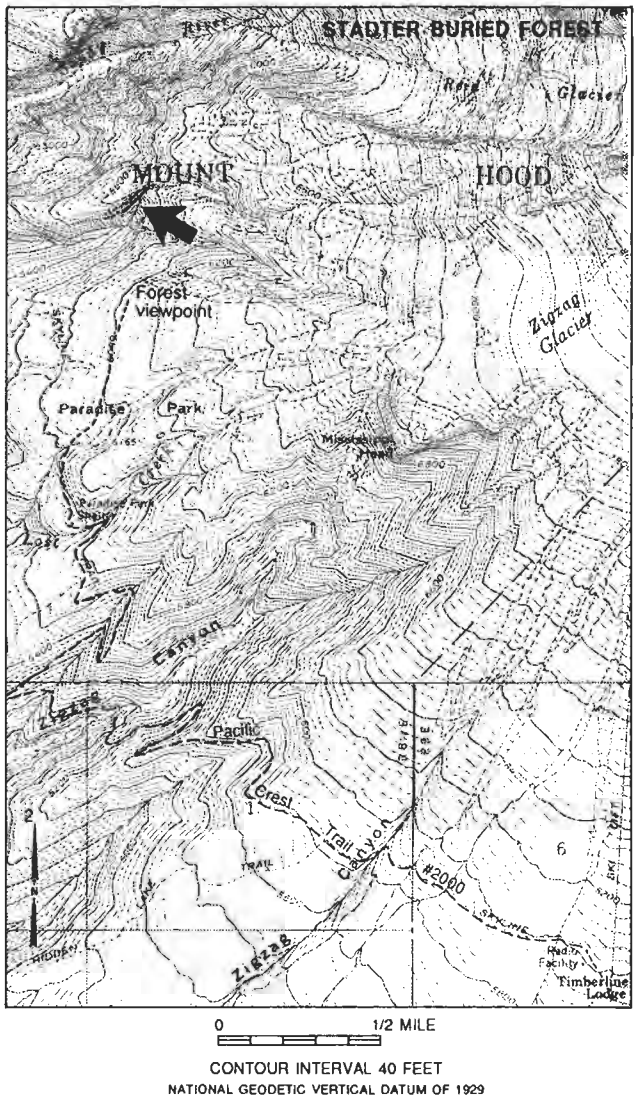

Figure 2. Location (stippled area in northwest quadrant of map) and access map for the Stadter buried forest. Base is from Mount Hood South 7½-minute quadrangle.

Figure 3. View across the canyon to the Stadter buried forest. The trees grew in soil developed on the light-colored rocks of a lava flow.

Between twenty and thirty logs averaging 1 to 2 ft in diameter are exposed along approximately 100 ft of the canyon wall (Figure 3). All are prone, are aligned more or less due west, and show considerable abrasion on their surfaces. All are in an extremely good state of preservation, due probably to the elevation, which keeps them frozen for much of the year, and their southerly aspect, which keeps them relatively dry the remainder of the year. The logs are lying on or within a foot or so of the top of a buried brown soil/colluvium layer that represents the ground surface of the time when the trees were alive. This soil developed on the surface of a thin lava flow that caps a thick sequence of steeply dipping clastic debris. The soil is easily traced for several hundred feet downstream and shows that the surface on which the trees grew was uneven and rolling. Overlying the soil are the layers of clastic volcanic debris that buried the forest, mostly laharic deposits but also a few pyroclastic flow deposits. These latter deposits are identified by the abundance of iron oxide staining, increased induration, and the presence of radially fractured clasts. Both the lahars and the pyroclastic flow deposits parallel the average gradient of the modern ground surface and commonly truncate against the undulating top of the buried soil layer. Wood samples from these logs have been dated at 1,700±70 radiocarbon years (Donald B. Lawrence, written communication, 1989), placing their burial near the middle of the time range for the Timberline eruptive period. Contrary to the original interpretation by Hodge (1931), these trees were buried by eruptive processes, not by glacial action.

Twin Bridges buried forest

There are actually two forests located here, one above the other, eroding out of a 25-ft-high terrace along the Zigzag River at the 2,820-ft elevation. Although the trees are exposed along the original route of Highway 26 and must have been seen by thousands of people, they have been described in only a limited way: the older (lower) forest was first described by Donald and Elizabeth Lawrence (1959), and the younger (upper) was mentioned briefly by the authors (Cameron and Pringle, 1986).

The older forest consists of half a dozen or more vertical snags sticking out of the talus along the right bank (right and left banks of a river are determined by assuming that the observer is always

