

Overview of Forests in Washington State

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Introduction

The name often used, the evergreen state, truly characterizes Washington State as forests cover over half its area. Timber harvesting and outdoor recreation in the forests are of great importance to Washington's economy. At the same time a sound environment is maintained and many acres of undisturbed forests exist. The purpose of this paper is to give an overview of the present status of forests in Washington States. Although descriptions may vary depending on the source, forest management aspects are emphasized in this paper. The intended audience is primarily foreigners who are not familiar with Washington. Almost all the information referred to here is based on recent publications.

The description of Washington forests consists of three aspects; natural forest conditions, forest management situations and socioeconomic analysis of the forest. First, the terrain and the climate of the State are outlined because these two factors fundamentally influence the forests existence and distribution. After a brief description of forest types and tree species which represent each region of the State, the forest resources statistics are shown classifying them by ownership, management objective etc. Secondly, silvicultural information, yield tables and management goals, especially within the concept of multiple use, are explained. A forecast of the timber harvest is also included. Lastly, the present forest policy and social and economic contributions of the forest are summarized.

The paper is framed within the framework of the relationship between forest and people and people's concern for forest management. For those who desire readings on biological aspects, timber products, or international trade related to Washington's forests, appropriate publications are listed in the reference list.

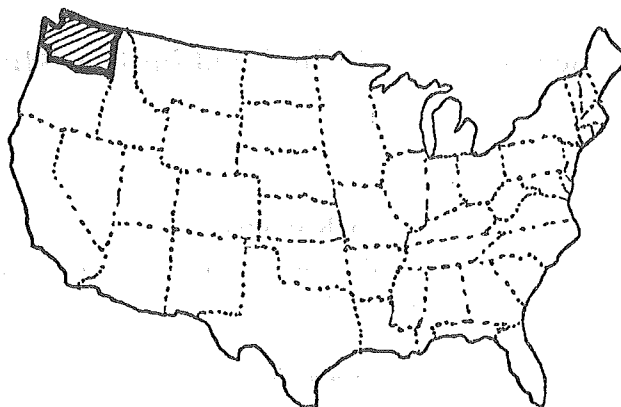


Figure-1 Washington State's location in the U. S. A.

Location, Terrain and Climate

Washington State is located in the northwest corner of the contiguous United States. It is bordered to the north by Canada, to the south by the State of Oregon, to the east by the State of Idaho and by the Pacific Ocean to the west. The total acreage of the State, including inland water is 43,642,880 acres, which is equivalent to around half of the area of Japan. As previously mentioned, 51 percent of the State land is forested. The State can be divided into two regions; west and east of the Cascade Range. These regions form distinct contrasts of forest conditions mainly because of the difference in precipitation.

Western Washington belongs to the Pacific coast forest zone where Douglas-fir, (*Pseudotsuga taxifolia*), western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*) dominate. These coniferous forests provide an abundant timber resource. On the other hand, Eastern Washington belongs mostly to the grassland desert-sagesbrush zone, and partly to Rocky Mountain forest zone where timber harvesting is of low importance whereas other demands on the forest such as watershed control, range management, wildlife and recreational use have high priority. These contrasts between the western and the eastern regions are caused mainly by difference in precipitation, which is strongly affected by the terrain; most importantly, the distance from the coast and the elevation and huge wind barrier effect of the Cascade Range which stretches from north to south in the middle of the State. Figure-2 shows the fundamental relationship between the terrain, precipitation and vegetation.

The State can be geographically classified into five areas as shown in Figure-3;

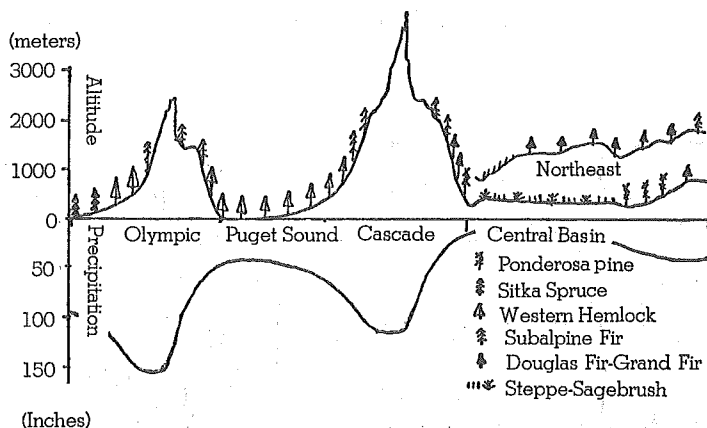


Figure-2 Terrain, precipitation and vegetation

(1) Olympic Peninsula, (2) Puget Sound, (3) Cascade Mountain, (4) Central Basin and (5) Northeast Mountain. Although this classification is crude, it may assist the reader in understanding the basic relationship between climate and forest distribution in the State.

Precipitation varies according to location. The areas of most abundant precipitation (80-150 inches) are on the west side of the Olympic Peninsula and on the western slopes of the Cascade (60-110 inches). The next modest area is the Puget Sound with a range of 30-50 inches/year. The driest areas are located on the eastern slopes of the Cascades and in the Central basin (10-20 inches). The Northeast mountain zone is also dry at a range of 20-40 inches/year. The seasonal distribution of precipitation is shown in Figure-5, in which Seattle and Spokane represent the Puget Sound and the Central basin areas respectively. This type of precipitation in the State is called "wet winter and dry summer" which forms a clear contrast to "wet summer and dry winter" of Tokyo which is located in the monsoon zone.

