As compared with past years' stages, the average for the month was: At Wenatchee, 2.4 feet below the normal; at Umatilla, 3.0 feet below; at Northport, 4.0 feet below; at Vancouver, 4.7 feet below; at The Dalles, 5.0 feet below, and at Cascade Locks, 8.2 feet below. As compared with the height of the water during the preceding month, the mean stage was 1.8 foot lower at Wenatchee, 2.6 feet lower at Umatilla, 3.3 feet lower at Vancouver, and 4.7 feet lower at The Dalles, while at Northport the mean June stage was 0.6 foot higher than that for May.

The river at Vancouver fell steadily from 17.2 feet on the 1st to 10.8 feet on the 30th; at the Dalles it rose from 28.9 feet on the 1st to 29.2 feet on the 3d and 4th, and then fell steadily to 20.3 feet on the 28th, on which date the river gage was destroyed by a boat colliding with the piling to which the gage was attached, the actual stage on June 30 was approximately 19.5 feet; at Umatilla the river was about stationary during the first 4 days of the month at a stage of 17.8 feet, but from the 5th to the close of the month there was an uninterrupted fall, the reading on the 30th being 12.9 feet; at Wenatchee there was a fall from 33.8 feet on the 1st to 27.2 feet on the 30th; and at Northport, the fall was from 22.6 on the 1st to 16.8 on the 30th.

Navigation on the Columbia was not interrupted during the month.

The Snake.—The mean of the daily stages at the several stations for the month averaged 4.5 feet below that for May, and it was 4.0 feet below the normal for June. The water was highest from the 2d to the 4th, and the lowest on the 30th. At Lewiston the river fell from 11.0 feet on the 1st to 3.4 feet on the 30th; at Weiser there was a slight rise from 7.5 feet on the 1st to 7.9 feet on the 4th, and then a gradual fall to 2.2 feet on the 30th; at Riparia, a rise from 10.2 feet on the 1st to 10.9 feet on the 2d and 3d was followed by falling stages, reaching a reading of 4.4 feet on the 30th. Navigation was not impeded, the regular weekly boat service to Asotin, Wash., which is 6 miles above Lewiston, being maintained throughout the month, and on June 9 a trip was made to the mouth of the Grande Ronde River, 38 miles above Lewiston. The boat service on the Snake River was, however, discontinued on June 30, owing to the low stage of the water, the gage reading at Lewiston on that date being 3.4 feet.

The Willamette.—This river continued to fall throughout June, the highest stages occurring on the 1st, and the lowest generally from the 28th to the 30th. At stations on tributary streams the highest water occurred between the 1st and the 12th, and at Estacada on the Clackamas River, the lowest reading occurred on the 15th, 27th, and 29th. The mean stage of the Willamette ranged between a normal stage at Wilsonville and 3.7 feet below normal at Portland, and was 2.1 feet below normal at Salem, and 1.6 foot below at Albany. The June mean stages at all stations were uniformly lower than those for the preceding month, being 1.3 foot lower at Eugene, 1.5 foot lower at Albany, 1.7 foot lower at Salem, and 3.3 feet lower at Portland. The great difference that appears at Portland was probably due to the high May stage which was caused by backwater from the Columbia.

At Eugene the fall from the 1st to the 30th was so gradual that, generally, it could not be readily measured, and the record shows 4 feet from the 1st to the 5th, inclusive, 3.6 feet on the 6th, and 3.0 feet for the remainder of the month. At Albany there was a steady fall from 2.3 feet on the 1st to 1.6 foot on the last 3 days of the month. At Salem, a stage of 1.5 foot on the 1st and 2d decreased to 0.6 foot on the 29th and 30th. At Wilsonville, there was a steady fall from 3.7 feet on the 1st to 2.1 feet on the 29th, a rise to 2.9 feet being recorded on the 30th, and at Portland, the fall was from 16.7 feet, which is 1.7 foot above flood stage, on the 1st to 10.4 feet, or 4.6 feet below the flood stage, on the 30th. On account of the low water and gravel bars, navigation was not possible above the mouth of the Yamhill River, but regular trips were made throughout the month to Newberg, which is a few miles below that point.

REPORTS OF STAGES OF STREAMS IN MONTANA DURING JUNE, AND THE PROSPECTIVE FLOW OF WATER FOR THE REMAINDER OF THE SEASON.

Missoula watershed—Bison Mountain: The Little Blackfoot is very much lower than usual. The snow in the mountains has all disappeared, the drifts having melted a month to 6 weeks earlier than usual. Bald Butte: There is less snow in the high mountains than for many years at this season. Hat Creek: There is no snow left in this locality, and the flow of water in the streams is now much below the average. The hay crop will be cut short on account of lack of water for irrigation. Ophir: Placer mining has been hampered by the shortage of water in the streams, the flow of which miners report to be less than half the average. No snow remains in places where it usually lasts till the latter part of July.

Bitterroot watershed.—Darby: The Bitterroot River is as low as it usually is at the beginning of August. There has been no shortage of water for irrigation up to the present time, but the supply for July and August will be largely dependent on rains. There is still some snow in the higher mountains, but there are fewer drifts than usual at the close of June. Sula: The East Fork is lower than usual at the close of June. The snow has melted earlier than usual in most places, but there are still some drifts remaining at high elevations in the Bitterroot Mountains.