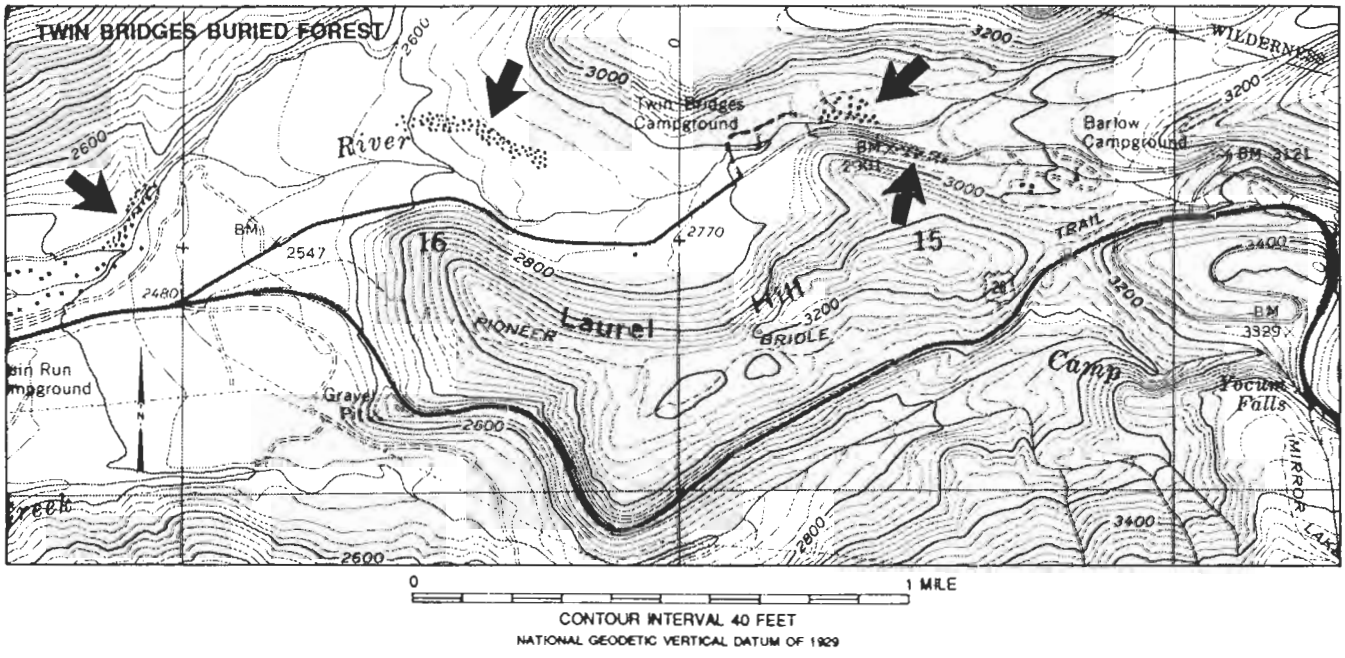

Figure 4. Location (stippled areas) and access map for the Twin Bridges buried forest. Base is from Government Camp 7½-minute quadrangle.

facing downstream) of the Zigzag River less than a quarter mile upstream from the site of the old Twin Bridges campground (Figure 4), now the trailhead for the Paradise Park trail. To get there, follow the trail upstream for about 100 yd and then head cross-country back to the river. The trees are exposed in a 25-ft-high cut bank that drops right into the Zigzag River. The old highway can be seen across the river on the left bank 10 ft above river level. There is a thick growth of young alder trees growing along the edge of the river that may hide the snags somewhat. The snags can also be seen from the old highway, especially during winter when the leaves are gone from the alders. Drive past the turnoff to the trailhead about a quarter mile until you can see the river to the left through the fringe of alders. You should be able to glimpse the snags through the trees despite their progressive burial by talus.

The older trees have been dated twice by the radiocarbon method with a considerable discrepancy in the results: the first date of 920±150 ybp by the Lawrences (1959), and the second of 550±130 ybp by the authors (Cameron and Pringle, 1986). Some of the discrepancy can be resolved by looking at the techniques used in obtaining the two dates. In obtaining the older date, the Lawrences were concerned about contamination from modern fungi and mold in the rotting outer layers of the trees, so an axe was used to chop into the interior of the tree to find unaltered, but older, wood. Sampling the older wood may have caused some of the discrepancy in dates, how much depending on the depth into the tree from which the sample came. Modern analytic laboratories now claim to be able to eliminate, or at least reduce, modern contamination through various cleaning processes. Our samples were taken from the first two or three rings below the bark in order to date, as closely as possible, when the tree died. If some modern carbon escaped the cleaning process, the second date could be too young. However, the second date correlates well with other radiocarbon dates from the Zigzag eruptive period. A lahar near the Upper Sandy Guard Station was dated at 455±135 ybp and tephra on the Muddy Fork at 560±150 ybp (both dates from Cameron and Pringle, 1986). Therefore we believe that this forest was buried by debris from the Zigzag eruptive episode.

The exposed trees in the lower portion of the Twin Bridges buried forest are Douglas firs, some of which are in an advanced state of decay (Figure 5). All still have their bark, even on the upstream sides, attesting to a generally passive burial. They are buried in a sequence of bouldery, fines-depleted flood deposits and volcanic debris flows. The top of the sequence is marked by sand and silt layers probably formed from reworking of debris upstream by post-eruption stream flow. This sequence of sediments resulted from volcanic activity during the Zigzag eruptive period, when the next-youngest dome growth episode after the Timberline eruptive period occurred. The Zigzag period was much smaller volumetrically than the Timberline, and the deposits here are the thickest yet found of this age on the mountain. The deposits are found here in a river basin with a very small catchment area near the vent, which may indicate that the eruptive activity was centered in an area "facing" the catchment, such as the downslope side of Crater Rock.

The passive nature of the initial burial of the exposed trees, as indicated by their intact bark, may be a function of distance from the original river channel. At least two snags are actually in the Zigzag River, indicating that the river was in another location at the start of the eruptive period. The height of the terrace that contains the Zigzag-age outcrop and its proximity to the right valley wall suggest that the channel was south of its present location, closer to the center of the valley, and that the snags were part of a forest growing on a low terrace or flood plain. As debris filled the main channel and the flows spilled out of the channel and through the trees, they lost much of their velocity and left the trees relatively unscarred.

This site has the distinction of possessing buried forests of two separate ages. Above the layered sands and silts at the top of the Zigzag-age section is a soil zone about a foot thick, topped by a lahar deposit and finally the modern soil layer. The buried soil layer supported a mixed forest of firs and cedars that was buried and killed by the single debris flow. Exposed in the outcrop along the Zigzag River are a few Douglas fir stumps and roots of various unidentified plants. Standing snags of cedar can be found back from the top of the bank and along the highest terrace in the campground and downstream to the confluence with Lady Creek. These snags are in a fairly advanced state of decay; all have lost their bark and an unknown thickness of outer wood. Nevertheless, the outermost layers available have been dated by radiocarbon methods at 270±150 ybp (Cameron and Pringle, 1986), indicating they were killed by debris flows produced by the most recent major eruptive episode, the Old Maid eruptive period.

After cessation of the Zigzag eruptions, the floor of the Zigzag valley was probably fairly flat and filled to a depth even with the top of the Zigzag-age deposits. Trees immediately began to take root across this surface, expanding outward from the seed sources along the untouched valley walls. Within a hundred years or so, a mixed conifer forest once again covered the streambanks. The Old Maid eruptive period began around 1760 A.D. (based on preliminary dendrochronologic work done around the mountain by the authors), but due to the location of the vent (apparently on the upslope side of Crater Rock), the vast majority of eruptive debris was directed into the White River and Sandy River drainages. Only a single lahar of this age is known to have entered the Zigzag River drainage. The lahar covered the valley floor to an average depth of 3 ft in the vicinity of the Twin Bridges buried forest and killed the trees growing on the old Zigzag-age surface. The firs rotted away rapidly in the moist environment of the deep, shaded valley and are found only as root mats and stumps buried

Figure 5. Two trees in the Zigzag-age portion of the Twin Bridges buried forest.

in the debris flow deposits. The cedars rotted much more slowly and can still be found as isolated snags 6 to 10 ft tall.