The annual total snowfall in the Cascade is from 200 to 400 inches. However, the Puget Sound and the low lands of the Olympic Peninsula have little snowfall due to mild winter temperatures.

Normal daily maximum, minimum and average temperatures in Seattle and Spokane are shown in Table-1. The low lands of the Olympic Peninsula and the Puget Sound have mild winters, the minimum temperature in January does not drop lower than freezing point. This enables Douglas fir and other conifers of the temperate climate zone to exist there widely and to grow vigorously. Eastern Washington has a typical continental climate. The daily range between maximum and minimum temperatures is fairly large, and an extreme

contrast between hot summers and cold winters presents severe conditions for tree growth.

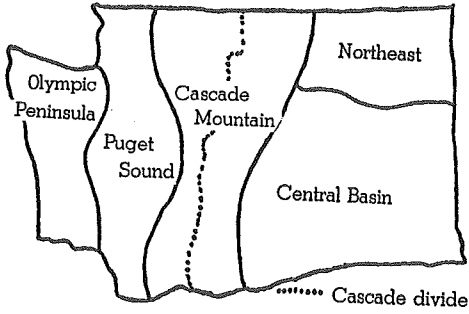


Figure-3 Five areas in Washington State

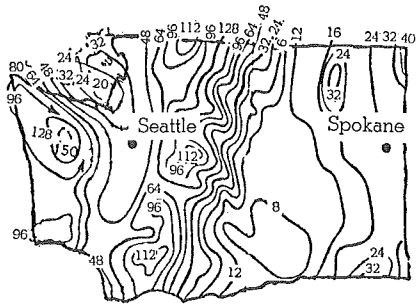


Figure-4 Annual total precipitation (inches)

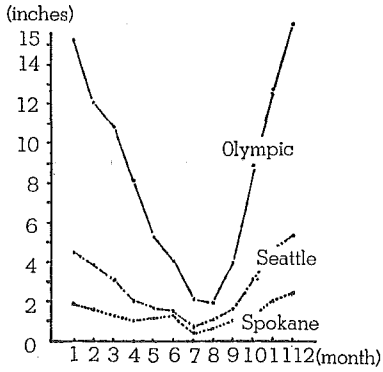


Figure-5 Mean monthly precipitation

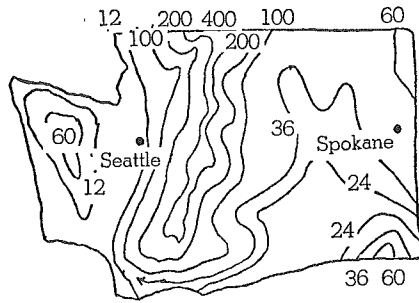


Figure-6 Annual total snowfall (inches)

Table 1 Normal daily maximum, minimum and average temperature (F)

		Seattle											
Month		1	2	3	4	5	6	7	8	9	10	11	12
Max.		44	47	51	58	66	70	76	75	69	60	50	46
Ave.		38	41	44	49	56	60	65	64	60	52	44	41
Min.		33	35	36	41	45	50	54	54	51	44	38	36

		Spokane											
Month		1	2	3	4	5	6	7	8	9	10	11	12
Max.		31	37	47	59	68	74	84	81	73	59	42	35
Ave.		25	30	39	47	56	61	70	68	60	49	35	30
Min.		19	23	29	36	43	49	55	54	47	38	29	24

Forest Types and Distribution

A rough sketch of the North American forest distribution may be useful in understanding the makeup of forests in the State. Forest type is sensitive to local natural conditions. Following is a very rough overview. North America has five forest zones and three non-forest zones. The forest zones are; 1) Pacific coast, 2) Rocky Mountain, 3) Southeastern, 4) Central hardwood and 5) Northern. The non-forest zones are; 1) Intermountain desert-scrub, 2) Great Plains grasslands and 3) Tundra.

The characteristics of each forest zone are described briefly as follows: 1) Pacific coast: a mild climate and abundant precipitation along the Pacific coast enables dense coniferous forest distribution. 2) Rocky Mountain: on higher slopes in the Rocky Mountain areas with cold winters and short growing season in summer, coniferous trees predominate. 3) Southeastern: on the sandy coastal plain of the Southeastern United States, pines and broad-leaved trees are



Figure-7 Forest zones in North America

adapted to drier soils. 4) Central hardwood: rich soil and fairly even precipitation enable the wide distribution of hardwoods, although much of the original forest cover was cleared for development. 5) Northern: this zone has a short growing season and low temperatures. In the far northern area, a few species of conifers, birches and willows dominate. In the Southeast with a rather milder climate, the distribution of conifer and broad-leaved tree mixtures occur.

Washington State is overlapped by the Pacific coast and Intermountain desert-scrub zones. According to the elevation and the precipitation, forests in the State are classified into seven subzones.

(1) Arctic Alpine (AA: Olympic 5500+, Cascade 6500+ feet) This zone is restricted to high peaks of the Cascade and Olympic mountain ranges. No trees grow there, but dwarf shrubs and heathers form extensive mats together with herbaceous plants.