Clarks Fork watershed.—The water is as low as it usually is a month later. The snow, except drifts, melted earlier than heretofore, and very little remained in the mountains at the end of June. Saltese: The St. Regis River is unusually low. The snow in the Bitterroot Mountains melted earlier than usual, and there will be a shortage of water during July and August. Noxon: The flow of water in Bull River was near the average during June. There are still some deep snow drifts on the north slopes, but the indications are for low water the remainder of the season.

Kootenai watershed.—Snowshoe: There is still some snow in the drainage basins of Snowshoe and Libby creeks, but the stage of water is lower than usual for June.—*R. F. Young, Section Director.*

MISCELLANEOUS PHENOMENA.

The prevailing winds were from the west. The amount of sunshine was nearly normal, except at Seattle, where there was a considerable deficiency. The percentage of possible sunshine was 75 at Spokane, 43 at Seattle, and 56 at Portland. Frosts were general in the interior during the early part of the month, serious damage to the apple crop resulting at a few places. Thunderstorms were of frequent occurrence and were reported generally on the 5th, 6th, 19th, and 20th. Several places suffered from hailstorms, that at Dufur, Oreg., on the 20th, which seriously damaged the apples over a wide area, being the severest. Sleet was reported at Ophir, Mont., on the 8th. Solar halos were observed on the 5th, 10th, 12th, and 25th, and in some places on other dates. An unusually severe sand storm occurred at The Dalles, Oreg., on the 11th. The highest wind was reported from North Head, Wash., where a maximum of 62 miles per hour from the southeast was reached on the 20th.

AVALANCHES IN THE CASCADES AND NORTHERN ROCKY MOUNTAINS DURING WINTER OF 1909-10.

By EDWARD A. BEALS, District Forecaster.

For a week beginning February 25 and ending March 3, 1910, there were a great many avalanches in the Cascade and northern Rocky mountains. Avalanches in these mountains are of common occurrence every year, but this year there were more than ever before known, and not only were they heavier and more frequent in places where they occur every year, but in places

where none had ever occurred before there were many large and destructive ones.

Through the cooperaton of the section directors and their correspondents in Washington, Idaho, and Montana, details regarding 36 avalanches, commonly known as slides, have been collected, and in addition some valuable information has been furnished the district editor regarding the behavior of slides by persons familiar with their characteristics. (See Table 1.)

It is seldom that avalanches in this district cause loss of life or damage property, except that once in a while a miner, prospector, or trapper living high up in the mountains is killed or has his cabin destroyed, and as these casualities happen in such remote regions they are seldom reported to the press and but little is known about them. This year, however, avalanches caused the loss of over 100 lives and destroyed several hundred thousand dollars' worth of property. The most destructive avalanche was the one at Wellington, Wash., at 1:45 a. m., on March 1, 1910. It swept 2 trains, 3 large locomotives, 4 powerful electric motors, the depot, and a water tank off a ledge and into a canyon 150 feet below.

Other slides occurring at about the same time, both to the east and to the west of this one, made it impossible to quickly get adequate help and wrecking appliances on the ground and it was nearly 2 weeks before all the bodies were recovered. The exact number of lives lost is not known, but 87 bodies were recovered and it is believed a few have not yet been found.

TABLE 1.—*Description of 36 avalanches in the Coast, Cascade, and northern Rocky mountains, winter of 1909–10.*

WASHINGTON.—CASCADE RANGE.