White River buried forest

This forest has been mentioned in passing at least three times in scientific literature (Lawrence and Lawrence, 1959; Crandell, 1980; Cameron and Pringle, 1987) but has never been given the attention that it deserves. Locally, it is sometimes known as the "Buried Forest" or "Ghost Forest," though the latter name has also been applied to the stand of dead trees flanking either side of the White River canyon near timberline that were killed but not buried by a hot tephra fall during an Old Maid-age eruption (Lawrence, 1948; Cameron and Pringle, 1987).

An easy hike gives an overview of this forest, located near the bottom of White River canyon east of Timberline Lodge at an elevation of between 5,000 and 5,500 ft. To get there, head east from the lodge along the Timberline Trail for about a quarter mile to the Buried Forest Overlook (Figure 6). Here the trail skirts along the top of the canyon wall and provides an unobstructed view of the buried trees, seen as individual snags sticking out of the steep exposure of the valley fill material 500 ft below your feet. Between 10 and 15 snags scattered along 400 or 500 yd of the exposure can be seen from the overlook. A closer examination of these trees can be made by following the trail for about a mile and a half to the bottom of the White River canyon and then walking upstream to the beginning of the exposure. Beware of rockfall from the steep valley walls if you decide to do this.

The trees of the White River buried forest, identified by Lawrence and Lawrence (1959) as mountain hemlock, were buried by volcanic deposits during the Old Maid eruptive period. These trees have yielded radiocarbon dates ranging from 185±120 ybp (Cameron and Pringle, 1986) to 260±150 ybp (Crandell, 1980) and were probably killed during some of the first eruptive pulses of the Old Maid period. The trees are rooted in a much older soil layer that appears to be formed on glacial material rather than volcanic

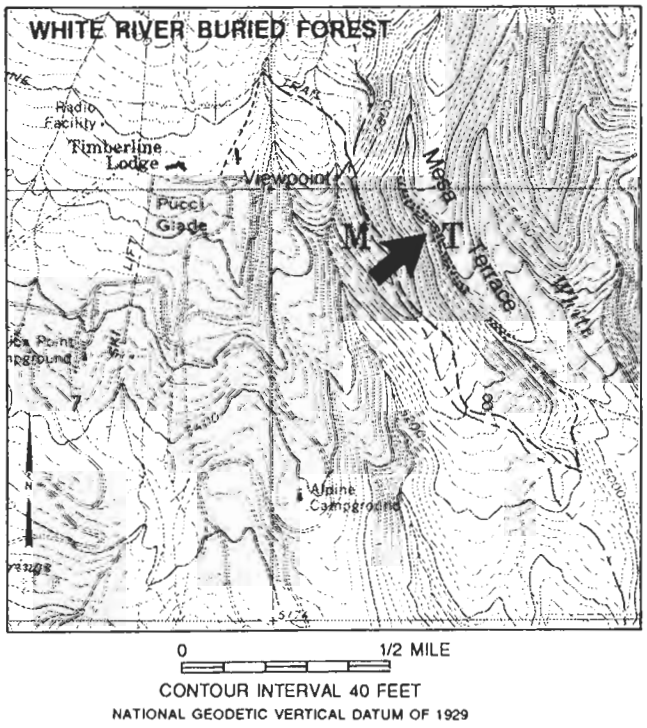

Figure 6. Location (stippled area) and access map for the White River buried forest. Base is from Mount Hood South 7½-minute quadrangle.

deposits from the older Holocene eruptive periods. In fact, no post-glacial volcanic material other than Old Maid-age has yet been found in the upper White River drainage.

Most of the obvious topography in the upper White River canyon is the product of glacial action. The Buried Forest Overlook is situated on a right lateral moraine from a major glacial advance, and at least three left lateral moraines are visible across the canyon as knife-edged ridges. Before the start of the Old Maid eruptions, the valley between the innermost moraines was probably broadly U-shaped and covered by a forest of hemlock. Debris from the first Old Maid-age eruptions began filling the valley with bouldery deposits. Many of the trees in this buried forest still have their bark intact, indicating that the material was deposited in a low-energy situation; however, they are no longer in their normal vertical orientation. They are, instead, inclined in a downstream direction by up to 30°, indicating that deposition, though passive, was forceful enough to push the trees over slightly. The snags are also of a uniform height, between 3 and 5 ft, which may represent a hiatus in deposition after the trees were buried to this depth. A pause of a few years would have allowed the portion of the trees above ground to start to decay or at least desiccate and become brittle. When eruptions started again, new deposits would have broken the trees off near ground level, forming snags of a uniform height.

The Old Maid-age eruptions filled the White River valley to a depth of around a hundred feet. Subsequent erosion by two streams draining White River Glacier cut through the deposit on either side of the valley, exposing the buried trees and leaving a flat-topped remnant in the valley center known as Mesa Terrace. The trees of this forest are in such a fine state of preservation that they are prime candidates for dating using dendrochronologic techniques (a study that is just beginning) and should provide a definite date for the start of the Old Maid eruptive period.

Upper Sandy buried forest

The Upper Sandy buried forest is the most extensive on Mount Hood. Trees can be found eroding out of streamside terraces in an almost continuous strip along the Sandy River from near Ramona Falls in the Mount Hood Wilderness Area downstream to the community of Brightwood. It should be noted that, except for the area actually on Old Maid Flat (within the boundaries of Mount Hood National Forest), much of this forest is on private land, and care should be exercised to respect the rights of the landowners. The cedar snags of the Old Maid Flat area have been mentioned previously in the scientific literature (Crandell, 1980; Cameron and Pringle, 1986, 1987). They have even been mentioned in a river-running guide (Willamette Kayak and Canoe Club, 1986, p. 143), though they were mistaken for pilings driven into the river bottom.

