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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

FOREST CONDITIONS

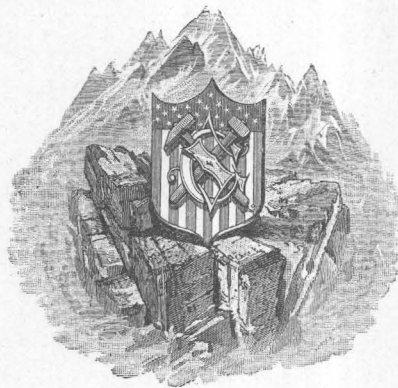
IN THE

CASCADE RANGE, WASHINGTON

BETWEEN THE WASHINGTON AND MOUNT RAINIER
FOREST RESERVES

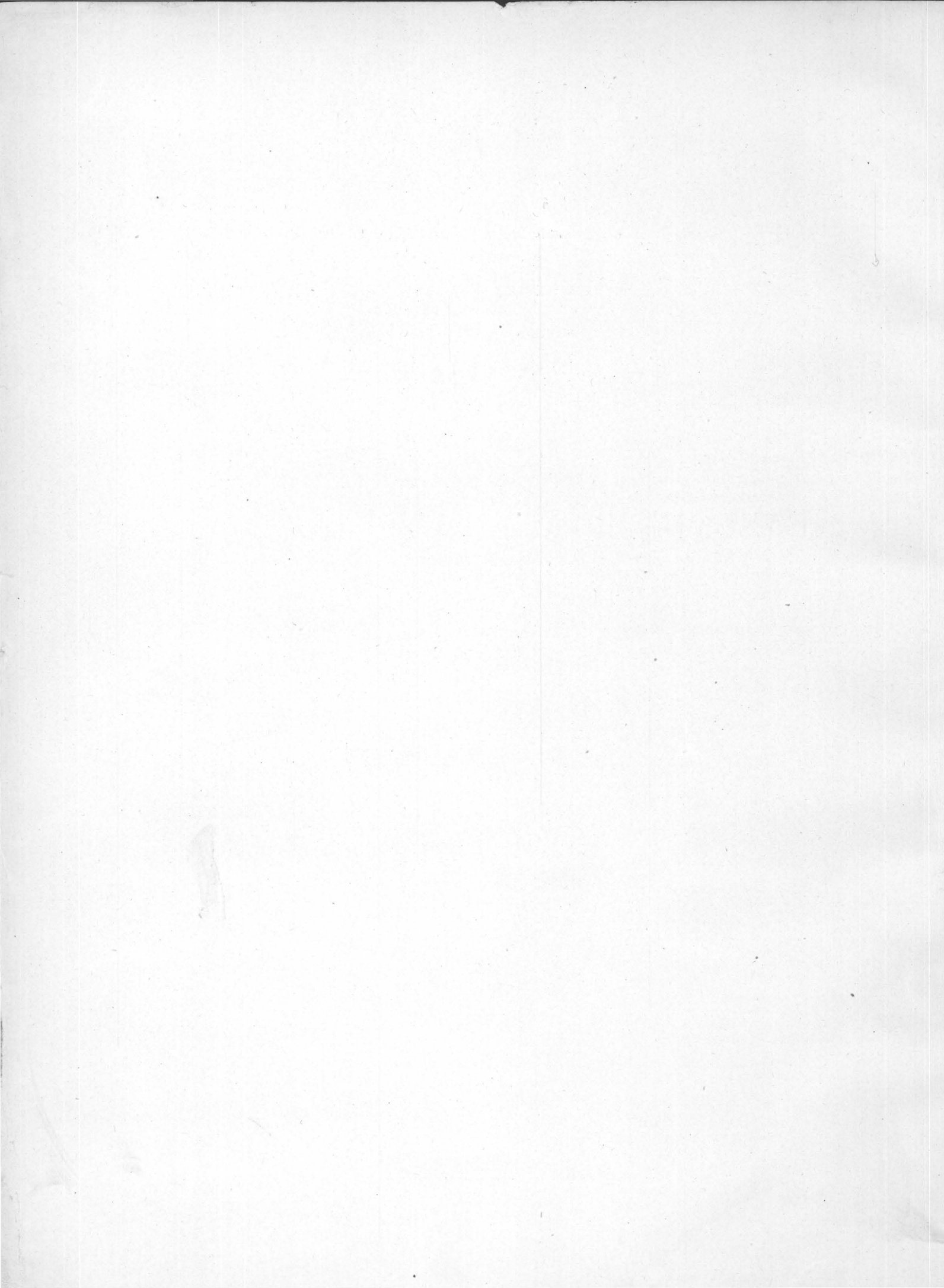
BY

FRED G. PLUMMER



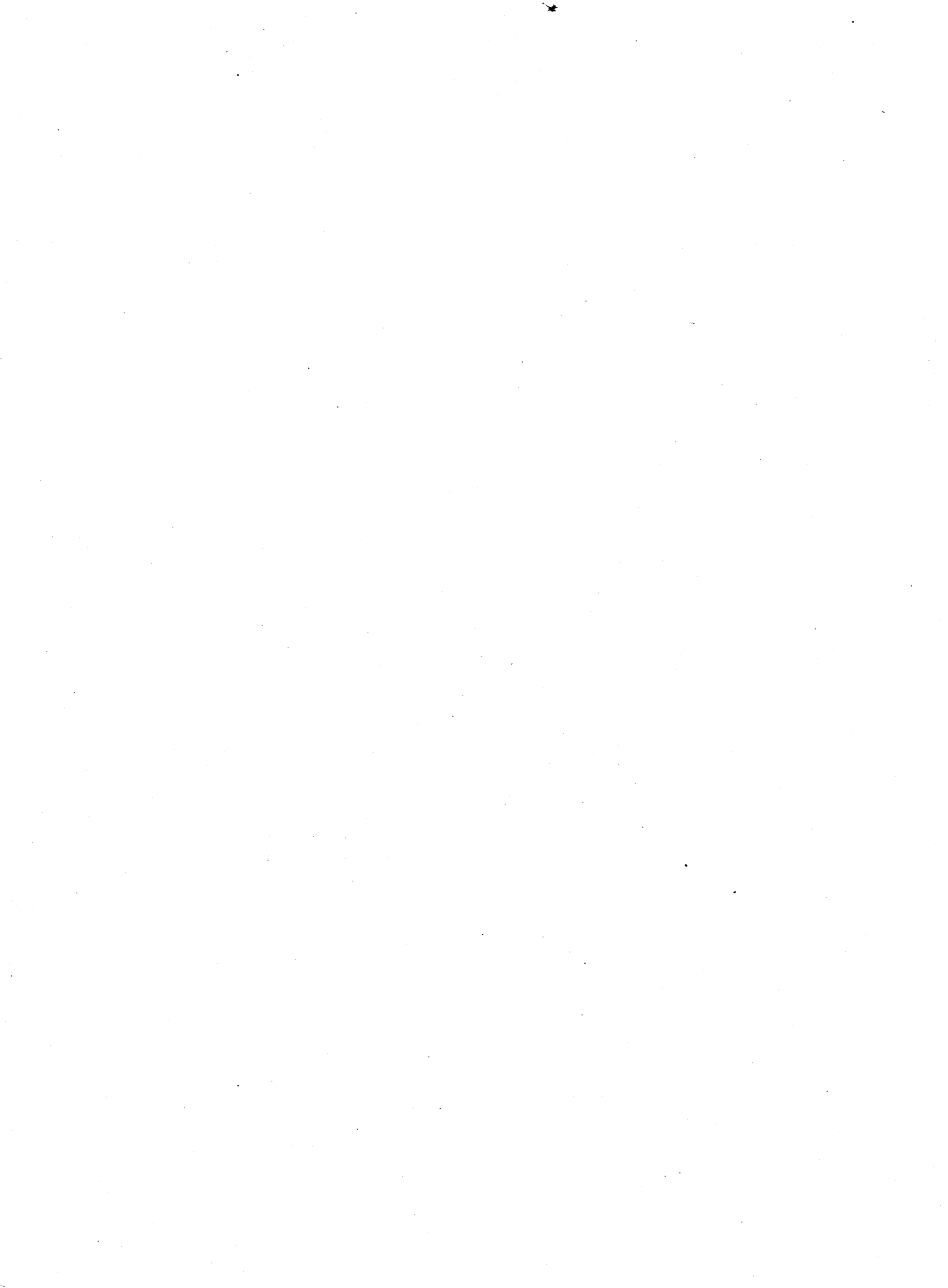
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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., June 17, 1902.

SIR: I transmit herewith, for publication in the series of Professional Papers, a report on forest conditions in that part of the Cascade Range lying between the Mount Rainier and Washington forest reserves, prepared by Mr. Fred G. Plummer.

Very respectfully, yours,

HENRY GANNETT,
Geographer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

FOREST CONDITIONS IN CASCADE RANGE BETWEEN THE WASHINGTON AND MOUNT RAINIER FOREST RESERVES.

By FRED G. PLUMMER.

GENERAL DESCRIPTION.

This report covers that portion of the Cascade Mountains in the State of Washington lying between the Mount Rainier Forest Reserve and the Washington Forest Reserve. It may be more particularly described by Government subdivision surveys as comprising townships 19 to 28 north, and from range 9 east eastward to the Columbia River.

The land-classification map submitted herewith, Pl. I, covers 2,800,000 acres, of which 261,350 acres are naturally timberless areas, such as arid lands, lakes, and glaciers. The remainder, or 2,538,650 acres, is a naturally timbered country, but has lost 204,140 acres, or 8.04 per cent, by fires, and 41,640 acres, or 1.64 per cent, by logging, thus leaving 2,292,870 acres which can at this time be called timber lands. Although these burned and logged areas have to be deducted in estimating the timber, they are nevertheless included in the maps showing the distribution of the various species, for the reason that they lie within the timber zones, and either are or will be restocked with those species that now form the bordering forests.

Of the total area, 179,400 acres, or 6.4 per cent, are estimated as arable; and of this, 13,614 acres, or 7.6 per cent, are under cultivation. The detailed treatment of these areas will be found under the several watersheds and also under the heading "Irrigation."

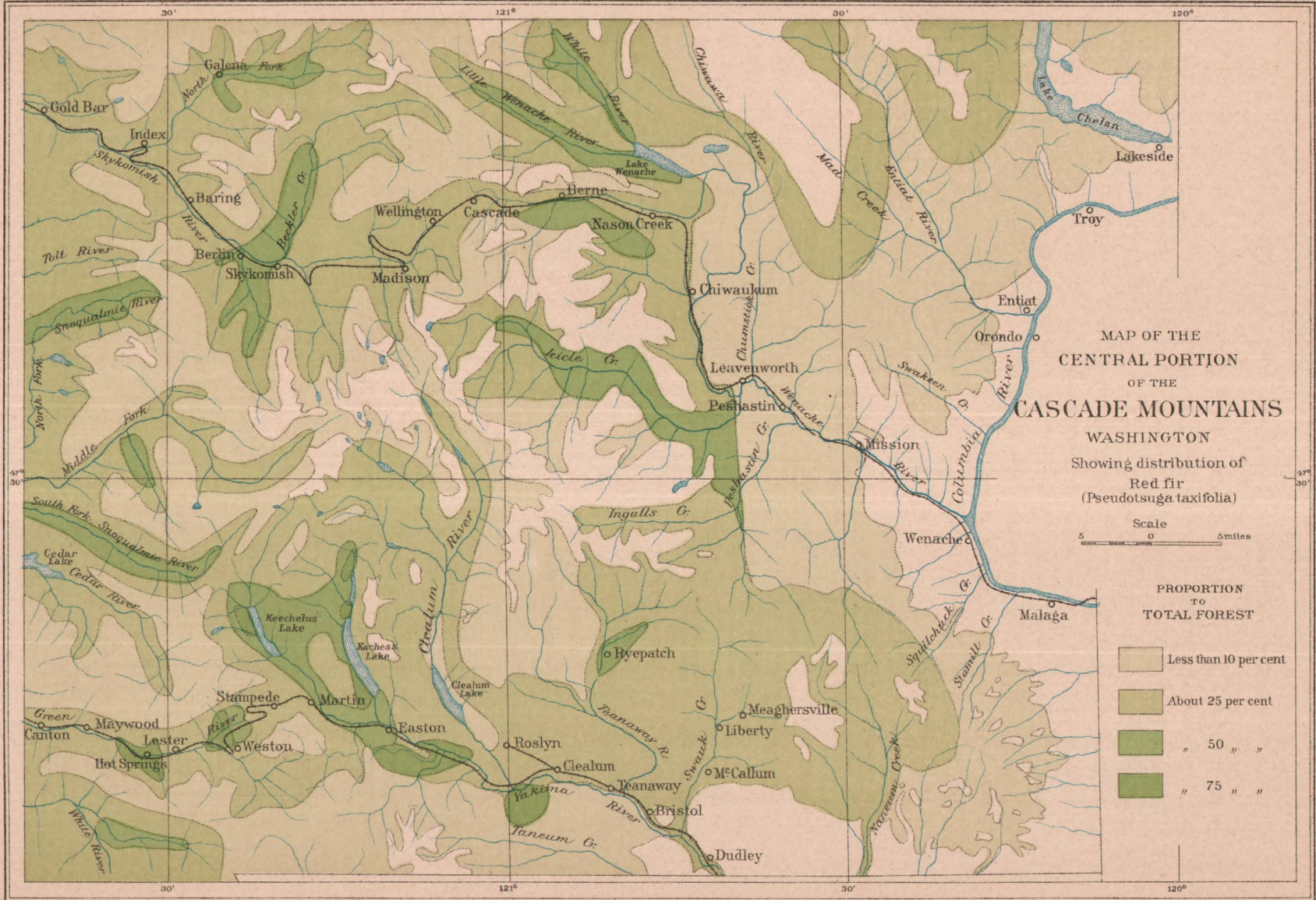
The estimate of the timber now standing upon the 2,292,870 acres of timbered land is 12,001,510 M feet B. M., which gives an average per acre of 5,234 feet B. M. This estimate at first sight appears low, but it results from the fact that 1,520,700 acres, or 66 per cent, of the timbered area are upon the eastern slope of the mountains, which supports a much more open and lighter forest than does the

western slope. The average stand of timber for the western slope is 9,506 feet B. M. per acre, while that for the eastern slope is but 3,064 feet B. M. per acre.