Number.	Place.	Date.	Time.	Character of country.	Slope.	Number killed.	Property loss.	Slide or roll.	Debris.	Cause.	Remarks.	Reporters.
1	Entiat Valley (T. 27 N., R. 19 E.).	Feb. 18	12 noon....	.....	w.	0	$50	.....	Mostly snow.....	.....	Came down an old slide.....	E. McCrea.
2	Wellington.....	Mar. 1	1:45 a. m.	Burned over. Numerous dead snags.	se.	87*	300,000	Slide...	Some green timber near bottom destroyed..	Heavy snowfall, followed by rain.	Two Great Northern Railway trains swept from track. Crushing power due to weight rather than velocity. Length, 1,200 feet.	J. Maloney. A. B. Hensel. J. V. Presser.
3	Bern, No. 1.....	Feb. 27	4:00 a. m.	Severely burned off. Seedlings 6 feet high.	n.	0	.....	Slide...	Logs and dead saplings.	Heavy snow on crusted layer beneath.	Slides occurred at intervals for 4 days. Chinook winds during this time.	H. B. Smith.
4	Bern, No. 2.....	(About) Mar. 2	.....	Severely burned off. Seedlings 6 feet high.	n.	0	.....	Slide...	Enormous quantity of logs and dead saplings.	Rotary plough going through first slide thought to have caused the second.	A big slide. Eighty feet of snow in one place on the Great Northern Railway track.	H. B. Smith.
	Merritt (near).....	Feb 25	5:00 p. m.	Wooded and open.	s.	0	.....	Slide...	Covered 10 acres.	Heavy snow on crusted layer beneath.	Cut down about 10 acres of standing timber.	H. B. Smith.
6	Cascade Tunnel (East).	Feb. 25	4:00 a. m.	Wooded.....	n.	2	.....	Slide...	Large amount of big timber	Heavy snow on crusted layer beneath.	Nearly all large timber in path destroyed.	H. B. Smith.
7	Gaynor, No. 1.....	Feb. 26	3:00 p. m.	Bare canyon.....	s.	0	.....	Rolling	Some green timber.	.....	Had sufficient force to cross canyon 75 feet deep, and more, onto railroad track beyond. About 2 miles long Started high in canyon.	H. B. Smith.
8	Gaynor, No. 2.....	Feb. 27	.....	Bare canyon.....	s.	0	.....	Slide...	Small amount of green timber destroyed	Rotary boring through the first slide.	.....	H. B. Smith.
9	Drury.....	Mar. 1	2:00 a. m.	Abrupt and rocky: some timber.	s.	1	.....	Slide...	.....	Heavy snow on crusted layer beneath.	Thunderstorm, with rain and snow, occurred just before and during slide.	H. B. Smith.
10	Wellington. 2½ miles west).	Mar. 13	Night	.....	.....	1	.....	Slide...	.....	.....	Several people injured.....	J. Maloney.
11	Telma (T. 28 N., R. 16 E.).	Feb. 25	4:00 p. m.	Open and rocky, except a few trees at foot of hill.	sw.	0	500	Slide...	.....	Slope where slide started 45°. Heavy fall of rain and snow.	300 feet wide and 20 feet deep. Slid into valley a distance of 650 feet.	R. J. Huston.
12	Katches, No. 1 (Sec. 33, T. 21 N., R. 13 E.).	Feb. 27	.....	Open.....	....	0	.....	Rolling	Snow and rocks.	Rain melting the snow	300 feet wide, down a rocky mountain into a little lake.	H. A. Shandy.
13	Katches, No. 2 (Sec. 8, T. 21 N., R., 13 E.).	Feb. 26	1:30 p. m.	Open and steep to within 500 feet of lake then timbered.	s.	0	.....	Slide...	Trees, rocks, and snow.	Rain causing snow to melt next to loose rocks.	At starting place about 200 feet in width. All debris was dumped into lake.	H. A. Shandy.
14	American River Yakima Co.	Mar. 12.	.....	Heavily timbered.	s.	0	.....	Slide...	Trees and boulders.	Heavy fall of snow in in short period, followed by a continued rain.	Slide about one-half mile in length. Large amount of timber destroyed.	J. W. Anderson.
15	Roslyn (coal mine)	Mar. 1	4:00 a. m.	Wooded.....	n.	1	.....	Slide...	.....	There was a fall of 14 feet of snow, after which chinook wind and rain set in.	The first snow slide on record for 20 years.	G. Kappen.
16	Hoodsport (Sec. 12, T. 22 N., R. 4 W., W. M.	Nov 28	6:30 p. m.	Open. Some brush.	se.	0	500	Slide...	Earth and logs washed away by ocean.	Heavy rains softened ground.	One person seriously injured. One dwelling, woodshed and other outbuildings destroyed.	Fred Hanson.

IDAHO.—ROCKY MOUNTAINS.

1	Mace.....	Feb. 27	11:10 p. m.	Steep hillside. Partly opened and partly wooded.	se.	12	$12,000	Rolling	Rocks, snow, and timber.	Probably high wind broke off and started overhanging snow.	10 to 40 feet deep and 1,200 feet long, 400 feet wide. Violent winds preceded the slide by a distance of 100 feet.	L. H. Hayes. W. J. Hall. W. G. Weigle.
2	Burke.....	Feb. 28	4:30 a. m.	Rather wide, draw partly open and partly wooded.	se.	5	.....	Rolling	Rocks, snow, and timber.	Probably high winds broke off and started overhanging snow.	10 to 25 feet deep, 300 feet long, 200 feet wide. Violent wind rush preceded the slide.	L. H. Hays. W. J. Hall.
3	Bear Gulch, 7 miles northeast of Murray.	Feb. 27	Between 10 and 12 p. m.	Hills burned over, leaving them quite bare.	n.	0	.....	Slide...	Rocks, snow, and timber.	About 18 feet of very light snow falling; afterwards about 1 foot of heavy snow fell on top of the light snow, which was followed by heavy rains.	Killed 5 head of horses and demolished the barns.	W. Keister.
4	Parogan Mine.....	Feb. 27	Between 10 and 12 p. m.	Timber quite thick.	n.	0	.....	Slide...	Rocks, snow, and timber.		Took away the shaft house and killed 2 head of horses.	W. Keister.
5	Seedar Creek Mine. (Granite Gulch.)	Feb. 27	Between 10 and 12 p. m.	Timber quite thick.	w.	0	.....	Slide...	Rocks, snow, and timber.		Took away the compressor building.	W. Keister.
6	Meadows.....	.....	3:00 p. m.	Wooded.....	se.	0	75	Rolling	5,000 tons.....	Snow falling off trees.	Weather mild at time of slide..	E. E. Clark.
7	Little Camas.....	Jan. 5	.....	Few trees.....	sw.	0	50	Slide...	All snow.....	Melting of heavy snow coating.	No property damage.....	