(2) Hudsonian (H: 3000-6500 feet) This is a belt of open coniferous forest with a rich understory of shrubs found immediately below the Arctic Alpine zones. In the wetter meadow, there is an abundance of herbaceous plants forming beautiful flower meadows because of the heavy snow fall and short period

of vegetational activity. The natural succession of the vegetation is seldom allowed to be completed. The trees grow very slowly.

(3) Canadian (C: 2000-5000 feet) The tall dense subalpine coniferous forests are found in Cascades on both sides of the crest, in Olympic mountain and on higher range of the eastern Washington. Snow cover is deep, but because of mild climate with a moderately long growing season for plants, a rich under-story of shrubs and higher productivity of trees are formed.

(4) Humid transition (HTT: sea level to 1500-3000 feet) Below the Canadian zone, lush forests of low land are found on the western slope of the Cascades. This is a humid transition. On the other hand, on the eastern slopes the dense forests gradually give way to open forests and eventually to grasslands and desert. This is an arid transition. The tall forests of the humid transition are dominated by Douglas fir, western redcedar and western hemlock. Lodgepole pine (*Pinus contorta Dougl.*) along the ocean beach and Sitka spruce (*Picea sitchensis (Bong.) Carr.*) on the west side of Olympic peninsula are common. Deciduous trees like red alder (*Alnus rubra Bong.*) are found as early invaders on clear cut areas.

(5) Arid transition timbered (ATT: 1800-3000 feet) At higher parts in this zone, the forest is similar to that of the Canadian zone. With decreasing elevation, several species are replaced by Douglas fir and by ponderosa pine (*Pinus Ponderosa Laws.*). Ponderosa pine forms pure stands on the lower slopes just above the grasslands. Because of drier conditions, the forests are more open and many species of grasses are found there.

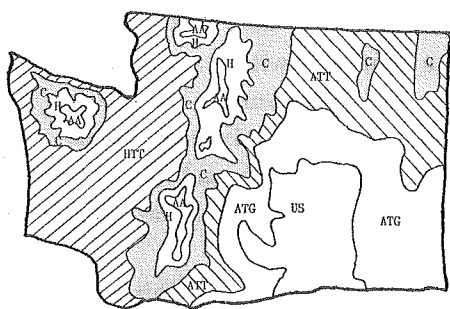


Figure-8 Forst type classification

(6) Arid transition grassland (ATG: 1500-2400 feet) The open ponderosa pine forests of the eastern slopes of the Cascades are gradually replaced by grasslands. There are many broad-leaved species and shrubs are common along streams. This is an agriculture area.

(7) Upper Sonoran (US: 200-1900 feet) The lowlands of the Columbia basin are extremely arid and the lands are predominately of the shrub-steppe.

Forest Areas

In Washington State, especially in the eastern region, forests gradually change into open space, that is, into sage-scrubs or grasslands where the bound-

ary between forest and other lands is not clear. Forest is defined as follows; the land where ten percent of the area is covered by trees, and a minimum area is one acre. Around 22 million acres of forest in the State are categorized by ownership, as federal, state and private forests. Each category is further classified in detail as follows: The federal forests are managed by five organizations; National Park Service, Bureau of Land Management, Bureau of Indian Affairs and the U.S. Forest Service. The state forests are totally managed by the State Department of Natural Resources. The private forests are classified as industry forests with their own milling and processing facilities, and other private forests.

Most of the forests are managed for timber production, watershed, range, wildlife and recreational uses, hence the term "multiple use". However, some of the forests are completely withdrawn from timber utilization and are not expected to produce timber crops. Annual yields are less than 20 cubic feet per acre of industrial wood in natural stands, such forests are defined as non-commercial forests, whereas forests for utilization are defined as commercial forests. The managements in commercial forests are also restricted by many regulations. Table-2 shows the acreage of the forests in the State by ownership and by commercial or non-commercial classes.

Table 2 Acreage of the forests in Washington (1000 acres)

Owner	Total acreage	Commercial	Non-commercial
National Park Service	1,782	—	1,782
Bureau of Land Management	48	38	10
Bureau of Indian Affairs	1,768	1,732	36
Department of Natural Resources	1,827	1,764	63
Forest Service	7,951	5,184	2,766
Private industries	4,369	4,369	—
Other privates	4,496	4,496	—
Total	22,241	17,583	4,657

In commercial forests, 88 percent of the area is coniferous forest where the dominant species are Douglas fir, western hemlock, ponderosa pine, western redcedar, Sitka spruce, grand fir (*Abies grandis*), Lodgepole pine and some other subalpine species. Hardwoods occupy only 12 percent of the area, and are mostly distributed in the western region. The dominant hardwood species are western red alder, birch, big leaf maple (*Acer macrophyllum Pursh*) and aspen (*Populus tremuloides michx.*)

A proper distribution of forest age classes is an important managerial goal.

When a stand is older than 105 years it is referred to as oldgrowth, although the definition of oldgrowth differs by ownership.