The most easily reached areas in which to see remnants of this forest are on Old Maid Flat, specifically in the Lost Creek picnic area, and along the Ramona Falls trail between the falls and the junction with Portage Trail, and in the lower valley of the Clear Fork (Figure 7). The Lost Creek picnic area is a little less than 3 mi up Old Maid Flat from the turnoff from the Lolo Pass road. The route is well marked, and the road is paved all the way, but the last half is a one-lane road with turnouts, so watch for oncoming traffic. The picnic area is designed for use by the handicapped and has paved, level trails suitable for use by wheelchairs. (As of this writing [1990], the area is being expanded to include wheelchair-access campsites.) The trees in this part of the buried forest are exposed, for the most part, in the bed of or directly adjacent to Lost Creek. Follow the trail upstream from the parking area for the best views.

At least 20 snags have been located along this reach of Lost Creek. All are conifers, ranging in diameter from 1 to 4 ft and in height from 2 to 10 ft. Most show little sign of abrasion during burial, and many still possess their bark. Constant saturation by the waters of Lost Creek has kept the portions of the trunks near

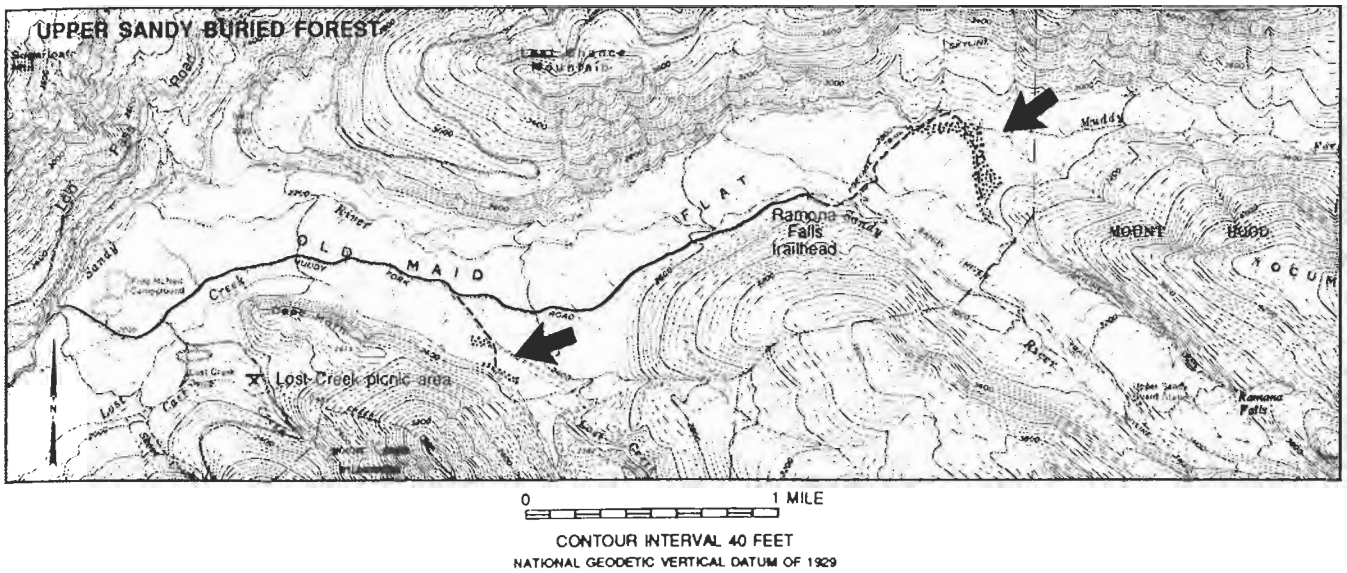

Figure 7. Location (stippled areas) and access map for the Upper Sandy buried forest. Base is from Bull Run Lake 7½-minute quadrangle.

water level in a good state of preservation, but their upper parts are fairly long gone in decay, especially in the firs (Figure 8). Strangely enough, many of the cedar snags are cut off near ground level and can be easily mistaken for modern stumps. Thick moss and lichen growth on the cut surfaces of the snags indicate that the cutting occurred many years ago. Apparently early inhabitants of the area saw these snags as a source of standing firewood, or, in the case of the cedars, as already seasoned shake bolts. Buried snags can be distinguished from modern snags by their lack of a root swell or buttressing near their base, by the rotting and embayment of the wood right at ground level, and by touch. Run your hand along the trunk and follow it below the ground surface. A snag will keep on going into the ground, but a modern tree rooted at the surface will immediately break up into roots.

The Lost Creek site is in a backwater area where lahars of Old Maid age, flowing down the valley of the Sandy River, ponded in the mouth of Lost Creek valley and actually flowed upstream into the tributary valley for a short distance. As the flows turned the corner to enter the valley, they lost much of their momentum, which explains the lack of abrasion on the snags. Lost Creek itself was probably dammed by the accumulating deposits, forming a small lake (Cameron and Pringle, 1986). The swampy beaver-pond area at the end of the trail in the picnic area may be a remnant of this lake. When Lost Creek finally broke through the barrier, it did so along the boundary between the new deposits and the valley wall, eventually exposing the buried trees now seen in the channel.

The biggest collection of trees in Upper Sandy forest is farther up Old Maid Flat, along the trail between Ramona Falls and the Portage Trail crossing of the Muddy Fork. It is reached by driving another 1¾ mi beyond the Lost Creek turnoff to the end of the road. Much of this section of road is just a track bulldozed on the surface of the Old Maid-age deposits and is very rough. A parking area is at the end of the paved section of road, and a trail parallels the rough portion of the road. Follow the Portage Trail to the northeast to the junction with the Ramona Falls Trail. The trees of the buried forest are found on both sides of the trail for the first half mile toward Ramona Falls. As with the Lost Creek site, these trees were buried by lahars produced during the Old Maid eruptive period. Only one snag has been dated by radiocarbon techniques (Crandell, 1980), and it yielded a date of <250 ybp. Provisional dendrochronologic work by the authors suggests that the main Old Maid-age debris flow swept over Old Maid Flat in the early 1780's A.D.