*87 bodies recovered; probably others not yet found. †See Mr. Weigle's report.

TABLE 1.—*Description of 36 avalanches in the Coast, Cascade, and northern Rocky mountains, winter of 1909–10*—Continued.

MONTANA.—ROCKY MOUNTAINS.

	Place.	Date.	Time.	Character of country.	Slope.	Number killed.	Property loss.	Slide or roll.	Debris.	Cause.	Remarks.	Reporters.
1	Saltese (1½ miles northeast).	Feb. 26	9:00 p. m.	Mountain bare; timber at base.	s.	0	Small...	Slide...	Snow and broken trees.	Heavy snow and 24 hours of rain.	Occurred on spur of Bitter Root Mountains known as Meadow Mountain.	E. K. Tarbox.
2	Saltese (2½ miles northeast).	Feb. 26	Night.....	Mountain bare; timber at base.	s.	0	Small...	Slide...	Snow and broken trees.	Heavy snow and 24 hours of rain.		
3	Passing track near Highgate.	Feb. 23	Noon.....	Sparsely timbered.	w.	0	Delayed traffic.	.....	Clear snow.....		200 feet long, 12 feet deep on railroad tracks.	G. T. Van.
4	Java (1 mile east).	Feb. 23	3:00 p. m.	Sparsely timbered. Dead and down timber.	w.	0	$50	.....	Snow and timber; very little earth and rock.	Old snow thawed, then froze, new snow fell and slid easily.	500 feet long, 15 feet deep....	G. D. Eddy.
5	Fielding (1 mile west.).	Feb. 27	Noon.....	Sparsely timbered. Dead and down timber.	w.	0	Delayed traffic.	.....	Snow. Not much timber		1,500 feet long; 5 feet deep....	G. D. Eddy.
6	Highgate (4 miles east.).	Mar. 3	4:00 p. m.	Sparsely timbered.	w.	0	Delayed traffic.	.....	Snow.....		100 feet long, 3 feet deep.....	G. D. Eddy.
7	Highgate (½ mile west.).	Feb. 27	1:30 a. m.	Timbered.....	w.	0	.....	.....	Snow and trees	Heavy fall of new snow on top of old snow which was crusted over.	800 feet long; ½ mile wide, 10 to 25 feet deep.	G. T. Van.
8	Highgate siding....	Feb. 27	12:15 a. m.	Partly timbered..	w.	0	.....	.....	Snow and trees	Heavy fall of new snow which slipped over old crusted snow.	900 feet long, ½ mile wide, 10 to 20 feet deep.	G. T. Van.
9	Adair (½ mile, southwest.).	Feb. 26	2:00 p. m.	Bare, except few dead trees.	w.	3	.....	.....	Mostly snow, few trees.	Weight of snow on slope.	150 feet long, 50 feet wide, 20 feet deep.	O. Miller.
10	Drexel (1 mile, west.).	Feb 27	Unknown.	Bare at top, timbered at base.	e.	0	Delayed traffic.	.....	Snow and trees	Weight of snow on slope.	350 feet long, 70 feet deep, 300 feet wide.	O. Miller.
11	Drexel (½ mile west.).	Feb. 4	Day.....	Burnt timber....	n.	0	.....	.....	Snow and dead timber.	Heavy snow, followed by thawing weather.	½ mile long, 150 feet wide, from 40 to 100 feet deep.	

OREGON.—BLUE MOUNTAINS.

1	Cornucopia.....	Feb. 24	11:30 a. m.	Wooded.....	s.	1	$500	.....	.....	About 4 inches of new and light snow settled during thawing weather and became heavy.	Incline of slope about 25°.....	L. Panter. L. G. Morgan.
2	Red Mountain.....	Mar. 2	.....	Steep, rough and barren.	s.	0	.....	Part rolling.	.....	Rain made the snow exceedingly heavy and it slid.	25 feet deep at bottom.....	L. Panter.

The loss to the railway company was not far from $300,000 in equipment, and suits have been entered for personal damages by the survivors and by the relatives of those who lost their lives.

Next to the Wellington avalanche in destructiveness was the one at Mace, Idaho, at 11:10 p. m., on February 27, 1910. This slide traveled about a mile from the top of the mountain to the base of the canyon just below the town. It left a pile of snow and débris 300 feet wide, 800 feet long, and between 20 and 40 feet deep. Fourteen houses were completely wrecked and 12 lives were lost. On the following day a smaller slide came down the canyon above the town of Burke, Idaho, which is only three-quarters of a mile east of Mace, and wrecked several buildings and killed 5 persons. Several lives were lost in other slides in Washington, Idaho, and Montana, and one was lost in Oregon, making a total so far as can be determined of 113 in all.

For the reason that there are more people living in valleys having railroads running through them than in the wild and mountainous sections where avalanches were most numerous, the descriptions obtained were mostly of avalanches occurring along the line of the railroads traversing the mountain passes. A few reports were received from the miners and others living well up in the mountains, but on account of the great number of avalanches occurring in these places the writers did not attempt to describe individual slides, but only gave information regarding their general characteristics. From these reports it is judged that between February 24, and March 3, 1910, the snow slid to a greater or less degree in the steep canyons of the mountains in this district and that there were thousands of avalanches, many of which would rival in magnitude the largest of those described in the list appearing in the tables.