The summit of the Cascade Mountains, as delineated upon the map, is that irregular line which marks the division of the surface drainage westward into Puget Sound and eastward into the Columbia River. This geographical summit is not colinear with the geological summit, nor with the "botanical summit," by which is meant that line which would divide the characteristic western from the eastern growth. Upon the large-scale map this line would be a band or strip varying in width from 4 to 8 miles, and in this strip the timber features of both slopes would overlap, and this overlap strip would extend along the eastern slope, paralleling the geographical summit. In other words, the timber of the western slopes has flowed eastward over the geographical summit—freely through the low passes and with difficulty through the higher saddles or over the ridges and peaks.

The climatology of this region must of necessity be written in a very general manner, as the data are of a fragmentary character and not always trustworthy. The first general truth is that the western slope is a region of excessive humidity, which, with the timber, overlaps slightly onto the eastern slope. The remainder of the eastern slope shows a decrease of precipitation eastward, reaching its minimum in the arid regions of eastern Washington, approximately in R. 30 E. Extremes of temperature prevail east of the mountains, while the western slope has a more equable climate. As a result, the greatest depths of snow are found in the overlap, where the precipitation is great and the winter temperatures are low. The precipitation is heaviest in the Snoqualmie and Cedar River watersheds, and in these it is probably greatest in the Middle Fork Basin, in T. 23 N., R. 11 E. The testimony on this matter from the few who knew the region would warrant the belief that the rainfall exceeds that of any other point in Washington, Clearwater perhaps excepted. Observations at North Bend, in T. 23 N., R. 8 E., show 90 inches annually, and all agree that it rains very much more at Middle Fork. Without vouching for the correctness of this, it is fair to say that my experiences during the last week of the ordinarily dry month of August were exasperatingly confirmatory. In one day, while walking 10 miles along the valley, I crossed more than seventy running streams, of which seven were about 15 feet wide. These streams drained the northern side of that prominent spur of the Cascade Mountains which ends in Preacher Mountain, and none of them could have been over 3 miles in length.

Snoqualmie and Cedar River watersheds, mentioned above, together with the Yakima watershed, on the eastern slope, are deserving of special mention in this report for the reason that the entire minimum flow from their catchment basins will be utilized in the near future for purposes of vital importance. Snoqualmie River now furnishes light and power for the cities of Tacoma and Seattle; Cedar River



supplies the water to Seattle, and the Yakima irrigates the most important farm lands of the State. Fortunately, large lakes which can be made into impounding reservoirs are well situated in all these watersheds, and their utilization is already receiving serious consideration.

The Northern Pacific and Great Northern railways cross the Cascade Mountains in the area under consideration in this report. For the protection of their roads from forest fires and from falling trees, the rights of way have been cut from 50 to 400 feet in width, according to the condition and size of the timber and the topography. The desire is to remove every tree or snag which threatens the roadbed, sparing nothing which in falling would reach the tracks.

The Cascade Range has been no barrier to the shipment of lumber since the building of these railroads. Large quantities of the fir, spruce, and cedar of the western slopes are shipped for use in eastern Washington, as the better quality of the timber fully compensates for the additional hauling. The yellow pine and tamarack, found only on the eastern slopes, are inferior to the western woods and are never shipped westward except as crates or boxes for fruits or melons.

TREES AND SHRUBS.

List of trees and shrubs found in central Washington.

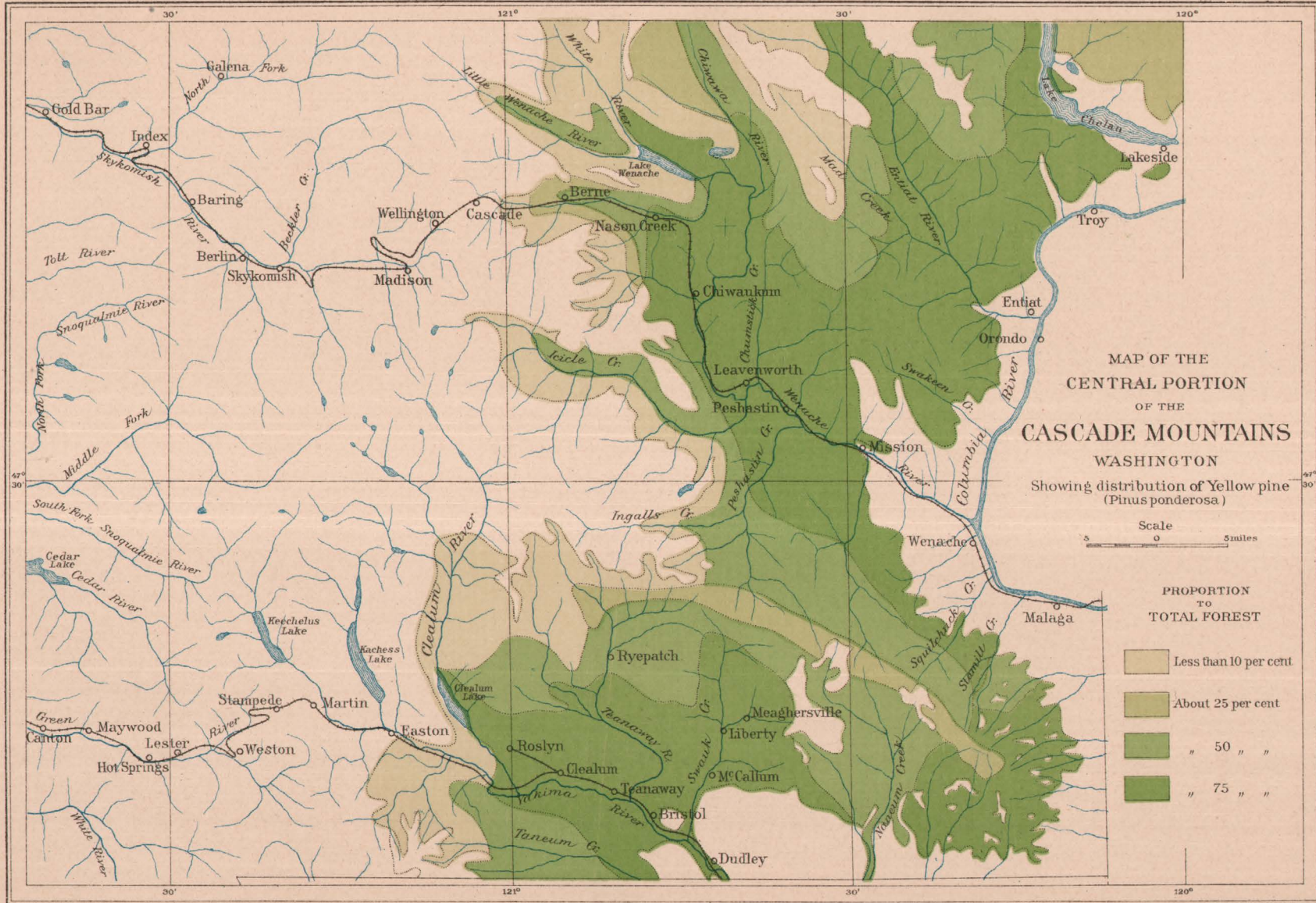
CONIFERS.

White pine	<i>Pinus monticola.</i>
Yellow pine	<i>Pinus ponderosa.</i>
Lodgepole pine	<i>Pinus murrayana.</i>
White-bark pine	<i>Pinus albicaulis.</i>
Noble fir	<i>Abies nobilis.</i>
Lovely fir	<i>Abies amabilis.</i>
White fir	<i>Abies grandis.</i>
Subalpine fir	<i>Abies lasiocarpa.</i>
Mertens hemlock	<i>Tsuga mertensiana.</i>
Patton hemlock	<i>Tsuga pattoniana.</i>
Engelmann spruce	<i>Picea engelmanni.</i>
Red fir	<i>Pseudotsuga taxifolia.</i>
Red cedar	<i>Thuja plicata.</i>
Alaska cedar	<i>Chamæcyparis nootkatensis.</i>
Tamarack	<i>Larix occidentalis.</i>
Alpine larch	<i>Larix lyallii.</i>
Yew	<i>Taxus brevifolia.</i>
Creeping juniper	<i>Juniperus nana.</i>

DECIDUOUS TREES AND SHRUBS.

Cottonwood	<i>Populus trichocarpa.</i>
Quaking aspen	<i>Populus tremuloides.</i>
Maple	<i>Acer macrophyllum.</i>

Vine maple.....	<i>Acer circinatum.</i>
Dwarf maple.....	<i>Acer glabrum.</i>
Mountain alder.....	<i>Alnus viridus.</i>
Red alder.....	<i>Alnus oregona.</i>
Mountain ash.....	<i>Sorbus occidentalis.</i>
Longleaf willow.....	<i>Salix fluviatilis.</i>
Lyall willow.....	<i>Salix lasiandra lyalli.</i>
	<i>Salix glabra.</i>
Silver willow.....	<i>Salix sitchensis.</i>
Redberry elder.....	<i>Sambucus callicarpa.</i>
Blueberry elder.....	<i>Sambucus glauca.</i>
Sweet myrtle.....	<i>Ceanothus velutinus.</i>
Thorn apple.....	<i>Cratægus macracantha.</i>
Dogwood.....	<i>Cornus nuttallii.</i>
Highbush cranberry.....	<i>Viburnum pauciflorum.</i>
Bearberry.....	<i>Rhamnus purshiana.</i>
Syringa.....	<i>Philadelphus lewisii.</i>
Arrow wood.....	<i>Spirea discolor.</i>
Buckbrush.....	<i>Spirea rosea.</i>
Buckbrush.....	<i>Spirea corymbosa.</i>
Sumach.....	<i>Rhus glabra.</i>
Birch.....	<i>Betula sp.</i>
Chokecherry.....	<i>Prunus demissa.</i>
Wild cherry.....	<i>Prunus emarginata.</i>
Greasewood.....	<i>Purshia tridentata.</i>
	<i>Menziesia ferruginea.</i>
Sagebrush.....	<i>Artemisia tridentata.</i>
Hazel.....	<i>Corylus rostrata.</i>
Snowberry.....	<i>Symphoricarpos racemosus.</i>
Oregon grape.....	<i>Berberis aquafolium.</i>
Oregon grape.....	<i>Berberis repens.</i>
Devil's club.....	<i>Echinopanax horridum.</i>
Manzanita.....	<i>Arctostaphylos uva-ursi.</i>
Kinnikinick.....	<i>Arctostaphylos nevadensis.</i>
	<i>Lonicera involucrata.</i>
Red currant.....	<i>Ribes sanguineum.</i>
Mountain salal.....	<i>Gaultheria ovatifolia.</i>
Red huckleberry.....	<i>Vaccinium myrtillus microcephillum.</i>
Black huckleberry.....	<i>Vaccinium ovatum.</i>
Thimbleberry.....	<i>Rubus nutkanus.</i>
Salmonberry.....	<i>Rubus spectabilis.</i>
Blackberry.....	<i>Rubus ursinus.</i>
Raspberry.....	<i>Rubus leucodermis.</i>
Prickly gooseberry.....	<i>Ribes lacustre mollis.</i>
Blackberried gooseberry.....	<i>Ribes divaricatum.</i>



MAP OF THE
CENTRAL PORTION
OF THE
CASCADE MOUNTAINS
WASHINGTON
Showing distribution of Yellow pine
(Pinus ponderosa)

Scale
0 5 miles

PROPORTION
TO
TOTAL FOREST

[Lightest tan box]	Less than 10 per cent
[Light green box]	About 25 per cent
[Medium green box]	" 50 " "
[Darkest green box]	" 75 " "

DISTRIBUTION OF SPECIES BY ZONES.