Figure 8. Three snags along Lost Creek: one on the near bank and two on the far bank (one short, hollow snag at the water's edge and one tall snag just behind it).

Another portion of the Upper Sandy buried forest has just recently been discovered, so recently, in fact, that it could not be included on the location map. This portion is on the Clear Fork of the Sandy River, just upstream of where it joins Old Maid Flat. Once again, lahars spreading over the surface of the Flats flooded back upstream on a tributary, burying the forest on the valley floor. In this location, about 40 snags, which are a mixture of Douglas fir and cedar, many over 4 ft in diameter and 20 ft tall, are protruding from the bed of the Clear Fork, indicating that the river is now in a different location from its pre-eruption course.

To reach this area, follow the Old Maid Flat road from the turnoff on Lolo Pass Road. About half a mile down the road is a fork, the right-hand way leading up Old Maid Flat toward Lost Creek and the Ramona Falls trailhead, and the left toward Last Chance Mountain. Take the left fork, which stays up on the valley wall above the level of the Flats. About 1 mi beyond the fork, you will come to the bridge over the Clear Fork with a parking area immediately across the bridge. A fisherman's trail leads up the Clear Fork on the left bank for 200 yd to the start of the snag area. Snags are visible in the river for about a quarter of a mile.

The debris flows that buried these trees filled the channel of the Sandy River (which was probably in the same general location as the modern channel, as determined from deposit thicknesses throughout the valley) and spread over the relatively flat valley floor, covering it from one side to the other. The plant assemblage living on the Flats then was probably very similar to that found there today: large, water-seeking conifers (cedars and Douglas firs) near the edges of the flats and, more importantly, along incised stream channels, and plants more adapted to droughty soil conditions (lodgepole pine) near the center of the valley. When the debris flow swept over the flats, it filled the incised channels, killed the stands of large trees, and swept the smaller lodgepole pines away. The snags seen along the Ramona Falls trail probably mark the path of Ramona Creek and the Muddy Fork of the Sandy River and show that before the Old Maid eruptions, Ramona Creek followed a channel north of its present location and joined the Muddy Fork much farther upstream than it does today.

The snags themselves are impressive; between 30 and 50 are still standing, many of them reaching 100 ft in height and 4 ft in diameter. All of the standing snags at this site are cedar, and there are no cut stumps like those seen father down valley at Lost Creek. No fir or hemlock snags are present either, although fir and hemlock make up the majority of the trees blanketing the valley walls above the effects of the debris flows. Since fir and hemlock do not have the natural decay-resistant properties of cedar, snags of these species have completely rotted away. What remains are cylindrical "wells," the natural casts left in the mudflow deposits after the tree trunks disappeared (Figure 9). They appear as circular holes up to 21 ft deep, sometimes partially overgrown with moss and lichen mats. If you climb down into these wells, you can sometimes see the shape of the swelling base of the tree and even the radiating root pattern at the bottom. This activity is definitely NOT recommended. The deposits are unconsolidated and prone to collapse, and the wells are sometimes narrow and partially filled with loose debris. The direction the debris flow was traveling can also be determined in the wells; larger rocks will be piled on the upstream side of the tree, smaller rocks on the downstream side. The depth of the well is, of course, equal to the depth of the debris flow deposit across the surface of Old Maid Flat plus the depth of the old incised channel of Ramona Creek or the Muddy Fork in which the tree was growing. Again, climbing into the tree wells is definitely NOT recommended. Be content with letting down a tape measure to determine depth. These wells are particularly common near the toe of Yokum Ridge, where the valleys of the Sandy and Muddy Fork come together.

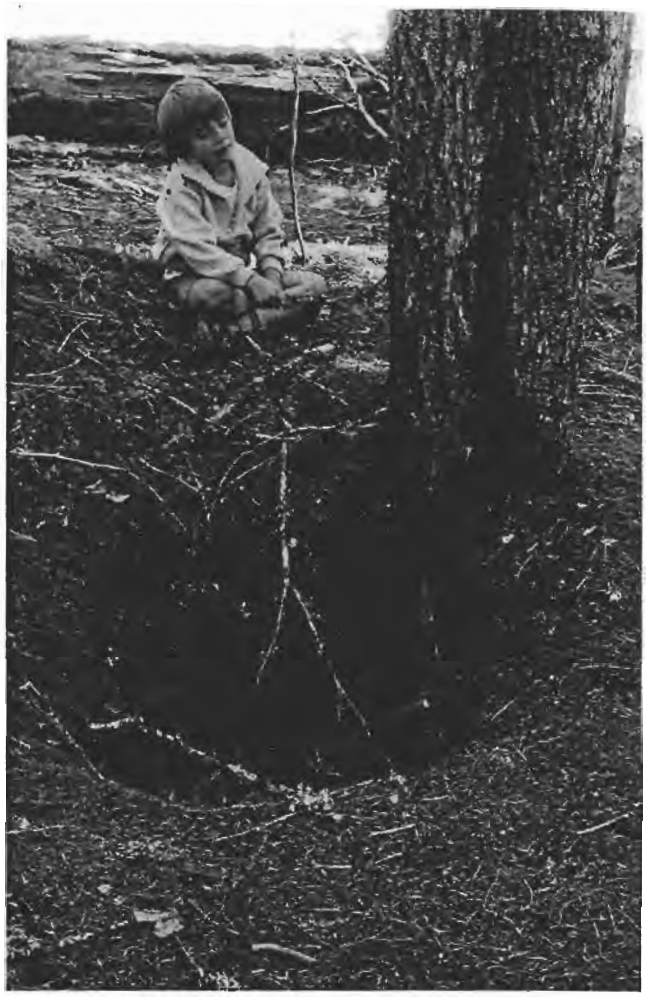

Figure 9. Typical example of a tree well, this one about 3 ft across and 4 ft deep, located near the Lost Creek picnic area.

Tollgate buried forest

This buried forest is also easy to get to, being located at about the 1,800-ft level along the banks of the Zigzag River adjacent to and upstream from the Tollgate Wayside east of Rhododendron (Figure 10). Most of the snags are on the left bank of the river, which is private property leased from the USDA Forest Service. They can be easily seen, however, from the public land on the right bank. This forest has never been described in the scientific literature and was only recently exposed by erosion when the river shifted its channel during the Christmas flood of 1964 A.D.