Avalanches in the Rocky and Cascade mountains are seldom destructive, except when the snow is wet and heavy. It is true that dry snow sometimes falls from cliffs and ridges where it is blown by the winds into overhanging masses and it comes tumbling and rolling down steep declivities to the valleys below. These avalanches raise great clouds of dry snow and it is possible that persons have been caught in them and smothered to death, but the writer does not know of any such cases. The winds preceding and accompanying these rolling masses of dry snow often attain great violence, but avalanches of this class seldom have sufficient weight to move boulders or to injure forests.

The dangerous avalanches are the sliding masses of wet snow and they may move fast or slow, and come from great distances or have but short paths. Their destructiveness depends upon their momentum, which is usually sufficient to sweep everything before them.

It was not the quantity of snow alone which fell this year that caused so many avalanches, but it was the manner in which it fell, and many of the people most familair with these phenomena knew a day or two before they occurred that slides were inevitable, and had they not sought places of safety more lives would have been lost than there were under the existing conditions.

During the first 12 days of January the weather was unusually cold and the snowfall was rather heavy, especially on the windward slopes of the mountains. This spell of cold weather was followed by milder conditions, and on the 22d of the month thawing weather set in that extended nearly to the summits of the mountains having altitudes of about 7,000 feet. Some slides occurred at this time but there was nothing unusual about them and they attracted little attention. Following this short spell of thawing weather it became much colder, the old snow crusted over and it almost reached the consistency of ice on nearly all the high mountain slopes. The snowfall during the forepart of February was quite heavy, but on account of the prevailing cold weather its consistency was light, being either fleecy or granular. It was blown into great drifts in the canyons and overhung the crags and ridges at the

summits of the mountain ranges, but it was too light to cause avalanches, and none occurred.

On the morning of February 23 a low pressure area made its appearance off the Washington coast, which was attended by milder weather, high winds, and a heavy fall of snow in the mountains. It was three days in passing from the coast to the eastern side of the Rocky Mountains, and during this time the snow accumulated in large quantities at the heads of the canyons. Numerous avalanches occurred during this storm, but they mostly came down in places where the snow slides every year and there was nothing unusual about them.

The storm of February 23 had barely crossed the mountains when another low pressure area made its appearance on the north Pacific coast, and it was quickly followed by a third disturbance. It took each of these storms two days to move to Alberta and they all followed nearly the same track.

The last two storms caused high winds and also heavy rains that extended well up the slopes of the mountains, while at the summits the precipitation was mostly snow which was very moist and heavy. In fact, as a result of these two storms all the recent falls of snow became soaked with moisture, while underneath was a layer of old snow having less moisture and beneath this was the first snow which had almost the consistency of ice, conditions that were ideal for the occurrence of avalanches.

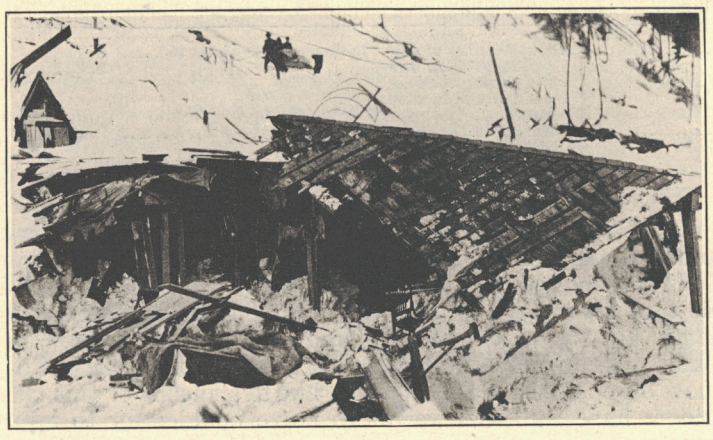

FIG. 1.—Mace, Idaho, avalanche showing near view house wrecked by the avalanche. It shows the remarkable force of snow which crushed alike dishes, stoves, and heavy furniture. Snow in many places completely filled the wrecked houses and the people inside were smothered to death. No. 1 (Idaho), Table No. 1. Photographed by R. W. French, Spokane, Wash. Furnished by Local Forecaster Charles Stewart, Spokane, Wash.

There is a difference of opinion as to what causes the slides to start, as few people have ever witnessed the beginning of an avalanche from a point sufficiently close to make reliable observations. We know that wet snow on the sloping roof of a building often slides off in great quantities whenever it has become thoroughly soaked with moisture and the water has wet the surface of the roof so as to make it slippery. The water acts as a lubricant and the snow slides when the point is reached where the inertia is overcome by the pull of gravity. There need be no jar to cause the movement, although a sudden jolt would cause premature action by disturbing the adhesiveness of the snow to the roof. It is very likely the same action takes place on a larger scale with avalanches. They begin to slide when the mass increases in weight to the point of becoming unstable and the action is premature when a jar occurs such as takes place when overhanging snow drifts come tumbling down from some steep crag or eminence and strike a field of snow approaching unstable equilibrium. The concussion starts the avalanche and it comes down as a slide, except the small portion from the overhanging drift which comes tumbling and rolling down for a shorter or greater distance according to the steepness of the slope.