Table 3 Conifer and hardwood (1000 acres, commercial forests only)

	Conifer	Hardwood	Total
Western region	7,770 (81%)	1,823 (19%)	9,593
Eastern region	7,750 (97%)	240 (3%)	7,990
Total	15,520 (88%)	2,063 (12%)	17,583

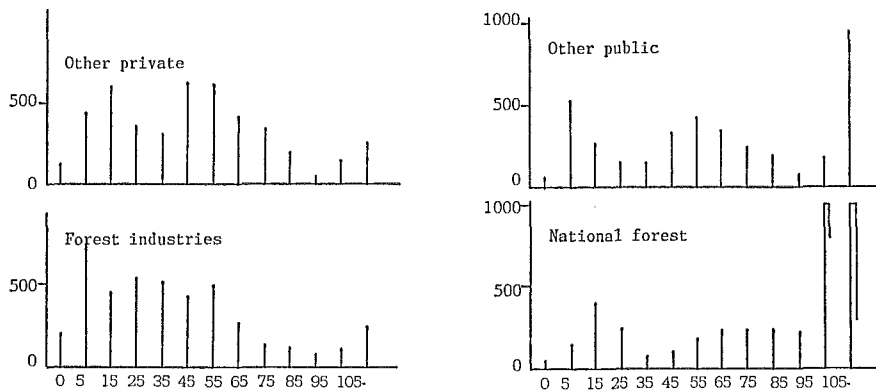


Figure-9 Age class distribution (1000 acres)

Table 4 Age distribution by ownership
Area by age class of all owner (acre)

Age	Conifer			Hardwood	Total
	West	East	Total		
0	432,570	0	432,570	0	432,570
5	848,591	666,949	1,515,540	342,332	1,857,872
15	761,302	741,640	1,502,942	216,797	1,719,739
25	704,634	150,495	855,129	430,609	1,285,738
35	603,938	60,124	664,062	395,325	1,059,387
45	802,735	410,391	1,213,126	272,868	1,485,994
55	844,710	660,052	1,504,762	207,974	1,712,736
65	507,932	685,603	1,193,535	64,624	1,258,160
75	331,440	638,558	969,998	21,886	991,884
85	246,231	517,773	764,004	2,135	766,139
95	137,996	291,677	429,673	5,041	434,714
105+	382,416	1,262,563	1,644,979	8,834	1,653,813
165+	1,220,766	1,915,911	3,136,677	8,863	3,145,540
Total	7,825,261	8,001,736	15,826,997	1,977,289	17,804,286

National Forest

Age	Conifer			Hardwood	Total
	West	East	Total		
0	37,119	0	37,119	0	37,119
5	59,277	84,062	143,339	0	143,339
15	281,594	111,487	393,081	3,968	397,049
25	205,262	34,376	239,638	6,420	246,058
35	40,390	25,841	66,231	5,513	71,744
45	648,654	65,966	714,620	779	715,399
55	75,498	108,494	183,992	879	184,871
65	93,087	124,763	217,850	9,006	226,856
75	82,355	154,327	236,682	0	236,682
85	64,639	194,743	259,382	855	260,237
95	44,729	198,785	243,514	0	243,514
105+	179,318	1,012,215	1,191,533	2,220	1,193,753
165+	1,013,900	686,298	1,700,198	0	1,700,198
Total	2,225,822	2,801,357	5,027,179	29,640	5,056,819

Other public forest

Age	Conifer			Hardwood	Total
	West	East	Total		
0	73,790	0	73,900	0	73,790
5	232,296	265,595	497,891	40,564	538,455
15	97,056	176,241	273,297	204	273,537
25	93,533	29,415	122,948	30,518	153,466
35	110,057	15,616	125,673	30,723	156,396
45	187,341	90,676	278,017	48,941	326,958
55	214,008	142,256	356,264	73,885	430,149
65	118,630	205,874	324,504	20,770	345,274
75	57,820	193,189	251,009	2,270	253,279
85	39,095	156,604	195,699	1,280	196,979
95	22,437	47,205	69,642	210	69,852
105+	60,378	120,137	180,515	270	180,785
165+	118,975	822,827	941,502	100	941,602
Total	1,425,116	2,265,635	3,690,751	249,771	3,940,522

Forest industries

Age	Conifer			Hardwood	Total
	West	East	Total		
0	196,495	0	196,495	0	196,495
5	475,745	145,196	620,941	119,627	740,568
15	306,717	58,212	364,929	83,685	448,614
25	316,388	0	316,388	207,063	526,451
35	315,662	11,058	326,720	186,259	512,979
45	329,504	18,225	347,729	78,985	426,714
55	321,615	102,428	424,043	64,831	488,874
65	102,428	111,379	258,175	16,278	274,453
75	80,727	46,037	126,764	0	126,764
85	71,386	37,244	108,630	0	108,630
95	42,267	23,905	66,172	4,831	71,003
105+	106,632	11,738	118,370	0	118,370
165+	68,486	169,380	237,866	4,831	242,697
Total	2,778,420	734,802	3,513,222	766,390	4,279,612

Other private forest

Age	Conifer			Hardwood	Total
	West	East	Total		
0	125,166	0	125,166	0	125,166
5	81,273	172,096	253,369	182,141	435,510
15	75,935	395,700	471,635	128,904	600,539
25	89,451	86,704	176,155	186,608	362,763
35	137,829	7,609	145,438	172,830	318,268
45	237,236	235,524	472,760	144,163	616,923
55	233,589	306,874	540,463	68,379	608,842
65	149,419	243,587	393,006	18,571	411,577
75	110,538	245,005	355,543	19,616	375,159
85	71,111	129,182	200,293	0	200,293
95	28,563	21,782	50,345	0	50,345
105+	36,088	118,473	154,561	6,344	160,905
165+	19,705	237,406	257,111	3,932	261,043
Total	1,395,903	2,199,942	3,595,845	931,488	4,527,333