About a dozen snags are visible along a quarter-mile reach of the river. Most are less than 5 ft tall and 3 ft in diameter, and apparently all are Douglas fir. The root mat of at least one is visible on the bottom of the river and is polished flat by the erosive action of the water. The trees of this buried forest are being eroded out of the flat expanse of the valley floor by side-cutting of the Zigzag River. None of these trees has been radiometrically dated, but soil profiles, vegetation assemblages, and upstream stratigraphy all indicate that they were buried during the Old Maid eruptive period.

The trees of this buried forest are about the same general size as the Old Maid-age portion of the Twin Bridges buried forest but are considerably smaller than those of the Upper Sandy buried forest on Old Maid Flat. This disparity in size can be explained by the amount of time each forest had to grow before being buried. In the case of the Twin Bridges and Tollgate forests, the trees

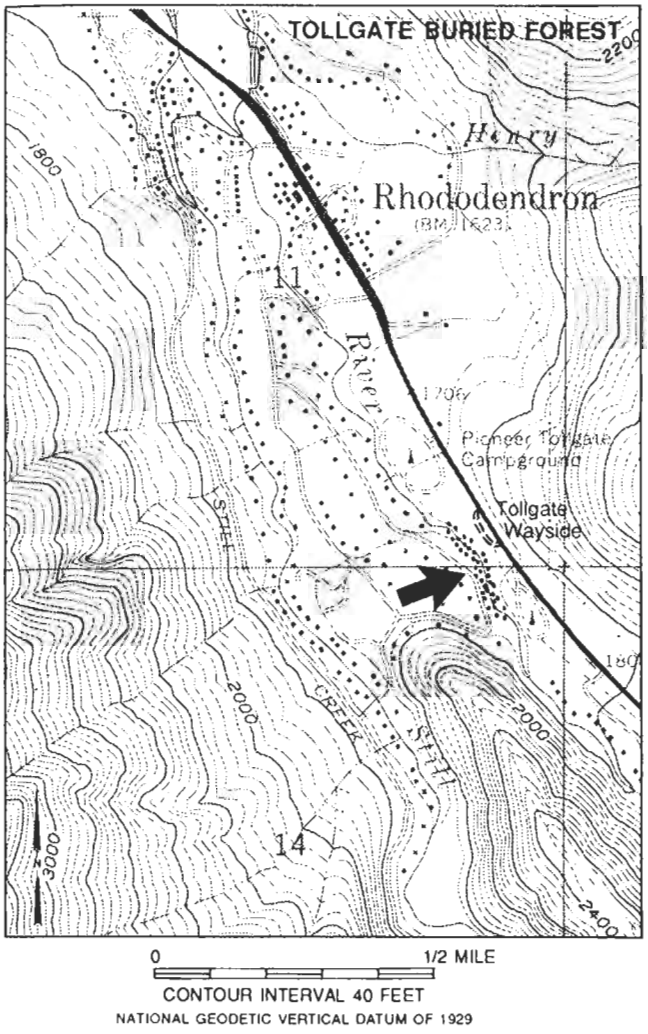

Figure 10. Location (stippled area) and access map for the Tollgate buried forest. Base is from Rhododendron 7½-minute quadrangle.

were rooted in debris produced during the Zigzag eruptive period. This creates a time span of about 250 years for the trees to colonize the surface and grow into a forest. In the Upper Sandy forest, the trees were rooted in deposits of the Timberline eruptive period and had at least 1,200 years to develop the old growth assemblage and spacing seen in the pattern of snags and tree wells.

At the start of the Old Maid eruptions, this site was occupied by a young, valley-covering forest composed mostly of Douglas fir. A single large lahar (the same one seen at the top of the cutbank at the Twin Bridges forest) overflowed the channel banks and deposited from 3 to 5 ft of material around the trunks of the trees. The easily decayed firs rotted off at ground level, but the below-ground portions of the trunk, kept constantly saturated by the proximity of the river, were preserved. Channel migration during modern floods has exposed these stumps only over the last 25 years.

Oxbow buried forest

The downstreammost buried forest of Mount Hood is probably the most difficult to reach. It is located along the banks of the lower Sandy River from Indian John Island to 3 mi below Oxbow County Park at an elevation of 50 to 150 ft (Figure 11). There is no road or trail access; the forest can be reached only by boat. The best example of this forest is located on privately owned land on the left bank downstream from Oxbow Park (the authors had the owner's permission when conducting studies of the deposits in this area). Although thousands of boaters pass by the snags of this forest each year, it has never been mentioned in the scientific or popular literature.

Over a dozen standing snags up to 20 ft tall and 6 ft in diameter are eroding out of 40-ft-high terraces along both banks of the Sandy River about 2 mi upstream from Dabney State Park. There are also two logs extending horizontally over the water for at least 50 ft from the middle of the terrace (Figure 12). Such a position is obviously possible only if the log is in a good state of preservation. All of the trees inspected here were Douglas fir, possessed most of their bark, and showed little or no damage from being buried. This forest was first exposed by erosion accompanying floods in the 1950's (George Casterline, oral communication, 1989). None of these trees have been dated radiometrically, but once again, soil development, vegetation assemblages, weathering depths, and stratigraphic relationships indicate that this forest was buried by material produced during the Old Maid eruptive period.

Exposures of the terrace show that the trees were not buried by a single flow but by a whole sequence of events. A basal unit 2 to 3 ft thick is from a lahar; probably the initial event to fill the river channel and leave deposits in the surrounding forest. The rest of the deposits are more typically fluvial in texture, having numerous thin (1- to 2-ft-thick) units of sand and gravel that are commonly cross-bedded. No soil layers were found between the fluvial units, indicating that all were deposited within a short span of time.

The trees are rooted in an extremely fine-grained, organic-rich layer that is an average of 3 ft above current mean water level. Modern floods generally keep large-diameter Douglas firs from growing within 8 or 10 ft vertically of the water; areas nearer to water level are colonized instead by fast-growing phreatophytes such as cottonwood, alder, and willow. The proximity of the large fir snags to the modern water level suggests that at the time of the Old Maid eruptions the channel of the Sandy River, at least in its lower reaches, was at a somewhat lower level.