FIG. 2.—Burke, Idaho, avalanche showing tail end of slide and the wreckage deposited there. This slide, although comparatively small, killed 5 people. No. 2 (Idaho), Table No. 1. Photographed by R. W. French, Spokane, Wash. Furnished by Local Forecaster Charles Stewart, Spokane, Wash.

Among the many very intelligent reports received from persons living where avalanches are of frequent occurrence and who are thoroughly familiar with their behavior is one from Mr. H. B. Smith, Postmaster at Merritt, Wash., who says:

> During my 15 years of residence in the mountains I have become very familiar with slides and I am in a position to speak on the subject better than a casual observer. There is only one cause for snow slides. In the first place there are no slides known to occur with the first fall of snow in the beginning of winter, no matter how much may fall, except in very steep places or from cliffs, and those slides are harmless to trees and small timber. It is only after the snow gets packed hard and is crusted that we get the big slides that are so dangerous to everything in their tracks.
>
> These big slides are caused by an unusually heavy snowfall on the top of a packed or crusted layer which forms a hard and slick surface for the new snow to slide on, or in other words, the old snow under the new acts like a tin roof on a house, and these conditions caused the heavy snow slides we had this winter. It snowed nearly 6 feet here at one time and I am advised that near the Cascade Tunnel, and at Wellington, the snowfall was nearly 11 feet. Now this enormous weight of snow resting on a smooth surface, which in some places was at an angle of 50°, was bound to slide.
>
> I have, however, observed that where most of the big slides occurred the large trees were nearly all rotten, having been killed by fires which raged through the mountains here a few years ago, caused more or less by the carelessness of the railroad company, and unless young trees are planted (and such trees should be planted from the very top down to the valleys otherwise they will offer no resistance), we will always have a recurrence of these slides under the same weather conditions, with the exception that it will not take quite so much snow to start them as it did last winter. Take the Wellington slide, for instance, it would not have happened under ordinary conditions; the timber was all dead, killed by fires, on the slope where the slide started. I can show you places where the slopes are much longer and steeper than at Wellington and where the snow slipped in places but was checked by live trees standing all along the slope.

Mr. A. E. Riter, living at Snowshoe, Mont., is another close observer, who writes very intelligently regarding the conditions causing avalanches in the Cabinet Range of Mountains. He remarks as follows:

> This place is situated within a mile and a half of the main backbone of the Cabinet Mountains, which near here are very steep. Slides occur here every winter, but they have usually confined themselves to certain places such as small draws and gullies, but during the period under discussion they came not only heavier and larger in those places, but in many other places as well. In fact it was practically all a solid slide for two and one-half miles on both sides of this gulch, although this did not all come at once. In many places it slid several times. Slides as extensive as these have never before been known either at this particular place or in the entire Cabinet Range. Buildings that stood for 12 or 15 years or more, never having been touched by slides before, were destroyed.
>
> A snowfall of a little over 8 inches occurred on February 20 and 21, with quite low temperatures. Again when it started snowing on the 22d, it was with a very low temperature. The heavier snow that came with the rising

temperature of the 23d and 24th became too much for the layer of lighter snow underneath to support, this latter acted almost like a roller bearing in starting the movement. This is my idea of the starting of the slides in my particular place. Once a slide has occurred, it was easy with the continued falling of heavy snow, for a repetition to occur in the smooth path formed. They occurred in places where they never did before, and at some of these places not until the latter part of the period mentioned, thus showing how unusual the conditions were. The ever increasing weight simply became too much for the steep mountain sides to hold. At many points slides occurred several times, and the later ones naturally traveled farther and had more force than the first one.

The country about here is generally wooded; that is, it originally was entirely and probably heavily so, but now there are some bare spots where the timber has been destroyed in various ways, mostly by fires, and there are many places where the land is only covered with burned and dead timber. Our slides occurred only at the heads of gulches, close to the main backbone of the range where the mountains are very precipitous and rocky, and a majority of them start where the snow lays on bare rocks. After they are once started they will travel over any kind of ground. During the time these slides were coming down I did not observe that it made any difference as to the direction in which the slope faced; there may be a difference on opposite sides of a range of mountains, but there is none on opposite sides of a gulch.

FIG. 3.—Avalanche near Snowshoe, Mont., February, 1910. This view shows the snow that was pushed out sideways at the foot of a slide by a rolling motion of portions of the mass. Photograph furnished by Mr. A. E. Riter, Mountain Snowfall Observer, Showshoe, Mont.

FIG. 4.—Avalanche near Snowshoe, Mont., February, 1910. View shows how the mass of snow on the right has broken away and slid farther than the main body of the slide This division formed a gulley where the man is standing about 40 feet wide and 15 or 20 feet deep. The movement of the slide was from left to right in the picture and the background is practically all an avalanche. Photograph furnished by Mr. A. E. Riter, Mountain Snowfall Observer, Snowshoe, Mont.