Inventory by age class of all owners (million cubic feet)

Age	Conifer			Harwodd	Total
	West	East	Total		
0					
5					
15					
25					
35	1,642	11	1,653		
45	3,598	663	4,261		
55	4,832	1,311	6,143		
65	3,179	1,533	4,712		
75	2,276	1,432	3,708		
85	1,610	1,268	2,878		
95	994	754	1,748		
105+	3,077	3,541	6,618		
165+	10,400	5,953	16,353		
Total	31,608	16,466	48,074	6,157	54,231

Silviculture and Timber Yield

The intensity of management can help to control the health and structure of the forest, especially in the area of timber yields. Silvicultural treatments differ by site and management goals. However, the following 7 types of silviculture regimes can be adopted as a standard;

(1) Natural: without any silvicultural treatment, stand establishment is done by natural regeneration.

(2) Natural+Fertilization: after natural regeneration, fertilization is repeated at ten years intervals.

(3) Plant: stands are established by site preparation and planting. Spraying for brush control is done five years after planting.

(4) Plant+Precommercial thinning: after stand establishment by planting, precommercial thinning is done at age 15.

(5) Plant+PCT+Commercial thinning: after precommercial thinning, commercial thinning takes place at 10 years intervals beginning at age 35 for high site, age 45 for medium site, and age 55 for low site lands, until final harvest.

(6) Plant+PCT+Fertilization.

(7) Plant+PCT+Fertilization+CT.

Current conifer management intensities for each ownership in Western

Washington are shown in Table-5.

Table 5 Conifer management regime, current in the Western Washington (%)

	National Forest	State	Other Public	Forest Industry	Other Private
Natural	—	—	35	1	35
Plant	10	—	20	6	20
Plant+PCT	10	15	10	17	10
Plant+PCT+CT	40	15	10	8	10
Plant+PCT+Fert	10	15	10	38	10
Plant+PCT+Fert+CT	30	55	15	30	15
Total	100	100	100	100	100

In order to examine differences between the management regimes, yields for several regimes on the sites of averages coniferous stands are shown in Figure-10. The site classes are determined according to tree height at age 50; this also explains the productivity in terms of cubic feet annual growth per acre.

Table 6 Site class

Site class	Cubic feet per acre
1	225 or more
2	165 to 224
3	120 to 164
4	85 to 119
5	50 to 84
6	20 to 49

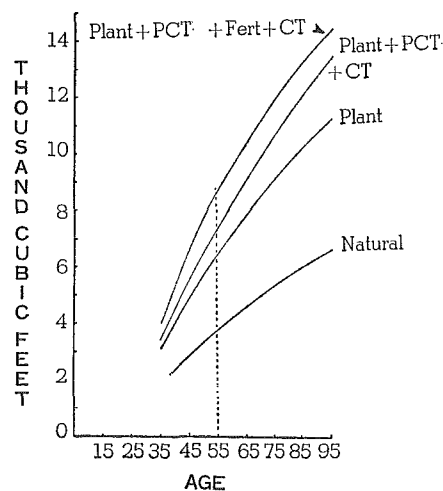


Figure-10 Yield table

The yield tables of Douglas fir and western hemlock, the dominant species of the Washington forests are shown in Table-7 and 8. And the actual yields realized by current management are supposed to be around 80-60% of normal basal area depending on their density.

Table 7 Douglas fir (Cubic feet/acre)

Age	Site Class				
	V Very Low	IV Low	III Medium	II High	I Very High
35	1,330	2,352	3,680	5,491	7,017
45	2,536	3,944	5,725	8,125	10,025
55	3,625	5,397	7,591	10,549	12,832
65	4,578	6,697	9,279	12,767	15,446
75	5,376	7,828	10,787	14,780	17,878
85	6,000	8,778	12,117	16,587	20,137
95	6,433	9,530	13,268	18,189	22,232
105	6,654	10,070	14,241	19,585	24,173
115	7,006	10,511	14,815	20,620	25,064
125	7,284	10,876	15,333	21,272	25,822
135	7,524	11,193	15,784	21,886	26,494
145+	7,744	11,481	16,235	22,490	27,137

Table 8 Western hemlock

Age	Site Class				
	V Very Low	IV Low	III Medium	II High	I Very High
35	976	1,654	2,370	3,316	4,337
45	1,927	3,230	4,584	6,362	8,283
55	2,852	4,640	6,559	9,076	11,798
65	3,715	5,885	8,295	11,458	14,882
75	4,478	6,966	9,792	13,507	17,537
85	5,105	7,881	11,050	15,224	19,761
95	5,559	8,630	12,068	16,608	22,554
105	5,802	9,215	12,847	17,661	22,917
115	6,174	9,595	14,162	19,034	24,383
125	6,452	9,984	15,522	20,320	25,722
135	6,702	10,355	16,610	21,300	26,840
145+	6,933	10,657	17,491	22,120	27,857

Management Goals and Brief History

The goals of forest management today in the United States can be described by the "multiple-purpose" and "sustained-yield". The management goals of forest planners in Washington are also based on these concepts, but people have different expectations of what forest management ought to be. User's attitudes can be classified into three groups; development, conservation and preservation. Those who emphasize "development" see the timber as a basic

source of wealth. On the contrary, those who support preservation expect forest to be preserved as is. The attitude of conservation is between development and preservation. Conservation combines a belief in the need for intensive management with one that requires attention be given to non-timber values of the forest. Different evaluation standards between the timber value and the non-timber values of the forest cause conflicts, which means that finding a resolution is one of the management goals of today.