The various species of cone-bearers found in the State of Washington have generally been considered in four zones, although it is difficult, indeed, to establish a line of division at any altitude, owing to the fact that the species vary greatly in altitudinal range on opposite slopes of the mountains, and also according to conditions of exposure and moisture. The assignment of the various species to these zones was in conformity with the conditions found in the basins of streams tributary to Columbia River where it cuts the Cascade Range, in latitude $45^{\circ} 30'$. The four zones referred to are as follows:

Forest zones in Washington at latitude $45^{\circ} 30'$.

Yellow-pine zone	Below 3,000 feet
Lodgepole-pine zone	3,000 to 5,000 feet
Subalpine-fir zone	5,000 to 6,000 feet
Whitebark-pine zone	6,000 to 7,400 feet or to timber line

The species are assigned to the zones as follows:

Species comprising forest zones in central Washington at latitude $45^{\circ} 30'$.

YELLOW-PINE ZONE.

Yellow pine	<i>Pinus ponderosa.</i>
Red and yellow fir	<i>Pseudotsuga taxifolia.</i>
White fir	<i>Abies grandis.</i>
Red cedar	<i>Thuja plicata.</i>

LODGEPOLE-PINE ZONE.

Lodgepole pine	<i>Pinus murrayana.</i>
White pine	<i>Pinus monticola.</i>
Engelmann spruce	<i>Picea engelmanni.</i>
Yew	<i>Taxus brevifolia.</i>

SUBALPINE-FIR ZONE.

Subalpine fir	<i>Abies lasiocarpa.</i>
Lovely fir	<i>Abies amabilis.</i>
Noble fir	<i>Abies nobilis.</i>
Mertens hemlock	<i>Tsuga mertensiana.</i>
Alaska cedar	<i>Chamæcyparis nootkatensis.</i>
Tamarack	<i>Larix occidentalis.</i>

WHITE-BARK-PINE ZONE.

White-bark pine	<i>Pinus albicaulis.</i>
Patton hemlock	<i>Tsuga pattoniana.</i>
Alpine larch	<i>Larix lyallii.</i>
Creeping juniper	<i>Juniperus nana.</i>

As might be expected, the assignment thus made will not apply to the area under consideration. The difference in latitude is not great, amounting to only 150 miles, but the climatic conditions are quite different, and compel a new assignment of the species to these zones. It does not appear necessary to change the names of the zones, as the conditions are such as to warrant their use to the northern boundary of the United States, at latitude 49°.

The accompanying diagram, Pl. VII (p. 20), shows the range and development of the trees having any value as timber, including some of the deciduæ; and on comparison with a similar diagram^a prepared by me for the Mount Rainier Forest Reserve, it shows a general lowering in altitude. The diagram made for the Mount Rainier Forest Reserve, with its average latitude of about 46° 30', shows an intermediary condition between the assignment just given for latitude 45° 30' and that which will now be given for latitude 47° 30'.

Species comprising forest zones in central Washington at latitude 47° 30'.

YELLOW-PINE ZONE.

Yellow pine.....	Pinus ponderosa.
Red fir	Pseudotsuga taxifolia.
White fir	Abies grandis.
Red cedar.....	Thuja plicata.
Mertens hemlock.....	Tsuga mertensiana.

LODGEPOLE-PINE ZONE.

Lodgepole pine.....	Pinus murrayana.
White pine	Pinus monticola.
Engelmann spruce.....	Picea engelmanni.
Noble fir.....	Abies nobilis.
Lovely fir.....	Abies amabilis.
Tamarack.....	Larix occidentalis.
Alaska cedar	Chamæcyparis nootkatensis.
Yew.....	Taxus brevifolia.

SUBALPINE-FIR ZONE.

Subalpine fir	Abies lasiocarpa.
Patton hemlock	Tsuga pattoniana.

WHITE-BARK-PINE ZONE.

White-bark pine.....	Pinus albicaulis.
Alpine larch.....	Larix lyallii.
Creeping juniper	Juniperus nana.

The range and development of the Alpine larch and creeping juniper are not shown on the diagram, as they did not deserve the extended observations necessary for their determination.

^a Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. V, Pl. XLI, p. 102.



MAP OF THE
CENTRAL PORTION
OF THE
CASCADE MOUNTAINS

WASHINGTON
Showing distribution of
Mertens hemlock
(*Tsuga mertensiana*)

Scale
5 0 5 miles

PROPORTION
TO
TOTAL FOREST

- Less than 10 per cent
- About 25 per cent
- " 50 " "

EXAMINATION OF A TYPICAL ACRE.

For the purpose of making a detailed record of the amount of vegetable growth supported by the average soil of the Cascade Mountains, an acre was measured near Martin, a station on the Northern Pacific Railway, in an area which had just been estimated as bearing 2,000 to 5,000 feet B. M. per acre. Every tree and sapling, living or dead, was measured and counted. The result was 6,930.8 feet B. M., or 1,930.8 feet more than the maximum of our estimate; but this does not mean that the estimate was erroneous. The fact is that a Michigan mill would cut about 4,000 feet from this acre, and a large western Washington mill would not touch it at all, for their cruisers would note so many piles, ties, telephone poles, or cords of wood, all roughly estimated, and pass on, looking for logs that would square at least 14 inches at the small end. Therefore the following lists of coniferous trees, deciduous trees, and shrubs and flowering plants will be found most interesting and valuable as correctly showing the yield of 1 acre of wildwood.

Number and estimates of the trees found on 1 acre, near Martin.—Elevation 2,700 feet.

Species.	Living.			Dead.			Down.		Total number feet B. M. loggers' scale (Doyle).				
	Over 12 inches diameter.	4 inches to 12 inches diameter.	0 inch to 4 inches diameter.	Real contents, feet B. M.	Over 12 inches diameter.	4 inches to 12 inches diameter.	0 inch to 4 inches diameter.	Real contents, feet B. M.	Fallen.	Cut.	Living.	Dead.	Total.
Red fir (<i>Pseudotsuga taxifolia</i>)	25	7	18	7,231	37	30	...	1,472	2	8	2,892.4	588.8	3,481.2
Mertens hemlock (<i>Tsuga mertensiana</i>)	27	53	60	6,065	9	...	...	1,498	1	...	2,426.0	599.2	3,025.2
White pine (<i>Pinus monticola</i>)	3	7	216	351	...	...	...	...	1	...	140.4	...	140.4
Lodgepole pine (<i>Pinus murayana</i>) .....	...	...	10	...	...	...	...	...	...	...	...	...	...
Lovely fir (<i>Abies amabilis</i>)	1	10	50	384	...	...	...	...	...	...	145.6	...	145.6
Noble fir (<i>Abies nobilis</i>)	1	1	...	346	...	...	...	...	...	...	138.4	...	138.4
White fir (<i>Abies grandis</i>) .....	...	...	...	...	...	...	...	...	1	...	...	...	...
Red cedar (<i>Thuja plicata</i>) .....	...	6	45	...	...	...	...	...	2	...	...	...	...
Total	57	84	399	14,377	46	30	...	2,970	4	11	5,742.8	1,188.0	6,930.8

There were also found upon this acre the following deciduous trees and shrubs and flowering plants:

Deciduous trees and shrubs and flowering plants found on sample acre near Martin, Wash.

DECIDUOUS TREES AND SHRUBS.

Populus trichocarpa.	Ribes cereum.
Salix glabra.	Vicinium myrtilloides.
Alnus viridus.	Vicinium parviflorum.
Sorbus occidentalis.	Berberis aquafolium.
Acer circinatum.	Pachystima myrsinites.
Amalanchier alnifolia.	Rosa gymnocarpa.

FLOWERING PLANTS.

Xerophyllum tenax.	Lillium columbianum.
Senecio triangularis.	Linnæ borealis.
Chimaphila umbellata.	Epilobium angustifolium.
Clintonia uniflora.	Pedicularis contorta.

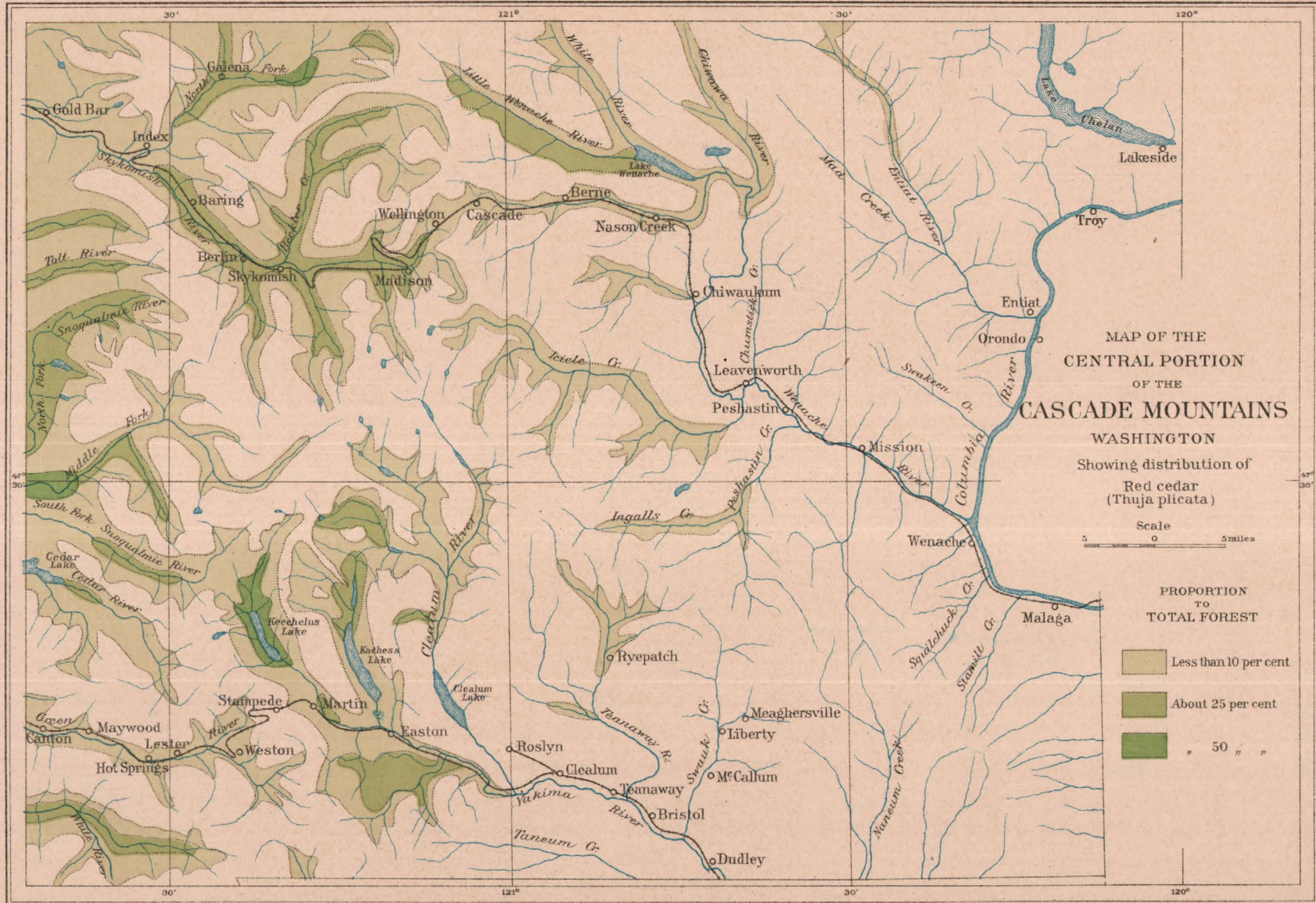
DEFECTS AND DISEASES OF TIMBER TREES.

The forests of this region are, generally speaking, free from serious defects and disease. Those defects which exist are mostly attributable to old age, storms, and fire.

Trees, like every other product of nature, reach an age of maturity. When the life-giving sap no longer ascends to their topmost branches to impart new life and strength, there follows a period, varying in length according to location and exposure, when the tree, like ripened fruit, is at its best. Following this come the elements of disease or decay, and the work of destruction begins either at the center of the base or at the crest, which the sap has failed to reach. Usually it is the former cause, the heart decay beginning before the top has ceased to grow. Year after year the disintegration goes on until the heart wood is entirely destroyed; but the old shell remains standing for many years, protected from the winds by the surrounding trees.

This is the condition that prevails among the red firs (*Pseudotsuga taxifolia*), Mertens hemlock (*Tsuga mertensiana*), white fir (*Abies grandis*), and some other species of the lower zones where no burns have taken place. Numerous old trunks of this kind may be seen which appear like solid shafts, but an examination shows them to be thus defective. An estimate of a tract from which these are eliminated often materially reduces the amount of standing timber from what it appears to be at first glance.

In the canyons and on sheltered slopes the conditions as stated above are common, but in the alpine or subalpine zones the fierce storms usually destroy the



trees when the trunks become materially weakened. In these zones the greatest defect is what is commonly called "wind shake." The lovely fir (*Abies amabilis*) and Patton hemlock (*Tsuga pattoniana*) are the most frequently injured, showing wide seams from their bases almost to their tops. The white pine (*Pinus monticola*), being soft and flexible, does not suffer materially from this cause. Heart shake is common among the red fir.