FIG. 5.—Ruins of the American Kootenai Mining Company's stamp mill wrecked by an avalanche on February 27, 1910. On the extreme left can be seen stamps still standing, which is all that is left of the mill. Picture was taken a month after the avalanche occurred and for this reason only is débris visible. Photograph furnished by Mr. A. E. Riter, Mountain Snowfall Observer, Snowshoe, Mont.

The first slides occurred during the forenoon of February 24 and they continued at intervals, doing a limited amount of damage, until the morning of the 25th. There was then a let up until the night of the 26th when they started again and continued until the morning of February 28. It was during the night of the 27th that they were the worst, coming the heaviest and in the greatest number. One building was struck 3 times by slides from the same place before it was completely demolished.

It is not possible to give much of a description of the wind rush attending slides, as a person close enough would perhaps not be able to stand up against it. We had windows broken in buildings that were 100 or 150 feet from a slide; that is, the building was in a line with the slide but beyond it. The panes of glass were not large, being about 12 inches by 14 inches in size. Alongside of and close to slides trees were broken off 15 and 20 feet above the surface of the slide, and there were limbs on the trees below the breaks showing the breaks must have been caused by the wind and not by the slide itself. Green trees more than a foot through at the point of breakage have been observed by myself, and there may be others larger. Limbs and twigs were carried considerable distances to the side and beyond the slides.

The noise I can only describe as a heavy roar, very much like the noise produced by a high wind, but having a heavier sound; that is, one can tell that it is something more substantial than wind that is making the noise. Where the slide travels through any timber with enough force to break it, it is attended by the crackling noise of trees and limbs breaking.

I think the slides start at the top with a rolling motion, although of this I have no proof, but after they once start the motion is principally sliding, although there will be parts that have a rolling motion. This rolling motion, however, is decidedly of a secondary nature. As they get toward the bottom where the ground is flatter, gullies will be cut in the surface of the slides by certain masses of snow that appear to have more force and motion than other parts. I have seen these gullies as much as 20 feet deep.

I have learned by digging into slides that trees, logs, limbs, and twigs are scattered through their entire mass; in some places so thickly that it is very difficult to work with a shovel. With the warm weather that has prevailed since the slides, resulting in the snow either settling or thawing to the extent of 2 or 3 feet, twigs and limbs have shown up in many slides to such an extent as to cover the surface entirely; this in places where there is probably anywhere from 10 to 25 or more feet of snow left on the ground.

At one point on the northeast slope of this range a 10-stamp mill was destroyed. Nearby a couple of boarding and bunk houses were destroyed. These buildings were about 20 or 25 miles south of Snowshoe in what is known as the West Fisher Mining District at the headwaters of the Fisher River. I have estimated this damage at $25,000. At Snowshoe a total of 14 buildings, mostly small, were demolished. These consisted of a boarding house, bunk houses, warehouse, and several small residences; the total damage to which I have estimated at $7,500, and this is conservative. Outside of these losses it is probable that a large number of log cabins throughout the mountains belonging to prospectors, trappers, and others have been destroyed, but no estimate of the number can be made. No persons were killed or injured, owing to the fact of there being so very few people in the mountains, especially at this season of the year.

When an avalanche comes down a wooded slope and sweeps clean all the big trees in its path, as was the case with a number of those this year, it is self-evident that no slide of a similar character had come down the same canyon before in many years, or there would have been no trees there to have been swept away. The question of planting trees to prevent the slides from starting, however, is another matter, but after they have once started, neither trees nor large boulders can stop them. The place to plant the trees is at the heads of the canyons, but here the soil is generally too thin to enable the trees to make any growth. In Switzerland where avalanches are also of common occurrence, efforts have been made to ameliorate the conditions by building stout embankments in places where they frequently start, or stout posts are placed as thickly as may be necessary in these localities. In some places high walls have been built with jutting angles so as to divert the snow torrent away from the inhabited sections below. Also in Europe the plan has been tried of leaving unmown grass in the canyons in the hopes that the blades when frozen would serve as pegs to prevent the mass from sliding, but the writer does not imagine this plan to be very feasible, especially under the conditions that prevailed last winter when the first falls of snow would have covered the pegs of grass and the top of this snow was crusted or frozen so as to make a slippery surface for the succeeding falls of snow to slide on.

Mr. John Maloney, in his report on slide No. 2, in Washington, stated that the Great Northern Railway track, except where protected by snowsheds, was buried in snow for a distance of 4 miles west of Wellington. It is very likely a form of snowshed could be devised which would protect the track of a railroad from ordinary slides, but it is hardly possible to provide for so many avalanches as were noted this year, especially when such a large proportion of them came down in places where slides were never before known to have occurred.