In order to understand these attitudes toward the forest, a brief historical review is useful. The history of forest management in the United States can be divided into three periods; (1) prior to 1891, (2) from 1891 to 1960 and (3) after 1960. The period prior to 1891 was an era when forests were considered an impediment to development and also an unlimited resource. But, the forests were not unlimited nor unexhaustive. The first forest reserves were created in 1891. Conservation concerns and forestry professional care were established. This was the beginning of a new era of timber management. Modern organizations and planning systems in forestry were introduced as well as research. The U.S. Forest Service was established in 1905 and the Forest Experiment Stations in 1928. The timber resource contributed to growth of timber industries and public interest, at the same time the importance of non-timber values became more obvious. The environmental movement promoted a fundamental changes in management emphasis. The Multiple-use and Sustained-yield Acts was passed in 1960; this is the beginning of the era of multiple use management rather than just timber oriented management.

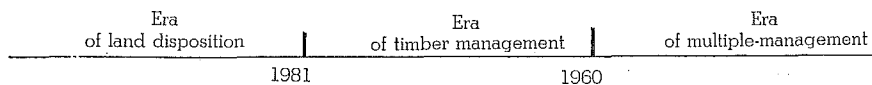


Figure-11 Forest management history

Since 1960 several legislative acts directed toward environmental protection were enacted; the Wilderness Act of 1973, the Natural Environmental Policy Act of 1969, the Endangered Species Act of 1973, the Forest and Rangeland Renewable Resources Planning Act of 1974 and National Forest Management Act of 1976.

The Acts of 1960 define "multiple-use and sustained-yield" as follows: "It is the policy of the Congress that the national forests are established and shall be administered for outdoor recreation, range, timber, watershed and wildlife and fish purposes." "Multiple-use means the management of all the various renewable surface resources of national forests so that they are utilized in the

combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output."

"Sustained yield of the several products and services means the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land". Thus sustained yield has been translated to mean the principle of "non-declining even flow" at the highest level.

Although concepts of multiple use and sustained yield are defined by the act, management practices and planning processes for the concepts have been developing. Public concern for the non-timber production values of forest has been increasing. However the emphasis of their management practices is different according to the owner's standards; industries and state emphasize timber products, but the National Forests respond to the multiple-use forest policy. Finding a proper resolution to the conflicts between users is the primary goal of forest management in Washington today.

Management Planning System

The forest management planning system is mandated by the federal laws;

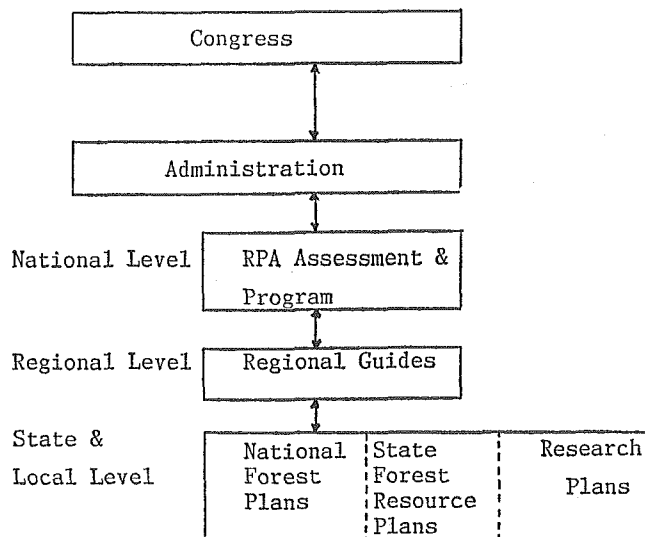


Figure-12 Forest planning system

the Forest and Rangelands Renewable Resources Planning Act, the National Forest Management Act and other related ones. The planning system is organized at three levels, that is, the national level, the regional level and the local level. The national plan provides long range resource assessments and guidelines for recommended management for the National Forests, and for the cooperative state and private forest programs. The regional plan works to transmit the national direction to local forest levels and attempts to respond to regional issues. The local plan includes 125 national forest plans, 37 state forest resource plans and 9 research plans. The forest plan in each national forest provides specific management direction for 10 years and long range direction for the next 50 years.

Forest planning documents include the forest plan, an environmental impact statement (EIS) and a record of decisions. The EIS discloses the environmental conditions and impacts caused by the forest plan alternatives. The forest plan clarifies the management direction and proposes several alternatives. A draft EIS and forest plan are issued for public comments; through this process the public is given an opportunity to influence and change the final plan. The most impressive features of this planning system are public involvement and alternatives. The public is encouraged to be involved in the planning process and it is given several opportunities to express its views for forest management. Through this involvement, public awareness and support for forest management are expected to increase. Since no single plan can meet all the needs, several alternative plans are generally presented to the public and a favorable final plan is selected. Each alternative responds in a different way to the needs.

Concerning the timber harvest, sustained yield and the highest possible level of harvest are emphasized, though further "departure" can be allowed. That is, timber harvest over the sustainable yield level can be planned for a short term due to economic or other reasons.