Surface fires creep through the forests of yellow pine (*Pinus ponderosa*), burning the humus and litter, frequently running up the trees and igniting the resin which exudes from the trunk or base of the limbs. This results in cavities at the base and a loss to the logger of several feet of the "butt cut." Many complaints are made by lumbermen in the yellow-pine regions of loose black knots, which lower the grade and consequently the market value of a large percentage of the contents of a tree. The cause of this is not obvious, but it is probably due to the annual growth of the tree covering the cambium bark of the limb. When the limb dies by fire or is cast off by natural growth and the knots are covered over by successive layers of wood and bark, the cambium disintegrates from around the body of the incased limb, with the result that the limb becomes loosened from the main body of the tree. Shrinkage of the dead wood may be also a factor in this result.

Very little disease is apparent. Some mistletoe (*Arceuthobium*) was seen in the yellow-pine zone, on the yellow and lodgepole pines, but not in sufficient quantities to injure the trees. Lichen is mostly confined to dead trees in swampy localities.

On steep hillsides avalanches do much damage to timber by stripping off the bark or snapping off the trunks. Great weight of snow often tears the limbs from the trees, and water finding lodgment in the cavities causes decay.

MARKETS AND PRICES OF LUMBER.

Among the timber cruisers and lumbermen west of the summit of the Cascade Mountains the red fir, the red cedar, the spruce, and sometimes the hemlock are known as timber, and if a section of land is called a "timber section" it is understood that it supports a sufficient stand of one or more of these species to make it worth cutting. But logging is by no means confined to the species mentioned, for when a logging road or tramway is once laid into a section it is the practice to remove everything of merchantable value.

As the most extensive of the heaviest stands of timber are in the lower zone, below an altitude of 3,000 feet, and as these lower areas are the most accessible for logging, the species of trees there represented have become best known commercially, but the time is not far distant when the noble fir, lovely fir, hemlock, Alaska cedar, and others, desirable for one purpose or another, will be favorably received

in the market. Modern logging machinery and methods, as applied by skilled labor, have reduced the "inaccessible" areas to a minimum, and it may be truly said that no forest of desirable trees is beyond the possibility of attack.

Aside from a very small local consumption, all the timber of the western slope is tributary to the Puget Sound ports, for either the domestic or the foreign trade, both of which are steadily increasing.

The current market prices (December, 1900) show a slight increase from a year ago, and the few following prices on red fir are given for information:

Prices of lumber in Washington.

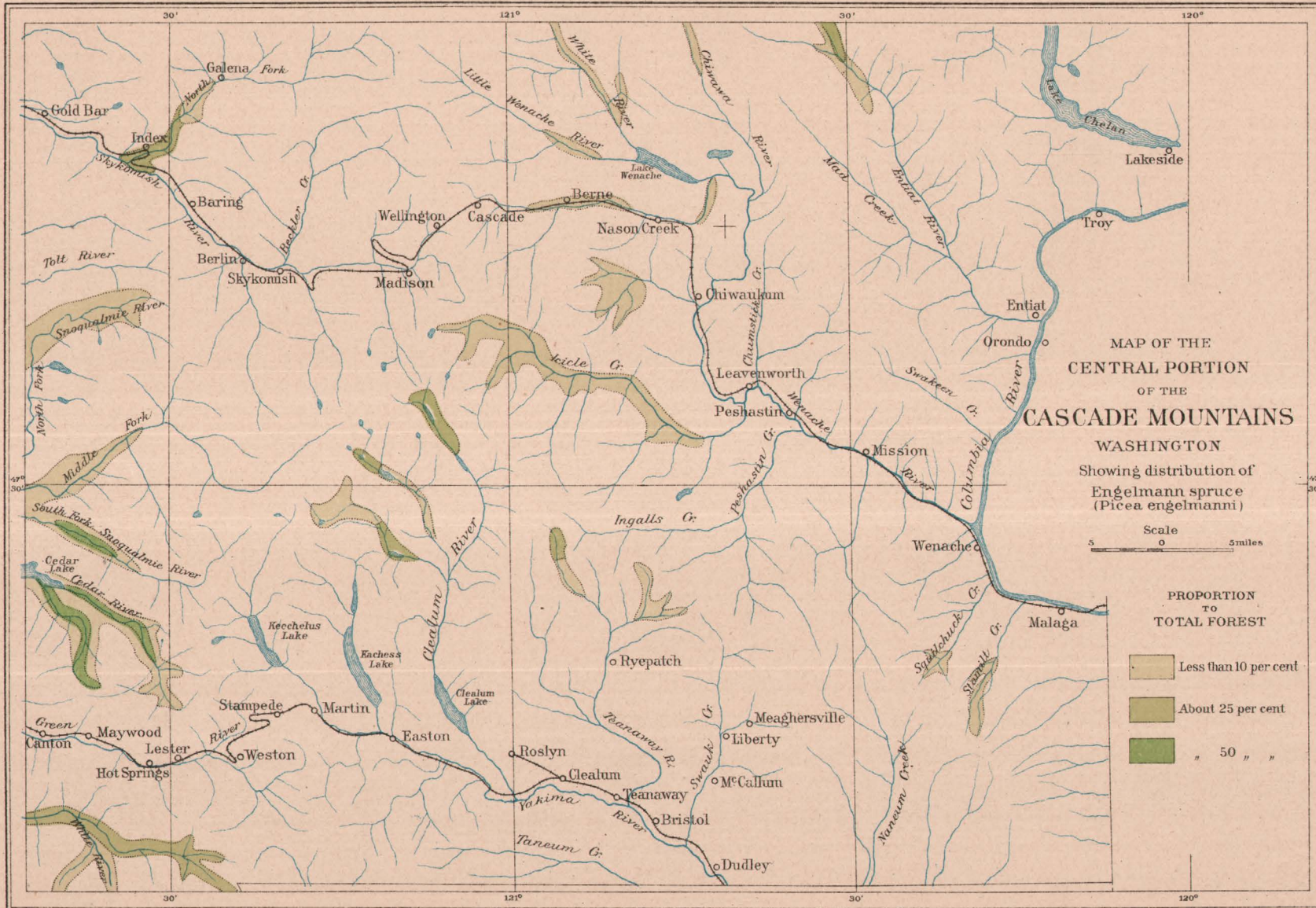
Grade.	Size.	Finish.	Per 1,000 feet B. M. at—	
			Seattle or Tacoma.	North Yakima.
Common.....	1 by 12 inches	Rough	\$7. 50	\$13. 50
Common.....	1 by 12 inches	Surfaced two sides	10. 50	16. 50
Flooring V. G. No. 1...	1 by 4 inches	Dressed and matched...	20. 00	25. 50
Flooring V. G. No. 2...	1 by 4 inches	do	19. 00	24. 50
Ceiling No. 1	$\frac{5}{8}$ by 6 inches	Beaded or plain	15. 40	19. 00
Ceiling No. 2	$\frac{5}{8}$ by 6 inches	do	14. 40	18. 00
Wainscoating No. 1	$\frac{5}{8}$ by 4 inches .....	.....	12. 00	17. 00
Wainscoating No. 2	$\frac{5}{8}$ by 4 inches .....	.....	10. 00	15. 00
Shiplap, common.....	1 by 8 inches .....	.....	8. 50	14. 50
Fencing No. 1	1 by 4 inches .....	.....	8. 00	15. 00
Fencing No. 2	1 by 4 inches .....	.....	7. 00	14. 00
Pickets	1 by 3 or 1 $\frac{1}{4}$ by 1 $\frac{1}{4}$ inches .....	.....	.....	.....
Lath.....	$\frac{3}{8}$ by 1 $\frac{1}{2}$ inches by 4 feet .....	.....	a 2. 00	a 3. 00

^a Per 1,000.

The prices on large or long timbers remain the same as given in my report on the Mount Rainier Forest Reserve.

East of the summit of the Cascade Mountains yellow pine (*Pinus ponderosa*) comprises about 85 per cent of the total output of timber for economic uses. Fifteen sawmills are located on the eastern slope, and these are mostly small plants operated during the summer season to supply the local demand. This includes the materials for the construction of irrigation flumes and fences and for the manufacture of fruit boxes and crates to supply the demands of the enormous fruit-growing industries of the Yakima, Wenache, Entiat, and Chelan valleys.

Red fir is cut where obtainable and used for various building purposes, but the wood is inferior to the soft growth of the moist western slope, being harder and much more brittle. According to a section foreman, railroad ties cut from red fir growing at high altitudes or on the eastern slope will last two years longer than



those cut from Puget Sound timber. Large amounts of red fir and yellow pine are cut for cord wood, and when contiguous to railroads are shipped to interior towns. During construction work on the Northern Pacific and Great Northern railways some yellow pine, lovely fir, tamarack, Engelmann spruce, and red cedar were cut for bridge timbers and ties, but the total amount is insignificant. Some ties of red cedar are used by the Great Northern Railway; and although they resist decay, they do not hold the spikes well and are therefore not as desirable as those made of tamarack or red fir.

The market prices of yellow-pine lumber which prevail throughout this region are as follows:

Prices of yellow-pine lumber in central Washington.

Clear, rough No. 1	per M feet B. M..	\$16.00 to \$18.00
Clear, rough No. 2	do....	12.00 to 14.00
Clear, rough No. 3	do....	8.00
Cord wood	per cord f. o. b..	2.25 to 2.50

On Squillechuck Creek near Wenache a small plant has been established for the purpose of manufacturing wooden irrigation pipe. This is done by sawing out the center of the sticks, which are from 6 to 12 inches in diameter and 10 feet in length. One end of the pipe thus made is tapered, and the other end is reamed out to form a bell to receive the tapered end of the adjoining pipe. The pipe is laid underground and is claimed to be long lived. Yellow pine is preferred for this purpose, and the core of heartwood taken from the stick is used for fence pickets. If successful, this plant will be of great value to the farmers of that vicinity.

DETAILED DESCRIPTIONS OF AREAS.

SKYKOMISH RIVER WATERSHED.

Prospecting and development work has progressed to a considerable extent and over large areas of this watershed, more particularly on the North Fork and its tributaries and on Miller River and Money Creek. The Great Northern Railway follows the main valley to Stevens Pass, where a tunnel recently constructed passes under the summit, and the valley has thus been opened and its resources made tributary to points both east and west.

Sawmills are in operation at Skykomish, Berlin, Baring, Index, and Gold Bar, all the finished lumber being shipped by rail excepting that for the small local demand at Skykomish and Index. The Skykomish River is drivable, and along its banks considerable cutting has been done, principally of cedar shingle bolts. This culling of individual trees at most accessible locations does not make a logged area, or necessarily precede the clearing of the bottom land for cultivation, but when clearings are made for that purpose the timber is not wasted. Although 15,000 acres of this valley are good agricultural land, only 90 acres are in cultivation.

Areas logged clean are often used for wild pasturage, as the rich soil of these bottoms supports a good growth of grasses and weeds upon which stock do well. In such areas the stumps of trees and the stubble of young growth are generally left to rot until burned or grubbed out to prepare the surface for the plow. The clearing of such land is worth \$100 to \$150 per acre, and there is little or nothing saved by waiting ten years, or even a lifetime, before removing the stumps. The stump of a newly cut tree burns better than a rotten one, or is lifted and split more thoroughly if powder be used. It means hard work in any case, and the pioneer in such areas earns all that he gets and generally more.

The land-classification map accompanying this report (Pl. I, in pocket) shows the location of the burns. The fact that a line of burned areas closely follows the alignment of the Great Northern Railway strongly suggests that they originated from the construction and operation of the road. Details of dates and circumstances were not obtainable, for railroad men are of a roving disposition and none were met who had been there long enough to give any information. Other burns in this watershed, including those near Cady Pass, have spread from the fires of prospectors and campers.

The principal timber trees are the red fir, red cedar, and hemlock. White fir and Engelmann spruce are also found in considerable quantities in the valley bottoms. Lovely fir has a wide distribution in this watershed and is an important tree in the middle zones. White pine is represented in the mixed forests, but does not make a strong showing in battle with the firs and cedars.