The 35 ft of rapidly deposited fluvial material that forms the bulk of the terrace at the Oxbow buried forest exemplifies the complex range of impacts a volcanic eruption can have on downstream environments. At least one primary volcanic flow did travel this far (approximately a 45-mi flow path from the vent area) and is preserved as the basal unit that surrounds the trees. By far the majority of the terrace, however, is composed of secondary fluvial deposits brought down through normal stream processes. Vast quantities of material were deposited in and adjacent to stream channels near Mount Hood by lahars, pyroclastic flows, and sediment-laden stream flow during the Old Maid-age eruptions. This deposition raised the local river base level and created a stream environment of high gradients and loose sediment. This loose sediment was easily eroded and transported downstream, temporarily filling the lower valley as it moved along. Almost immediately, the river started cutting back down through this sediment pile, transporting the eroded sediment to even lower reaches of the valley. The mouth of the Sandy River is occupied by a broad delta, composed, at least in part, of the reworked volcanic debris from upstream.

SUMMARY

At least three times at six different sites during the post-glacial history of Mount Hood, forests have been overwhelmed and buried by debris from volcanic eruptions. The oldest of these buried forests, the Stadter forest, dates from the Timberline eruptive period 1,800 to 1,400 ybp. This forest was inundated by high-velocity lahars that pushed the trees over and abraded the trunks, removing all of the bark. The next oldest buried forest is the Twin Bridges (lower portion), which was buried by lahars and fluvial deposits

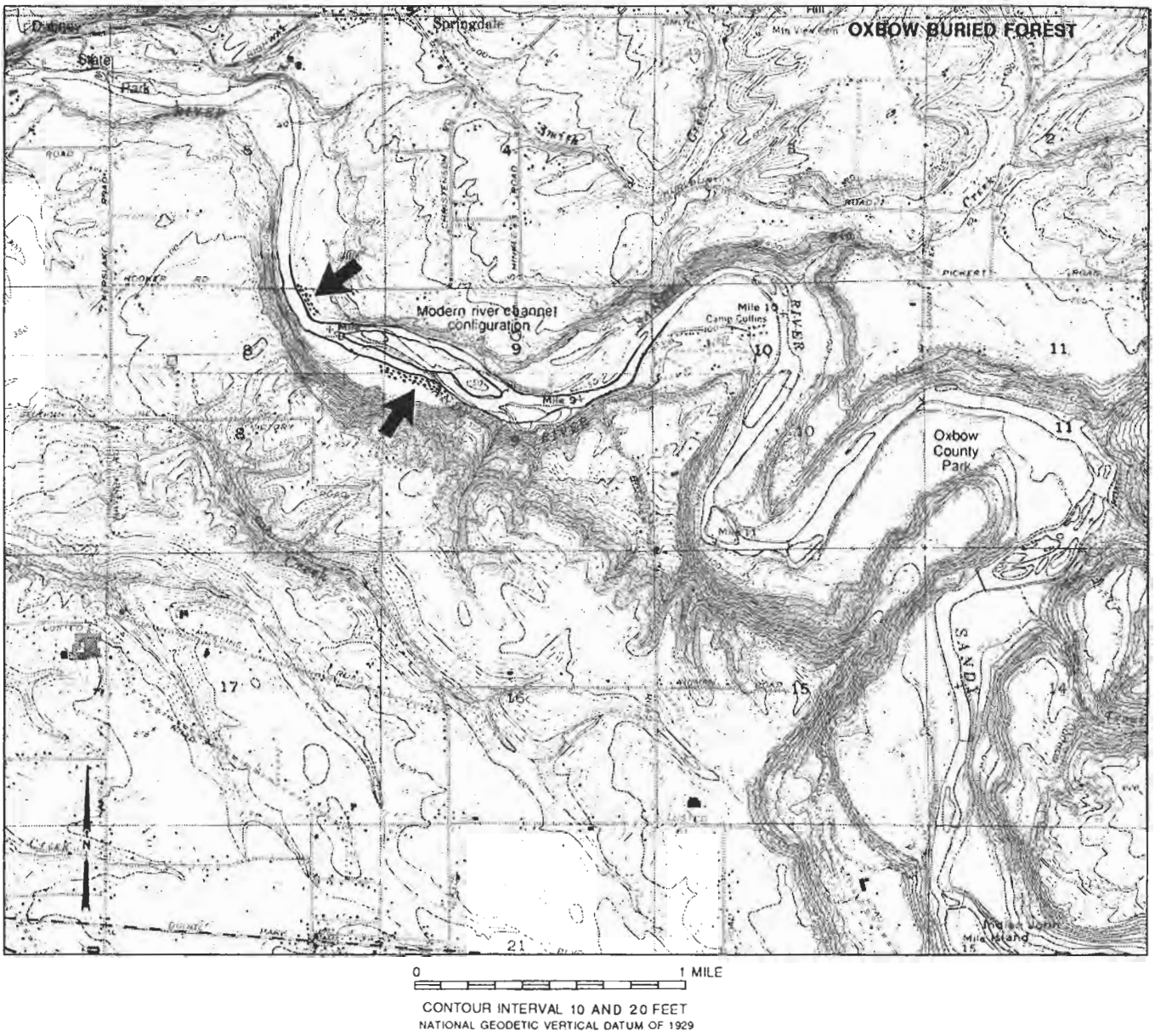

Figure 11. Location (stippled areas) map for the Oxbow buried forest. Note that the configuration of the present river channel is very different from that shown on available map. Base is from Washougal and Sandy 7½-minute quadrangles.

of the Zigzag eruptive period, 600 to 400 ybp. These trees are found adjacent to and in the modern channel, indicating that the river, before the onset of the eruption, was located somewhere else in the valley, probably more toward the center.

The other four forests (and the upper half of the Twin Bridges forest) all date from the Old Maid eruptive period, 1760 A.D. to 1810 A.D. Forest conditions ranging from relatively young, closely spaced stands of mostly Douglas fir (such as in the Tollgate forest) to the large, well-spaced cedars and Douglas firs of an old growth forest (as in the uppermost portion of the Upper Sandy forest and in the Oxbow forest) have been preserved by the protecting layers of debris.