Timber Harvest Forecast

In Washington the forest products industries are among the most important economic activities. The workers of the forest industries comprise 25 percent of the state's manufacturing workers. In other words, the timber resource is the main use among the multi-purpose management of the forests in the State. Because of that importance, forecasting a long-range timber harvest is necessary. Recently two types of timber harvest forecasts were made. One is based on an economic point of view and the other is made from a biological

point of view. The summary of the biological analysis is explained here.

The commercial forest lands used for the analysis are 17.8 million acres, with an estimated timber inventory for 1980 of 54 billion cubic feet. Timber yields are a function of management regimes. The seven regimes previously mentioned are considered as levels of management intensity, and the following three levels are simulated; 1) extensive, 2) current and 3) intensive. The extensive level means that regeneration is natural, and the intensive is by "plant+ precommercial thinning + fertilization + commercial thinning". The current is mainly based on Table-5 previously shown.

Table 9 Timber harvest forecast
(billion cubic feet)

		1970	1980	1990	2000	2010	2020	2030	2040	2050	2060	
extensive	Conifer in western region	10.143	10.880	10.170	9.468	8.668	8.167	7.507	6.985	6.498	6.185	
	Hardwood in western region	0.685	1.966	1.856	1.777	1.721	1.667	1.634	1.599	1.603	1.569	
	Conifer in eastern region	2.338	2.618	2.618	2.618	2.618	2.618	2.618	2.618	2.618	2.618	
	Total	13.166	15.464	14.644	13.863	13.007	12.425	11.759	11.202	10.719	10.372	
current	Conifer in western region	National forests	1.689	3.161	3.082	3.082	3.005	2.930	2.857	2.857	2.857	2.786
		Other public	1.567	1.907	1.971	1.998	2.027	2.131	2.262	2.286	2.316	2.316
		Forest industries	5.458	4.725	4.607	4.607	4.607	4.856	4.902	4.934	4.953	4.952
		Other private	1.429	1.800	1.710	1.625	1.543	1.616	1.593	1.555	1.529	1.482
		Total	10.143	11.593	11.370	11.312	11.182	11.533	11.614	11.632	11.655	11.536
	Conifer in eastern region	Hardwood in western region	0.685	2.246	2.262	2.276	2.287	1.707	0.535	0.504	0.489	0.556
		Conifer in eastern region	2.338	2.618	2.618	2.618	2.618	2.618	2.618	2.618	2.618	2.618
		Total	13.166	16.457	16.250	16.206	16.087	15.858	14.767	14.754	14.762	14.710
	intensive	Conifer in western region	10.143	12.271	12.398	12.528	12.505	12.759	13.558	14.385	14.411	14.457
		Hardwood in western region	0.685	2.250	2.272	2.287	2.298	1.986	0.979	0.294	0.289	0.286
Conifer in eastern region		2.338	2.618	2.618	2.618	2.618	2.618	2.618	2.618	2.618	2.618	
Total		13.166	17.139	17.288	17.433	17.421	17.363	17.155	17.297	17.318	17.361	

Non-Timber Services

Providing non-timber products is also an important management objective for the forest planner. Six categories of non-timber services have been identified in the State; 1) outdoor recreation, 2) watershed, 3) fish and wildlife, 4) range, 5) minerals and 6) wilderness. In order to maximize these services, quantitative analysis and several economic analysis of non-timber uses of forest are being developed. The inventory of non-timber resources and management assessment methods and presently at an advanced levels.

Outdoor recreation Camping, picnicing, motorized travel, water sports, boating, winter sports, fishing, hunting, riding, hiking, mountain climbing, resort use, recreation residence use, nature study, viewing scenery and visiting exhibits are thought to be common activities of recreation in forest land. There are two supply and demand dimensions to outdoor recreation opportunities. One is for developed areas and sites, the other is for dispersed recreation, where facilities are neither present nor desired.

Table 10 Current recreational use (1000, Washington State)

	Overnight stays			Day use		
	Developed	Dispersed	Total	Developed	Dispersed	Total
National Forest	1,308	668	1,976	2,565	7,519	10,084
National Park	876	—	786	6,739	—	6,739

National Forests=visitor days (12/visitor hours)

National Park Service=visits at site

Table 11 National Forests recreation use (visitor days in 1000, 1978)

	Total	Camping	Picnicing	Driving	Fish Hunting	Hiking. Scenic	Climbing Viewing	Resort use
Developed	5,181	2,616	114					340
Dispersed	8,855	1,336	264	2,641	1,673	2,283		—
Total	14,305	3,952	378	2,641	1,673	2,283		340

	Recreation residence	Winter sports	All other
Developed	323	1,149	908
Dispersed	—	86	572
Total	323	1,235	1,480

Table 12 Forest Service recreational facilities

	Number	Persons at one time capacity	Developed area (acre)
Campgrounds	380	29,600	
Picnic	60	3,500	500
Resorts	14	3,800	300
Residences	77	5,800	1,500
Winter sport area	17	66,600	6,800

As a result of increasing demand, the following problems exist. 1) Over-use of existing areas and facilities, 2) large tracts of land are needed, 3) funds for maintenance and operation of facilities are not adequate, 4) mobility of the participants (with cars, mobile-homes, snowmobiles) cause conflicts in the use of recreational areas.