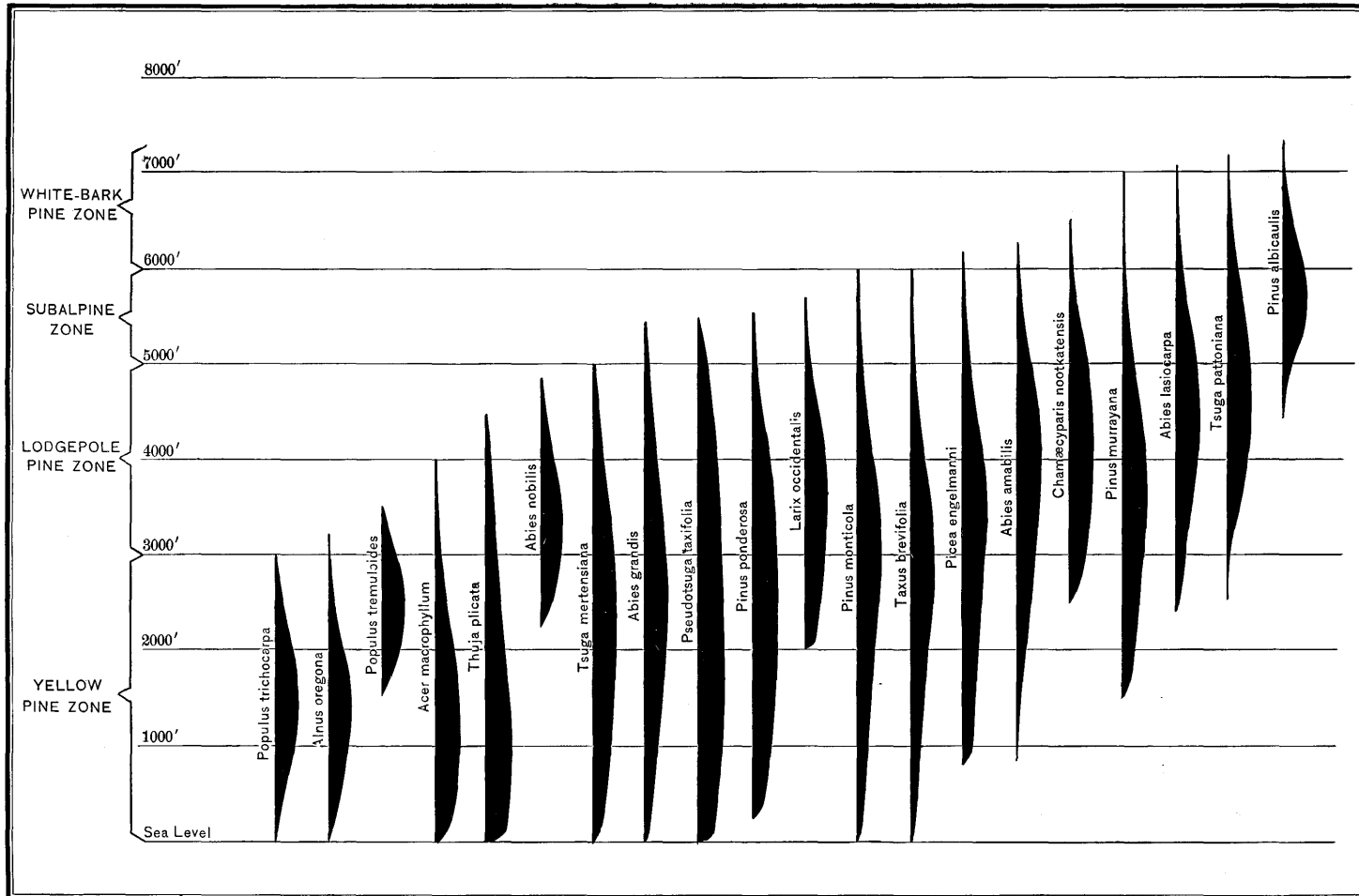
Proportions and amounts of timber species in Skykomish River watershed.

Species.	Per cent.	Estimated B. M.
Red fir	35	1, 127, 393, 750
Mertens hemlock.....	35	1, 127, 393, 750
Red cedar	10	322, 112, 500
Lovely fir.....	10	322, 112, 500
White fir	3	96, 633, 750
Engelmann spruce.....	2	64, 422, 500
Subalpine fir.....	5	161, 056, 250
Patton hemlock		
White-bark pine.....		
Total.....	100	3, 221, 125, 000

TOLT RIVER WATERSHED.

That portion of the Tolt watershed lying in ranges 9 and 10 east is covered by an unbroken forest of hemlock, red fir, red cedar, lovely fir, and some white pine.

This area is not traversed by any of the traveled routes across the Cascade Mountains, and this, together with the fact that it offers little to the prospector and



ALTITUDINAL RANGE AND DEVELOPMENT OF TIMBER TREE SPECIES.

nothing to the stockman, has given it immunity from the destruction likely to follow the advent of man. The stream is not drivable, but the timber will be quite accessible for skid roads and will find an easy outlet westward down the river valley.

Proportions and amounts of timber species in Tolt River watershed.

Species.	Per cent.	Estimated B. M.
Red fir	35	106, 333, 500
Mertens hemlock	35	106, 333, 500
Red cedar	10	30, 381, 000
Lovely fir.....	10	30, 381, 000
White pine	5	15, 190, 500
White fir	5	15, 190, 500
Subalpine fir.....		
Patton hemlock		
Total	100	303, 810, 000

SNOQUALMIE RIVER WATERSHED.

Three branches of the Snoqualmie, known as the North Fork, Middle Fork, and South Fork, drain this watershed. The two last mentioned rise in the main range of the Cascade Mountains, being separated from each other by a spur of the main range which ends in Grouse Ridge.

A wagon road follows the South Fork to Snoqualmie Pass, thence into the Yakima watershed, and it is along or near this route that the forests of the Snoqualmie watershed have suffered by fire. The large burn on Denny Mountain was first fired in 1865, and in 1894 a second fire destroyed much of the restocking and included new areas of the forest. The destruction has been almost complete, and there is no immediate danger of a third fire in this area, as there is nothing to burn. Judging from the position of this area, these fires occurred during long and steady north winds, which prevented their spreading over the crest of the hills into Pratt Creek Valley, and at the same time were not severe enough to cross the damp lands of the river bottom to the southward. On Teneriffe Peak the southern slope has been fired several times since 1893, and the area of timber destroyed extends more than 4 miles westward outside of the limits of the area mapped, and includes Mount Si, near the town of North Bend.

The nearest sawmill is near North Bend, 4 miles west of Grouse Ridge. Logging operations on an extensive scale were contemplated in T. 23 N., R. 9 E., but the plans have not yet matured. The streams are drivable for the greater part of the year.

These three forks of the Snoqualmie unite in T. 24 N., R. 8 E., about 3 miles above the falls where the plant of the Snoqualmie Falls Power Company is located. This plant supplies the cities of Tacoma and Seattle with electric power and light,

over wires with a transmission of 30,000 volts. The falls are 270 feet in height, and at the minimum flow of the river give 30,000 horsepower, of which 14,000 horsepower is now developed. As the supply of the river is derived mainly from the melting of ice and snow in the mountains, the importance to the Puget Sound cities of protecting this watershed is apparent.

Considering the entire watershed, red fir and hemlock predominate, forming two-thirds of the timber. In the North Fork Basin there is an unusually heavy stand of hemlock, which, if considered with similar areas in the Skykomish watershed (shown on Pl. IV), shows a broken belt of hemlock extending southwesterly from Chusallie Pass. In the Middle Fork Basin red cedar forms large percentages of the forest, but only over small areas. A peculiar feature of its forests is that the narrow strip of sandy bottom land along the upper valley is timbered with hemlock, while the red cedars and red firs have their best development upon the adjacent hillsides, which are so moist as to support a luxuriant growth of ferns, mosses, and devil's club (*Echinopanax horridum*). The South Fork also has a distinguishing feature in the high percentage of Engelmann spruce, which for a distance of 6 miles along the river benches has developed to an extent equaled only in the Cedar River Valley.

Arable and cultivated lands in Snoqualmie watershed.

Portion of watershed.	Acres arable land.	Acres cultivated land.
North Fork Valley	2,500	18
Middle Fork Valley	5,000	146
South Fork Valley	1,500	113
Total	9,000	277

Proportions and amounts of timber species in Snoqualmie watershed.

Species.	Per cent.	Estimated B. M.
Red fir	35	779,012,500
Mertens hemlock	30	667,725,000
Red cedar	10	222,575,000
Lovely fir	10	222,575,000
Engelmann spruce	7	155,802,500
White pine	3	66,772,500
White fir	5	111,287,500
Noble fir		
Subalpine fir		
Patton hemlock		
White-bark pine		
Total	100	2,225,750,000

CEDAR RIVER WATERSHED.

It is from this watershed that the city of Seattle draws its water supply for domestic, manufacturing, and municipal purposes. Its area is only 62,500 acres, but its location in a belt of abnormal precipitation insures an abundant supply at all seasons of the year. It is bounded on the north and east by high peaks, fairly timbered, and in their present condition capable of holding the snows well into the dry season. The slopes south of the river are less abrupt, and, being more protected from the sun's rays and the warm Chinook winds, will assist in giving the slow drainage desired to keep up the flow during the summer months.

The preservation of the heavy forests of the valley lands has been remarkable, for the evidences of small fires started by pleasure seekers, fishermen, and campers are numerous, but in every case the fires have failed to spread. The small burns in this watershed were upon the hillsides and occurred in small timber.

The moist valley lands are the home of the Engelmann spruce, red cedar, white pine, and white fir, which, added to the ever-present and predominating red fir and hemlock, give a mixed forest of unusual interest and beauty. It is entitled to the protection which its commercial importance demands.

The arable lands of Cedar River Valley have an extent of 1,000 acres, of which 24 acres have been in cultivation, but are now abandoned. Not a living man, beast, or bird was seen or heard during the four days spent there. The silence prevailing in this valley was very noticeable as compared with other portions of the Washington forests over which my observations have extended, for there is rarely a day that one may not hear the chatter of the squirrel, the stroke of a woodpecker, or the drum of a pheasant, or see the signs of bear, cougar, or deer. I have learned from others who have visited this valley that their experiences confirm the above.

Proportions and amounts of timber species in Cedar River watershed.

Species.	Per cent.	Estimated B. M.
Red fir	40	194, 520, 000
Mertens hemlock	30	145, 890, 000
Engelmann spruce	10	48, 630, 000
Red cedar	5	24, 315, 000
Lovely fir	5	24, 315, 000
White pine	3	14, 589, 000
White fir	2	9, 726, 000
Noble fir	5	24, 315, 000
Subalpine fir		
Patton hemlock		
White-bark pine		
Total	100	486, 300, 000

GREEN RIVER WATERSHED.

The area drained by Green River, comprising 95,500 acres, shows more evidences of extensive burns, both early and recent, than any other watershed examined. Seventeen thousand acres, or about 18 per cent of the total watershed, must be classified as "burned," as the restocking is still in the sapling state, and of no merchantable value.

The first of the destructive fires occurred about thirty-five years ago, as indicated by individual red firs, hemlocks, and Engelmann spruces of that age which survived later fires. In the vicinity of Hot Springs the underbrush and second growth has been destroyed by fire several times during the last twelve years, and the oldest second growth now showing upon the hillsides is 17 years old. The standing dead snags of the former old growth are of no value. In the bottom or adjacent slopes of the canyon are several small patches of the original forest, in which the growth is thrifty, although the trunks are scorched to a height of 50 feet or more.

During the last ten years three sawmills and two hotels have been destroyed by fire.

A mill in sec. 13, T. 20 N., R. 9 E., cut considerable good timber for local use, and at Lester a mill has cut the timber on about 160 acres for lumber. The remainder of the cutting in this valley has been done by mills since removed or destroyed, and includes an area of 300 acres at Hot Springs, which was cut for local consumption.

About 3,500 acres of bottom land in the Green River Valley may be called arable, but of this at least 80 per cent is of very poor quality. Volcanic rocks predominate in the form of ledges and large boulders, and render the valley uninviting. The entire cultivated area is only 5 acres, but clover started near Hot Springs has spread over 150 acres of the cut area and made a successful stand against the native weeds.

Proportions and amounts of timber species in Green River watershed.

Species	Per cent.	Estimated B. M.
Red fir	45	168, 356, 250
Mertens hemlock.....	30	112, 237, 500
Red cedar	5	18, 706, 250
Lovely fir.....	5	18, 706, 250
White fir	5	18, 706, 250
White pine	3	11, 223, 750
Noble fir.....	2	7, 482, 500
Subalpine fir.....	5	18, 706, 250
Patton hemlock		
Alaska cedar		
White-bark pine		
Total	100	374, 125, 000

WHITE RIVER WATERSHED.

The main forks of White River are supplied by the glaciers and snow fields on the northeast side of Mount Rainier. One of its principal nonglacial tributaries is the Greenwater, which heads in the Cascade Mountains and is within the limits of the examined area.

The old Naches Pass trail, which, prior to the construction of the Northern Pacific Railway, was a well-traveled route from eastern Washington to Puget Sound, follows the Greenwater to the summit. Northward from a favorite camping place at the mouth of the Greenwater is an extensive burn, joining and probably synchronous with the large burn of the Green River Valley, which may thus be traced to campers and packers as well as to the right-of-way clearing of the Northern Pacific Railway. At and near Naches Pass, which is one day's travel from the mouth of Greenwater and a camping place, are several smaller burns in light timber.