Not only do these forests tell us of past ecologic communities, but they graphically display the far-reaching effects of volcanic activity. The valleys of the Sandy, Zigzag, and White Rivers have been filled to depths of many tens of feet as far as 50 mi from the mountain by volcanic events and the subsequent erosion and downstream deposition. Mount Hood last erupted during the time of Lewis and Clark, and there is no reason to believe it will not do so again. These forests give us some idea of what can be expected.

ACKNOWLEDGMENTS

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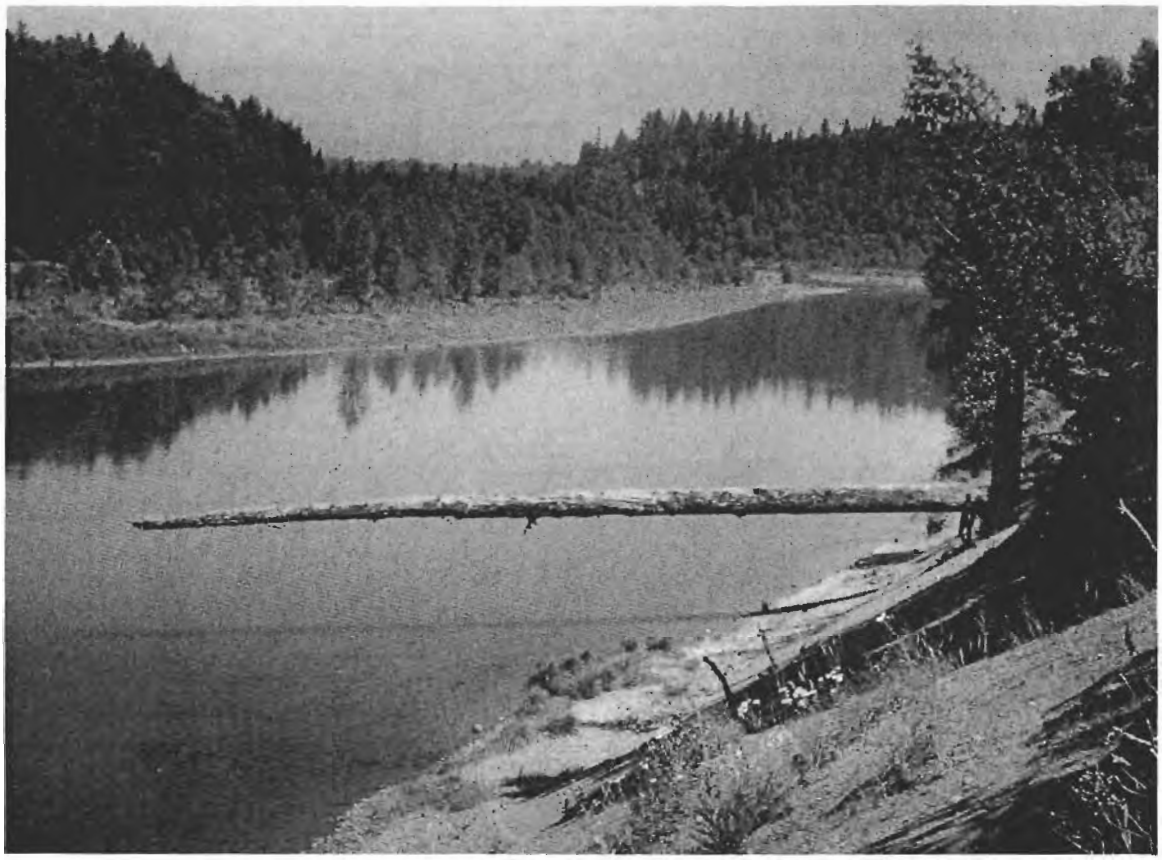

Figure 12. Snags of the Oxbow buried forest on the left bank of the Sandy River below Oxbow County Park.

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Gresham club displays rocks at Capitol

The Mount Hood Rock Club of Gresham has installed a new exhibit in the display case of the Oregon Council of Rock and Mineral Clubs (OCRMC) at the State Capitol in Salem. The collection will remain at the Capitol until May 15, 1991. The displayed specimens are from 10 Oregon counties and were provided by 25 adult and six junior members of the club.

Featured in the center of the upper shelf is a three-tiered riser showing more than 30 polished cabochons of different agates—Oregon Sunset, Graveyard Point plume, Carey plume, and ledge agate—and a heart-shaped cabochon of obsidian.

The display of the junior club members includes four operating clocks made with Wascoite, jasper, and thunderegg slabs; Oregon sunstone gem trees, one on a base of petrified oak wood and another on a myrtlewood base; a free-form cabochon of Jefferson County agate; and crystal specimens of stilbite plate and calcite.

The remaining space is taken up by a large sphere of Malheur County jasper; Morrow County opal, rough, polished, and faceted; two limb casts in the form of Owyhee and Biggs jasper scenic slabs; a small mahogany obsidian obelisk; an unusual "fir cone agate" specimen; a large thunderegg slab; two belt buckles; two mounted pendants; a faceted Oregon sunstone; a large round of petrified oak wood; and the name plate of the club fashioned of obsidian. *—OCRMC news release*

AGI offers new earth science resource

Earth Science Investigations, a new classroom resource has been published by the American Geological Institute (AGI).

Conceived for earth science programs for grades 8-12, this collection of investigations consists of 26 innovative study activities providing the concepts, vocabulary, and worksheets needed to complete them. The following selection of subjects may give a taste of the collection: *What earthquake waves tell us about Earth's interior. - Building a river. - Micro-weather patterns. - Comparing water hardness. - World time-day calculator. - Investigating tides. - Analyzing North American meteorite impact sites.*

The publication is available from the Customer Service Department of AGI, 4220 King Street, Alexandria, VA 22302-1507, for $34.95 per copy plus handling and postage charges of $4 for the first and $1 for each additional copy. For credit-card orders, a FAX number, (703) 379-7563, and two phone numbers, (800) 336-4764 and (703) 379-2480, are available. □