One of the clearest descriptions received regarding the course taken by a slide was from Mr. W. G. Weigle, Forest Supervisor, Coeur d'Alene National Forest, with headquarters at Wallace, Idaho. In referring to the Mace avalanche (Idaho, No. 1), he states:

This slide came into the canyon with such force that it passed clear across the canyon, destroying all the houses not only within its path, but several that were more than 100 feet away from the slide were demolished, evidently by the concussion. The large windows in a schoolhouse more than 300 feet distant from the slide were broken. One house that was not touched by the slide was turned entirely around and another house was crushed in, both by the concussion. The canyon where the slide entered is about 300 feet wide, and this was filled with densely packed snow to depths of 20 to 40 feet entirely across and up and down the canyon for a distance of about 800 feet. Small trees on the opposite hill from which the slide came, but directly in front of the slide, were all bent to the ground, evidently by the strong force of the wind preceding the slide. It descended from the summit of a mountain about a mile from the bottom of the canyon. At first it passed through a stand of timber, but the weight of the snow was not sufficient to break off any of the large trees. After it had descended the hill a few hundred yards it struck another timbered area, the trees of which ranged between 1 and 2 feet in diameter; it broke them all off close to the ground. The same condition existed throughout its path to the bottom of the canyon, most of the distance, however, being an open area or covered with brush. The slide did not pick up all the snow on the bottom, but in its lower course seemed to slide over a large part of the snow that was originally on the ground. At least 30 large slides occurred within a radius of 10 miles from Wallace, Idaho.

FIG. 6.—Débris from a snowslide on the opposite side of the gulch from where it came down. The lower one of the two stumps is about 2½ feet in diameter.

Mr. Weigle has furnished a photograph which shows the effects of the wind in bending the trees to the ground on the opposite side of the hill.

Mr. George D. Eddy, engineer in charge, Great Northern Railway, has been a close observer of the conditions connected with avalanches, and in his report regarding those which occurred between Fielding and Java, a distance of 8 miles, he furnishes excellent temperature and weather data for the period before and after the slides occurred. He says:

In addition to the information I have endeavored to give you in the reports (Nos. 4, 5, and 6, Montana, Table 1), and that you may be posted as to the conditions prevailing prior to the occurrence of these slides, perhaps you would care to know that along in the middle of January we had a snow

slide about one-quarter of a mile east of Highgate, which came down in a draw where no previous slides had been known to occur. This slide was some 400 feet long and 50 feet deep and originated more than half way to the top of the mountain.

The snow during this period of mild weather thawed sufficiently to become thoroughly saturated with water, then froze hard, thus giving a poor support for the snow, falling later, to cling to.

FIG. 7.—Débris on the opposite side of the gulch. Log is 4 feet through.

In the latter part of January we had rather heavy snowfalls followed by a short period of fair weather in the first part of February, with several snowfalls a few days later. On the 13th and 14th of February we had a hard snowstorm. The 15th and 16th were clear days, with temperatures of about zero at noon. On the 17th, 18th, and 19th the noon temperatures varied slightly from 10° above with no precipitation. On the 20th there was a noon temperature of −10° and cloudy weather, which was followed by a fall to −28° on the 21st, with a frosty snow in the air. This day the temperature was −16° and fair at noon. At 7 a. m. on the 22d the thermometer registered −40°, rising to −10° at noon; the day was fair. On February 23 at 7 a. m., I find it was snowing hard with a temperature of −7°, rising to 4° at noon with continued hard snowfall. This was the day of the first slide in this succession of slides. On the 24th the temperature had risen to 27° at 6:30 a. m., with snow, and it rose to 32° with rain in the afternoon.

The remainder of the month of February and the first day of March were characterized by heavy snowfalls with the temperature from 4° to 6° below the freezing point, which was followed by rain, with slightly higher temperatures on the second day of March.

The snow practically slid off the whole side hills. There were 12 different slides between Fielding and Java, 8 miles at one time. I have questioned those who witnessed the slides and all seem to agree that there was a violent wind accompanying the slides, immediately preceding and immediately following them. No noise of great volume accompanied the slides, excepting those containing timber which were accompanied almost solely by noises of the timber breaking. I am unable to learn of any slides that were rolling masses. They all were, according to witnesses, distinctly slides of snow.

No very satisfactory results are obtained in summarizing the data in Table 1. It is found that the slope faced the south in the case of 10 slides, and 9 occurred on a slope facing the west, 7 on the north, and 5 on the southeast, therefore the slope down which the slides come is nearly as apt to face in one direction as in another, and it is not the sun's rays that influence them, for if such were the case we would find the greatest number on the south slopes and the fewest on the north slopes. Also the time of day does not accord with the period of strongest insolation as there were nearly as many between 2:00 a. m. and 4:00 a. m. as there were between 2:00 p. m. and 4:00 p. m. The hours when they were fewest were between 6:00 a. m. and 11:00 a. m. and between 7:00 p. m. and 8:00 p. m. They were most frequent on February 27 in all localities, and on this day the temperatures were mild and rain was falling during the afternoon at high elevations and had been preceded by a heavy fall of snow; the winds in most places were blustery.

FIG. 8.—Débris on the opposite side of the gulch. The log on the immediate left of the man is a green spruce about 18 inches in diameter.

The property loss in the table amounts to $314,625, to which should be added the loss of $32,500 reported by Mr. Riter in the Snowshoe, Mont., district, which makes a total of $347,125, and there was probably an equal amount of damage done to the county roads. If we include the losses due to stoppage in traffic as well as the cost of repairs the total will be nearly three-quarters of a million dollars, besides the loss of over 100 lives, by the memorable avalanches in 1910.