The heavy timber of the bottom lands is red fir, red cedar, hemlock, and Engelmann spruce; on the hillsides there is noble fir, lovely fir, white fir, white pine, and Alaska cedar. Four thousand acres of the bottom lands may be classed as arable, as the soil is rich and deep, well watered, and less than 2,000 feet above the sea, but the clearing of this land for the plow will be so expensive as to be prohibitive for some time to come.

Proportions and amounts of timber species in White River watershed.

Species.	Per cent.	Estimated B. M.
Red fir	40	291, 780, 000
Red cedar	15	109, 417, 500
Mertens hemlock	15	109, 417, 500
Engelmann spruce	10	72, 945, 000
White pine	5	36, 472, 500
Lovely fir	5	36, 472, 500
Noble fir	3	21, 883, 500
White fir	2	14, 589, 000
Subalpine fir	}	36, 472, 500
Lodgepole pine		
Patton hemlock		
Alaska cedar		
White-bark pine		
Total	100	729, 450, 000

YAKIMA RIVER WATERSHED.

The principal tributaries of Yakima River are the Kachess, Clealum, Teanaway, Swauk, Taneum, and the Naneum. By the accepted nomenclature the main Yakima River heads near Snoqualmie Pass and runs through Keechelus Lake; but the Clealum is the longer and larger stream.

The Snoqualmie Pass wagon road follows up the main Yakima Valley, past Keechelus Lake and over the summit, on a route which has been traveled for forty years. Considering this the examinations show a remarkably small proportion of burned area as compared with the regions lying immediately eastward, but the numerous small burns in the vicinity of Keechelus Lake prove that campers and packers were not overly careful, and also suggest, what observation shows to be a fact, that the local conditions of humidity are not favorable to the spreading of forest fires. The Keechelus Basin, lying east of the summit of the Cascades and paralleling it, is in what may be termed the "overlap," and shares the characteristics of the forests of both the eastern and western slopes, excepting only the open yellow-pine forests of the lower eastern slopes. The forests are very "spotted," and any of the species represented may predominate over a small area, and the general forest is very mixed as to species. Several of the small burns mentioned occurred in July, 1865, and about the same time fire spread over considerable areas of Goat Mountain, south of the town of Easton. The year 1890 was a fruitful year for burns, several of which were in the young trees that had restocked previous burns.

Above Keechelus Lake, more particularly on Gold Creek, there has been considerable prospecting for mineral.

In the Kachess watershed, immediately eastward, the burns are of greater extent, and in the Clealum watershed, still farther east and within an area which has been both sheeped and prospected, fires have done great damage in both light and heavy timber. The large burned area shown on the map at the headwaters of the Clealum and the Big Salmon Lasac rivers is the result of three fires, in 1888, 1895, and 1898. A few scattered areas of the first burn were not refired during the later burns and show a scanty restocking of lodgepole pine, but the remainder of this entire burn presents a scene of desolation not equaled on the eastern slope. In the vicinity of Wapatos Lake the fires burned so deep into the soil as to absolutely destroy all vegetable matter, leaving only a clean surface of baked soil which will require a lifetime for nature to restock with timber. During the last season some fireweed (*Epilobium angustifolium*) and a few other weeds have preempted claims which they alone can hold, but not a coniferous sapling is to be seen except along the borders of the standing forests where the humus was not utterly destroyed.

From an inspection of the unharmed areas of old growth bordering this burn it is assumed that the destroyed forest was of red fir, white pine, Alaska cedar, and

lovely fir. Near the head of the Big Salmon Lasac the Alaska cedar reached a high state of development, comprising at least 40 per cent of the forest. The board measure per acre of Alaska cedar never runs high, but the wood is the most valuable of the Washington woods, and this burn beyond doubt destroyed much of it.

Southward from the area just described the country is scarred by dozens of burns, large and small, with outlines regular or irregular according to the conditions of exposure, the action of the winds, and the nature of the forest destroyed. Details regarding these were not obtainable, only the general statement that hardly a year has passed since 1865 but fire has burned or reburned some area. Some of the restocking would indicate that the date might be set back to 1860. To the southward of Yakima River the tamarack has been the principal reclamer of large areas, but in the restocked areas north of the main Yakima the conditions are varied, consistent with the very mixed bordering forests, from which a high wind may distribute the fertile seeds of the species when matured.

The Teanaway country, together with the Taneum and all the favorable and accessible areas eastward, has been plentifully sheeped. The forests are generally open, with very little forest litter, and are well watered. The lower country is well and permanently settled by industrious people, who appreciate the value of every little stream which may be diverted to make the naturally rich, but dry, soil productive and who deplore the existence of even the few burns which seem so insignificant when compared with those formerly described. The burns in this watershed as mapped will be a startling exposé of a threatening danger to the most important drainage basin in the State of Washington, so far as water supply for irrigation is concerned.

About 22,000 acres of this watershed have been logged, and of this area 5,258 acres are in cultivation. Mills have been operated at Easton, Big Creek, Roslyn, Clealum, Teanaway, Marysville, and in sec. 14, T. 20 N., R. 16 E. The mill at Marysville has a capacity of only 4,000 feet per day and supplies the local demand for the building of mining flumes and sluices. Along Swauk River the cutting has been mainly for mining timbers, used in the placer diggings, which have been in operation for the last twenty years. Yellow pine predominates in this region, but is not considered as desirable for mining purposes as red fir. The same is true at the coal mines at Roslyn and at Clealum, but at these points the local demand for building lumber is considerable.

Sixty-seven thousand acres are arable, and the location is better indicated on the map submitted herewith than it could be by a description. This estimate refers only to that portion of the Yakima watershed lying within the area examined. The estimates of the available lands lying outside, but which are largely dependent upon the upper watershed for water supply, are given under the heading "Irrigation."

Proportions and amounts of timber species in Yakima River watershed.

Species.	Per cent.	Estimated B. M.
Yellow pine	50	1, 305, 250, 000
Red fir	20	522, 100, 000
Mertens hemlock.....	10	261, 050, 000
Red cedar	5	130, 525, 000
Tamarack.....	5	130, 525, 000
Lovely fir.....	3	78, 315, 000
White fir	2	52, 210, 000
Engelmann spruce.....	5	130, 525, 000
White pine		
Noble fir.....		
Subalpine fir.....		
Lodgepole pine		
Patton hemlock		
Alaska cedar.....		
White-bark pine		
Total	100	2, 610, 500, 000

WENACHE RIVER WATERSHED.

The important tributaries of the Wenache River are the Little Wenache, White, Nason, Icicle, Chiwawa, and Peshastin.

The Little Wenache enters Lake Wenache through a wide bottom densely covered with a growth of deciduous underbrush and trees, the latter mainly willow, alder, and maple. In the upper basin is a fine forest of old-growth red fir, red cedar, white pine, and hemlock, besides a smaller growth of lovely fir. Some trees in this old growth have a diameter of 4 to 5 feet and make up a forest, such as is seldom seen in eastern Washington. This body of mixed growth extends along the river about 5 miles. Between it and the white-bark-pine zone the hemlock and lovely fir exclude all other species, except an occasional individual of the species named. At the forks of the Little Wenache a terrific fire has burned along the main stream and a distance of 4 miles up the South Fork, destroying millions of feet of timber, including some of the best cedar in the canyon. Doubtless this fire started from an old trapper's cabin. A smaller and less destructive fire, about 4 miles east of Cady Pass, was traceable to a campfire built on the trail which leads across the summit.

The forests of the Little Wenache are such as would delight the heart of the forest lover, and it is to be regretted that the Washington Forest Reserve does not include this watershed, or that protection of it is not assured from the destruction which is sure to follow the coming of summer campers to this delightful region.



BURN NEAR BERLIN, ON GREAT NORTHERN RAILWAY.

White River also flows into Lake Wenache. Its valley has been a favorite hunting ground for the Indians, as deer, goats, beaver, and smaller game were plentiful, and huckleberries were abundant on the hillsides which had been burned over many years before. About 2,000 acres of this valley is "beaver-dam" land and if cleared might be rated as agricultural, but its high elevation and position in relation to the mountains make this classification doubtful, and this area has not been included in estimating the arable lands of the Wenache watershed. It will, however, add to the value of this region for grazing purposes, as in its wild state it supports a rank growth of forage grasses. The evidences of very old burns are numerous, but restocking is well advanced. The causes of these old burns must be assigned to the Indians.

Nason Creek, before the advent of the Great Northern Railway, bore much good timber, but fires set to clear the right of way during construction work spread over considerable areas of the valley and adjacent hills, and these, together with the cutting for railroad uses, have greatly reduced the amount of standing timber. The best timber of the upper basin was found in the vicinity of the Cascade tunnel, and consisted of lovely fir, Patton hemlock, and Engelmann spruce, with some red cedar. Near Nason Creek station a mill having a daily capacity of 10,000 feet is in operation, and ships lumber to Wenache. Between this point and Merritt are about 300 acres of good hay land, but at an altitude which insures frosts every month of the year. The same is true of 250 acres lying between the mouth of the creek and the point where the railroad leaves the creek.

The pass through which the railroad runs via Skeeney Creek contains some good pine timber, but much of the best has been culled for saw logs and cord wood. Large quantities of cord wood are shipped to the timberless areas of central Washington.

Icicle Creek, from a point 3 miles above its junction with the Wenache, flows through a narrow canyon with walls rising in places 5,000 feet on either side. Its watershed is an irregular triangle bounded by the main divide of the Cascades on the west, the Mount Stuart divide on the south, and the Chiwaukum Mountains on the northeast. These three snow-capped ranges compel an increased humidity and frequent storms during the summer season, which, together with melting snows, maintain a large and constant waterflow. Owing to the abnormal precipitation and the general inaccessibility of the watershed few burns have occurred and these are of small extent. The arable lands of Icicle Valley are at the mouth of the creek, where the bottom widens to join that of Wenache River, and have an area of about 1,200 acres, of which only one-third is good, the remainder being rocky. Excepting this tract the soil formation of the watershed consists principally of rock in the form of ledges and boulders, owing to the wide range of altitude; nevertheless, the valley

supports a varied growth of the forest trees. All of the coniferous timber trees were found, excepting the noble fir (*Abies nobilis*), and it is very probable that this species is represented by some individuals, as its northern limit of distribution is at least latitude 48°. Here was found the woolly larch (*Larix lyallii*).

The Chiwawa Valley, below the Washington Forest Reserve, varies in width from a half to three-fourths of a mile. The soil in the upper portion, near the reserve, is scoria sand and decomposed pumice overlying a deposit of gravel and boulders, hence it is of very poor quality and utterly unfit for cultivation. It is the home of the lodgepole pine, which claims the entire bottom and extends far up on the hillsides of the western slope. The canyon is fairly well timbered, but the trees are mostly small or saplings. Many years ago extensive fires swept over this region, and these areas were reclaimed by the lodgepole pine assisted by the red fir, white fir, and the yellow pine in the more favored localities. Between Fish Lake and the Chiwawa is a dense growth of mixed species, including white pine. Some of this land, if cleared, would be fair agricultural land, but altitude and location are unfavorable, and the natural classification of the watershed is grazing land.

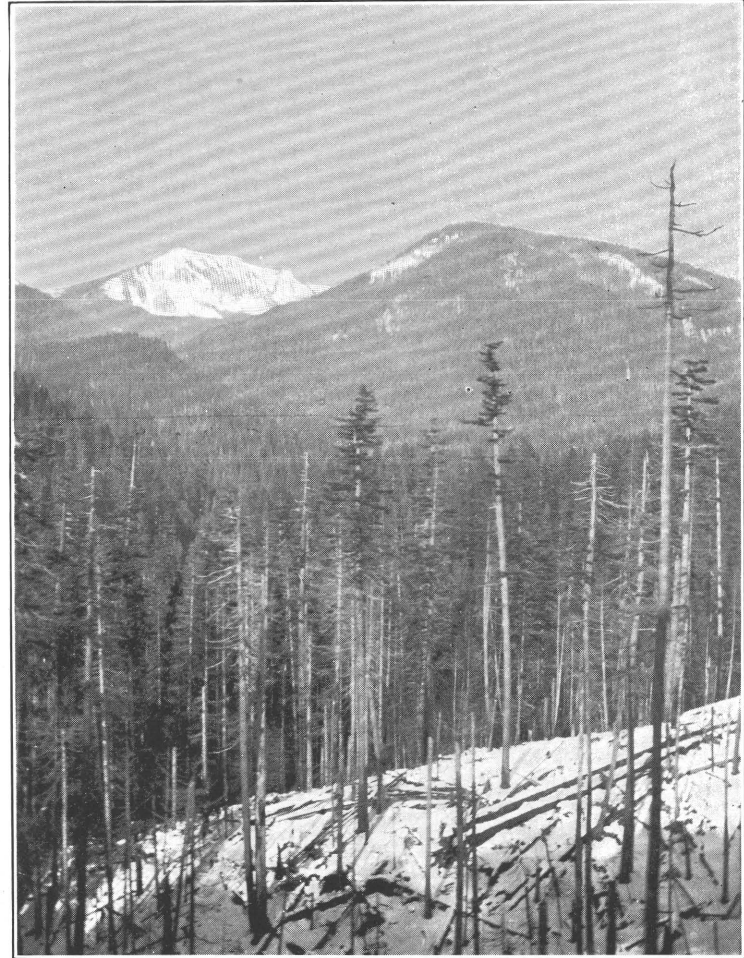
On Peshastin Creek headwaters the forest cover is mainly a young growth of tamarack which many years ago reclaimed a large burned area. Outside of this the yellow pine prevails, with some red fir and white fir and tamarack. The soil is rocky and extremely shallow throughout the canyon, and the only arable land in the watershed is at the mouth of the creek and at a point called Camas Land. Aside from its value as grazing land, which this watershed shares with almost every watershed on the eastern slope of the mountains, its value as mineral land has to some extent been demonstrated, and it follows that the timber, although of small size, already has a value for mining purposes. At Blewitt a 20-stamp mill handles the output of the mines, and a large number of tunnels have been driven into the mountains, all of which require more or less timber. Large numbers of poles have been cut in distant burns along the tops of the hills and slid down the mountains to the works. These are mostly tamarack, averaging 9 inches in diameter at the stump. In a short time this section will be denuded of serviceable timber and the young growth of the canyons will be utilized.

In addition to the descriptions of the main tributaries as above given, there remains to be described the main Wenache Valley. From Leavenworth to Columbia River, a distance of 25 miles, this valley, together with large areas of its adjoining slopes, is arable and well situated for agricultural purposes and for irrigation. Out of a total of 48,000 acres of arable land, 5,565 acres are in cultivation, and the fertility is therefore demonstrated.

Forty years ago the first white settlers came to this valley and engaged in stock raising, trading, and packing. Near the mouth of the river some of the small



A. RED FIR ON GREAT NORTHERN RAILWAY.



B. FOREST ON NORTHERN PACIFIC RAILWAY.

tributaries were diverted to irrigate garden patches, and since that time settlement has increased slowly but steadily. Before the building of the Great Northern Railway this region was approached by a road leading over the Wenache Mountains, or in part by Columbia River, for the Wenache itself is not navigable except for canoes, and then not at low water. Although the railroad has made the markets more accessible, and has stimulated industry to a considerable extent, still the increase in cultivated lands since the railway was built is not over 20 per cent of the total.

Proportions and amounts of timber species in Wenache River watershed.

Species.	Per cent.	Estimated B. M.
Yellow pine	65	1, 019, 850, 000
Red fir	20	313, 800, 000
Tamarack	5	78, 450, 000
Red cedar	3	47, 070, 000
White fir	2	31, 380, 000
Engelmann spruce	}	78, 450, 000
Mertens hemlock		
White pine		
Lovely fir		
Noble fir		
Subalpine fir		
Lodgepole pine		
Patton hemlock		
Alaska cedar	}	78, 450, 000
White-bark pine		
Total	100	1, 569, 000, 000

ENTIAT RIVER WATERSHED.

Entiat River flows through a deep canyon varying from a narrow gorge to a half mile in width. This canyon is settled to the northern line of township 27 north, a distance of about 20 miles, but many of the locations are abandoned the greater part of the year. Hay and cattle are the principal products of the upper valley. For a distance of 4 miles upstream from the mouth of the Entiat there is no timber, and in this region hay and fruit are the most important products. Fruit of an excellent quality is produced in abundance, and finds its local market at Wenache via the small steamers which ply Columbia River. From Wenache the distribution is made by the Great Northern Railway to points both east and west.

Irrigation is required for all crops. The soil is mostly light sand and decomposed country rock, and varies in depth from a few inches to 20 feet, with some

fine black loam in the basins of the upper valley. Beds of washed gravel and rock occupy much of the surface, and in the vicinity of Lake Creek showers of scoria have covered the ground to a depth of a foot or more.

The upper basins are covered by a dense growth of birch, quaking aspen, willows, and other shrubs, which have formed a deep vegetable mold. Of this land there is not more than 300 acres. In the entire valley there are 516 acres in cultivation, most of which is in the timberless area near the mouth of the river, where about 1,000 acres are under irrigation ditches. The amount of arable land in the valley is estimated at 4,900 acres.

Below the subalpine zone the timber consists of 90 per cent yellow pine, with some red fir, and in the moist places with white fir, Engelmann spruce, and occasionally white pine above 2,000 feet.

On the high divides between Entiat and Mad rivers extensive burns occurred years ago, and the very life was burned out of the soil, leaving it poor indeed. Here the lodgepole pine has demonstrated its wonderful restocking properties, and hundreds of acres have been reclaimed where other trees could not find sufficient nourishment in the soil to promote growth. Large areas of saplings were found where they grew like grain in a field—as many as forty to the square yard—varying from one-half inch to 4 inches in diameter and from 5 to 30 years in age. While this pine is an active reclaimer it is, unfortunately, short lived, and as a result the ground is sometimes covered to a depth of 4 feet with dead trees. These are a constant menace to succeeding growth, but in time these accretions form a litter and humus sufficient to promote the growth of other species, and under this protection a forest cover of a more permanent nature results.

The subalpine fir prevails at the higher altitudes, and the white-bark pine covers the summits in its characteristic manner.

Lumbering has been carried on during the last nine years. Two mills have been constructed, one of which, a small plant built in 1899, has cut only a few thousand feet. The Entiat Lumber Mills have a capacity of 10,000 feet daily, and have cut about 3,500,000 feet under the present management. The logs for these mills are driven down the Entiat during the high stage of the river, which usually occurs in May. All the cutting has been done on the river banks or culled from the slopes immediately above. Where ground has been cleared for cultivation the logs have been purchased from the settlers. Driving is expensive and the demand for lumber is not brisk except for the manufacture of fruit boxes.

Frequent earthquake shocks of slight intensity are a feature of this section.



A. HEAVY STAND OF RED FIR.



B. HEMLOCK ON MIDDLE FORK OF SNOQUALMIE RIVER.

Proportions and amounts of timber species in Entiat River watershed.

Species.	Per cent.	Estimated B. M.
Yellow pine	75	277, 462, 500
Red fir	15	55, 492, 500
Lodgepole pine.....	5	18, 497, 500
Red cedar.....	}	18, 497, 500
Engelmann spruce.....		
Mertens hemlock.....		
White pine		
White fir		
Noble fir.....		
Subalpine fir.....		
Patton hemlock.....		
White-bark pine		
Total.....	100	369, 950, 000

LAKE CHELAN WATERSHED.

The major portion of Lake Chelan is within the Washington Forest Reserve, and north of township 28 north. The lower end of the lake extends into the great timberless area of eastern Washington, although the bordering hills are fairly well timbered. Yellow pine is the prevailing species, with some red fir on the hills above 2,500 feet. Most of the timber is small, ranging from 6 to 20 inches in diameter, and is seldom clear. In such a forest logging is simply a culling out of the best trees, the remainder being fit only for posts or fencing.

There is a sawmill at Lakeside which has been in operation about seven years, and has cut on an average 400,000 feet B. M. per annum. Under the same management a small portable mill will be operated in the newly settled basin north of Chelan. The two mills will have a capacity of 1,000,000 feet yearly, all of which will be for local consumption. Most of the logs are brought down from the head of the lake and are handled with very little waste.

Bordering the lower end of the lake is an area of about 27,000 acres of unusually fertile land. In striking contrast to the conditions prevailing in the lower areas of the Entiat and Wenache watersheds, this soil produces fine crops of fruit and grain without irrigation. Farms are cultivated more than 1,000 feet above the lake, where no running water is to be seen. The orchards make a remarkably quick growth and the fruit is of the finest quality.

FOREST CONDITIONS IN CASCADE RANGE, WASHINGTON.

Proportions and amounts of timber species in Lake Chelan watershed.

Species.	Per cent.	Estimated B. M.
Yellow pine	85	94, 775, 000
Red fir	10	11, 150, 000
Lodgepole pine.....	5	5, 575, 000
Subalpine fir.....		
Patton hemlock.....		
White-bark pine.....		
Total.....	100	111, 500, 000

SUMMARY.

Stand of timber in central Washington.

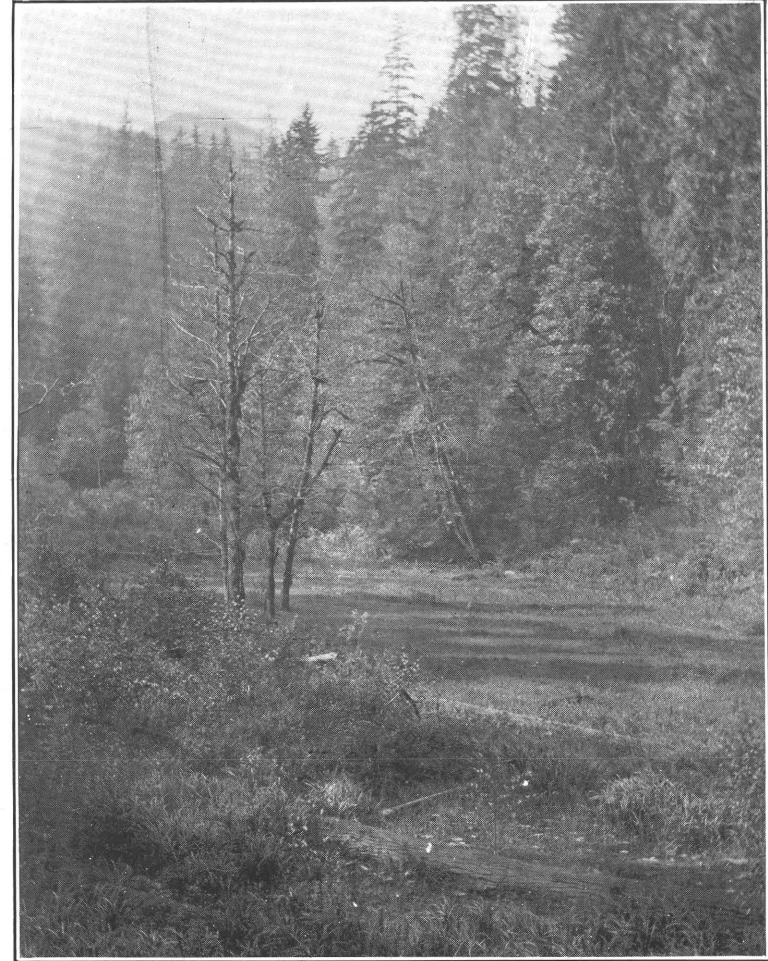
Watershed.	Area.	Stand.	Average stand per acre.
	<i>Acres.</i>	<i>Feet B. M.</i>	<i>Feet B. M.</i>
Skykomish	364, 800	3, 221, 125, 000	8, 800
Tolt.....	36, 460	303, 810, 000	8, 300
Snoqualmie.....	190, 000	2, 225, 750, 000	11, 700
Cedar.....	56, 100	486, 300, 000	8, 700
Green.....	76, 750	374, 125, 000	4, 900
White.....	48, 060	729, 450, 000	15, 200
Yakima.....	570, 000	2, 610, 500, 000	4, 600
Wenache.....	686, 200	1, 569, 000, 000	2, 300
Entiat.....	175, 500	369, 950, 000	2, 100
Chelan.....	89, 000	111, 500, 000	1, 250
Total.....	2, 292, 870	12, 001, 510, 000	5, 230

Classification of lands in central Washington.

Watershed.	Total.	Logged.	Burned.	Timberless.	Timbered.	Arable.	Cultivated.	Irrigated.
	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>
Skykomish	389, 000	850	21, 500	1, 850	364, 800	15, 000	90	.....
Tolt.....	36, 500	.....	40	.....	36, 460	.....	.....	.....
Snoqualmie.....	206, 000	200	15, 000	800	199, 000	9, 000	277	.....
Cedar.....	62, 500	.....	5, 500	900	56, 100	1, 000	24	.....
Green.....	95, 500	1, 750	17, 000	.....	76, 750	3, 500	5	.....
White.....	55, 500	40	7, 400	.....	48, 060	4, 000	5	.....
Yakima.....	754, 000	22, 000	85, 000	77, 000	570, 000	67, 000	5, 258	1, 700
Wenache.....	853, 000	13, 300	35, 500	118, 000	686, 200	48, 000	5, 565	17, 000
Entiat.....	212, 000	1, 000	15, 500	20, 000	175, 500	4, 900	516	1, 000
Chelan.....	136, 000	2, 500	1, 700	42, 800	89, 000	27, 000	1, 874	.....
Total.....	2, 800, 000	41, 640	204, 140	261, 350	2, 292, 870	179, 400	13, 614	19, 700



A. RED CEDAR, 20 FEET IN DIAMETER.



B. HEMLOCK, MAPLE, AND ALDER.

IRRIGATION.

It is estimated that there are five million acres of arid land in the State of Washington, all of which is in the central portion of the State, east of the Cascade Mountains and in the drainage basin of Columbia River. An estimate of the irrigation possibilities of these five million acres, as determined from data furnished by the Northern Pacific Railway Company, and from other sources, is as follows:

Estimate of irrigation possibilities in central Washington.

	Acres.
Under constructed canals and in cultivation	150,000
Under constructed canals, not in cultivation.....	100,000
Under canals surveyed but not constructed, and the feasibility of which, at reasonable cost, has been determined	1,080,000
Under canals projected, but feasibility at a reasonable cost is undetermined.....	510,000
Balance, presumed to be above possibility of irrigation, at cost justified by present conditions	3,160,000
Total.....	5,000,000

The Cascades and the other mountain ranges which encircle the arid district will afford, if properly conserved, an adequate supply of water for all of the land that can be watered within the limits of reasonable cost. As Columbia River flows through the arid district in a narrow, deep valley having steep slopes, it affords but few opportunities for irrigation. Its main tributaries, with the exception of Snake River, offer more favorable conditions, and in this respect Yakima River is the most important in the State.

Of the total of 250,000 acres now under constructed canals, 203,900 acres are supplied by Yakima River and its tributaries. Of this latter area, the drainage basin of Yakima River as covered by this report is the sole supply for 12,750 acres, and furnishes 68 per cent of the water for the remaining 191,150 acres.

Out of the 1,080,000 acres set forth above that can be irrigated at reasonable cost, 785,000 acres are in the Yakima watershed and will be dependent upon the area treated in this report for about 25 per cent of their water supply.

From careful estimates it appears that there are at present 131,260 acres of arid land dependent for their water supply upon that portion of the Yakima watershed treated in this report, and that this dependent area will eventually be increased to 325,700 acres when the proposed canals are constructed. To irrigate this greater area there will be required about 2,000 cubic feet per second of time, and as the minimum flow of Yakima River is only 800 second-feet, recourse must be had to storage for the additional 1,200 feet. Three lakes, the Keechelus, Kachess, and

Clealum, are well situated for the impounding of a reserve supply, and have areas and capacities as follows:

Areas and capacities of Lakes Keechelus, Kachess, and Clealum.

Lake.	Area.	Height of proposed dam.	Capacity.
	<i>Acres.</i>	<i>Feet.</i>	<i>Acre-feet.</i>
Keechelus.....	1,812	30	50,800
Kachess.....	3,968	30	91,000
Clealum.....	2,615	30	65,400
Total.....	8,395	.....	207,200

This storage will furnish 1,200 cubic feet per second for 87 days, no allowance being made for evaporation or contingencies. It is confidently believed that this storage will be a safe insurance against any unusual season of drought.

From all the above it will be evident that the construction of these reservoirs and the preservation of their natural watersheds is imperative. This means that logging should be done under proper restrictions, and that the wanton destruction of the forests by fire must cease.

In the Wenache and Entiat watersheds the conditions are not so urgent. The areas which can be covered by gravity canals are small, and the supply is ample. At present the Wenache covers 17,000 acres of land, and feasible canals projected will increase this to 23,500 acres. The Entiat supplies about 1,000 acres.

GRAZING.

In the area treated in this report grazing is confined to the eastern slope. A few horses, most of which are Indian cayuses, range upon the bunch-grass hills near Columbia River. But few cattle are raised aside from those kept for domestic purposes.

Owing to the extreme roughness of a large portion of this area, cut and broken as it is by steep rocky ridges and precipitous canyon walls, sheep grazing is practicable only in certain limited tracts. As yet it is confined to the Yakima slope south of Clealum, the Teanaway and its tributaries, the high divide extending from Columbia River westward to Mount Stuart, the southern slope of Mount Stuart, and the Entiat and Mad River divides near the Washington Forest Reserve. Sheep are driven into this area from Yakima, Ellensburg, from east of the Columbia River, and even from Oregon.

The sheepmen complain of the range being overstocked. One owner declared that if some new pasture is not discovered the sheep will die in the hills.

Starting in the early spring, as soon as the lambing season is over, they leave the low hills along Columbia River and are driven toward the high mountains, which are reached soon after the winter snows have melted. Here they must remain until the fall rains have caused the grass to grow in the lowlands. Forage plants do not grow profusely in any of these sections. At the lower altitudes, among the pine woods, the pine grass (*Calamagrostis suksdorfii*) is the most important. Sheep do not relish this grass, eating it only when nothing else is to be found. They pass over this very rapidly, and large areas are required to keep them constantly in fresh pasture. One band was seen on the Middle Fork of the Teanaway where the hills were covered with this grass, but it seemed to be almost untouched. The sheep were gathered in the ravines, browsing upon wild cherry, hazel, and vine maple. In the grazing areas there is very little underbrush except in the moist canyons and ravines, which are often inaccessible. At the high altitudes, such as the divides running down from Mount Stuart, various alpine grasses are found which make very desirable feed. Fat formed from this dry feed is much harder than that gained from the soft watery grasses of the swamps.

About the head of Mad River and the Entiat, grazing is mostly done at the altitudes above the yellow-pine zone, where a scrubby growth of subalpine fir, white-bark pine, and lodgepole pine forms a scattered forest which has been greatly reduced by fire. Willow, huckleberry, pea vine, lupine, and various grasses and juncus have covered the hillsides, but the trampling and cutting of thousands of hoofs has in many places denuded the ground of every trace of vegetation.

Upward of 60,000 sheep were said to be ranging in this section and upon the tributaries of Entiat River in the Washington Forest Reserve. About 15,000 were reported on the Teanaway, and a number of bands were in the Mount Stuart region.

MINERAL SPRINGS.

Springs of mineral, sulphur, or soda water are not uncommon in the Cascade Mountains, and there are some deserving of mention.

At Hot Springs, a station on the Northern Pacific Railway, there are five springs which have become well known by reason of their desirable medicinal properties and their accessibility. At this point a large hotel is being built to replace one destroyed by fire in 1899. Three of these springs have temperatures of from 120° to 122° F., and can therefore be used for bathing and heating purposes.

Analyses made in 1893 gave results as follows:

Analyses of water from mineral springs near Hot Springs station, Wash.

Constituent.	No. 1.	No. 2.	No. 3.
	<i>Grains per gal.</i>	<i>Grains per gal.</i>	<i>Grains per gal.</i>
Sulphate of lime	1. 3707	1. 3315	0. 7358
Sulphate of potash	2. 1666	2. 4353	1. 2439
Sulphate of soda			1. 5417
Chloride of potassium	10. 4302	12. 1715	
Chloride of sodium	2. 7564	1. 2964	9. 5762
Chloride of magnesium	0. 5840	Trace.	
Chloride of iron	0. 1810	0. 1343	
Carbonate of soda			0. 8234
Carbonate of magnesia			0. 0701
Carbonate of iron			0. 0408
Silica	4. 5552	5. 0808	4. 7479
Lithia	Trace.	Trace.	Trace.

On Burnt Boot Creek, a half mile distant from the Middle Fork of Snoqualmie River, are several large springs having excellent properties for the treatment of rheumatism. Prospectors have quarried out of the solid rock a bath tub of liberal dimensions, and if these springs were made accessible they would become popular. Even in their present condition they have been tested, as evidenced by crutches and canes found in that vicinity.

At Madison, on the line of the Great Northern Railway, is a hot sulphur spring, very similar in taste and temperature to those at Hot Springs on the Northern Pacific Railway, of which analyses are given above. A three-story hotel is in course of construction at this point, and it will undoubtedly prove a popular resort.

On the bank of Money Creek, about 5 miles above Berlin, on the Great Northern Railway, is a small spring said to contain soda and iron, but no chemical analysis has yet been made. Gas constantly escapes from the water. The taste is not unpleasant. This spring is always visited by passing miners, and during the summer months parties frequently camp in the vicinity, to avail themselves of the waters.

On the North Fork of Skykomish River, 5 miles east of Galena, are several large mineral springs, both hot and cold. Being located in a mineral region which has been pretty well explored, these springs are well known to prospectors, but they have no general reputation.

Near Peshastin Creek, in sec. 22, T. 20 N., R. 17 E., is a cold sulphur spring which is generally considered to possess excellent health-giving properties. In

years gone by it was a favorite camping place for the Indian tribes, who came from afar to bathe in its waters. A crude bath house is maintained by persons who have located at this point, but being remote from the main traveled routes, the spring is not of much importance.

On the Little Wenache River, about 8 miles above Lake Wenache, there is said to be a large soda spring of excellent quality. As its exact location was not learned, it was not visited. It is difficult of access and visited only by hunters. It will in time add to the attractions of Lake Wenache, which is destined to become a popular summer resort.

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Professional Paper No. 6.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of the United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Bulletins, Professional Papers, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, Methods of hydrographic investigation; N, Water power; O, Underground waters; P, Hydrographic progress reports. This paper is the third in series H, the complete list of which follows (all are Professional Papers thus far):

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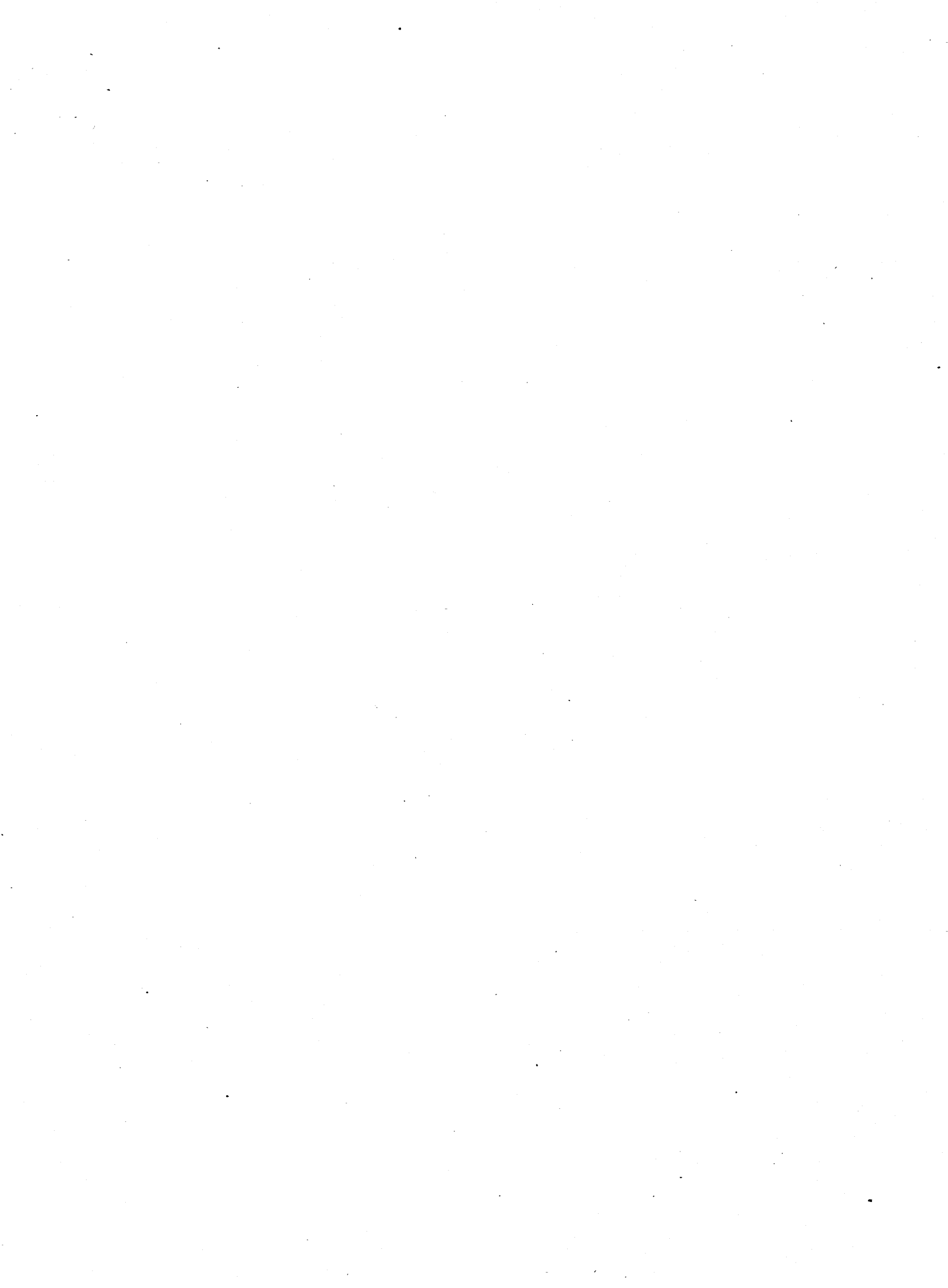
4. The forests of Oregon, by Henry Gannett. 1902. 36 pp., 7 pls.
5. The forests of Washington, a revision of estimates, by Henry Gannett. 1902. 38 pp., 1 pl.
6. Forest conditions in the Cascade Range, Washington, between the Washington and Mount Rainier forest reserves, by Fred G. Plummer. 1902. 42 pp., 11 pls.

Besides the foregoing, three volumes on forestry have been published, as Part V of the Nineteenth, Twentieth, and Twenty-first annual reports, each consisting of several papers.

Correspondence should be addressed to—

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
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Author.

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