Basic discussion of management emphasis is focussed on the following two view points, management of land with natural resources primary and human uses secondary, or management of land with human uses primary and natural resources secondary.

Watershed There is an abundant supply of water in Washington. Water resource problems are not a major problems. The timing and intensity of use and water quality are more significant issues. Although the water of the State is of a high quality, many areas in eastern region suffer seasonal degradation of water quality caused by summer time temperatures and agricultural practices. An example of conflict of water use is the need for water for generating electricity coincides with the need for water for fisheries.

Fish and wildlife Increased logging and accelerated reforestation decrease the habitat and diversity of wildlife. Also, increasing urbanization is removing more land from cultivation. More intensive use and conversion of lands is reducing this state's wildlife habitat. Further budgets for wildlife related activities which are mostly dependent on hunting license for their income are limited and not sufficient to support wildlife programs. The percentage of hunters in the population is declining and non-consumptive use of wildlife is dramatically increasing.

Fishery resource contributes to both commercial and sport fishing industries, as well as being attractive for recreation for the public. Chinook, coho salmon and steelhead trout are most important anadromous or sea run species which can all coexist with timbering activities on forest land if streamside

areas are managed to protect habitat. However, poor management of forest, minerals and forage can alter the stream environment and create conflicts.

Range and mineral Forestland can produce forage and brush grasses for domestic and wild grazing stock such as beef cattle, sheep, horses, deer and elk. The forests on the east side of the Cascade are more suitable for grazing. The following minerals are produced in the forest land in the State; cement, coal, sand and gravel, stone, zinc and uranium.

Wilderness Forestlands where the natural conditions are left undisturbed are called wilderness. It produces a variety of non-timber amenities and services, although most of them have no markets. For example, wilderness is used for recreation, watershed, provision of wildlife habitat, protection of endangered species and preservation of unique natural sites. However, the unique nature can be provided by wilderness, other uses can be provided by other forests including commercial forest.

Table 13 Wilderness area (1000 acres)

	Total area	Forested area	Percentage of forestland in the State (%)
Wilderness	3,199	2,001	8.8
Rare II addition	365	311	1.4
Alternative addition	2,635	1,657	7.3
Range of total wilderness plus proposal	3,587-5,834	2,312-3,658	10.1~16.1

Economic Contribution of Forest Products

The most significant contribution of the forest is the harvesting of timber and timber processing in manufacturing industries; lumber, plywood, pulp and paper products, and next important is recreational activities and tourism. Forests provide a variety of recreational opportunities such as wilderness appreciation, backpacking, camping, skiing, hunting and fishing as mentioned before. Forest related jobs accounted about six percent of total state employment, and the actual contribution of forest employees to the state economy is about 23 percent.

Although the timber related employment is projected to decline to 15 percent by the year 2000, the forest production is and can be a main economic

resource in Washington. The decline is the result of the reduction of the commercial timber resource, increases in the productivity of harvest and processing, and the comparatively rapid growth of other sectors. But the employment in recreation and commercial anadromous fisheries is expected increase significantly in the future.

Table 14 Labour productivity
(labour/million board feet/by scribner scale)
(1 scribner scale=0.166 cubic feet)

	1950	1960	1970	1985	1995	2005	2015
Logging	3.04	2.42	1.80	2.12	1.90	1.68	1.45
Sawmill	6.15	5.42	5.36	4.94	4.63	4.39	
Plywood mills	22.38	14.42	12.27	10.48	9.67	9.22	8.47

Table 15 Employment contribution made by forest product
outputs (Annual average)

	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020
Timber related manufacturing	71,267	65,134	56,539	48,872	42,863
Forest related recreation	11,057	12,068	14,633	17,460	21,252
Commercial anadromous fisheries	6,874	7,754	9,451	11,523	14,228
Total	89,198	84,956	80,623	77,855	78,343
Employment contribution in the state employment	5.8	4.4	3.5	3.0	2.6(%)
Employment contribution in the state basic employment	22.7	18.2	16.1	14.8	14.0

The recent slump in the housing market is having a particularly severe impacts on the smaller wood products firms. Employment opportunities are reduced by the closing of many of these mills. The effects of the timber production decline on small communities is serious especially in isolated timber production areas or where forest related activities were labour intensive.

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要 約

ワシントン州の森林

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北米大陸を代表する森林地域であるワシントン州の森林の現状と利用の動向とを林業経営の観点から調査した結果を報告する。資料の多くは大学、州天然資源局、アメリカ林野庁等の出版物に基礎を置いているが、現地踏査および林業関係者との討論を通じて得た著者の視点で本論は構成されている。

なお、これはワシントン大学における在外研究の一部であり、調査実施、原稿校閲について Prof. Dr. G.F. Schreuder から専門的な助言を受けた。

本論は次のような構成になっている。

(1) 地理・地形・気象をとりあげワシントン州の森林の自然立地を明らかにした。太平洋に接した多雨温暖な州の西側は樹木の生育に絶好の立地を備えている。しかし、カスケード山脈を境にして州の東側には極端な乾燥地帯が広がり森林の生存には厳しく著しく対照的である。

(2) 森林区分・分布を明らかにした。マクロな植生区分ではこの州は北米大陸の中で太平洋森林帯および内陸砂漠・かん木帯に属しておりカスケード山脈を中心にして、西側には Douglas fir, western redcedar, western hemlock を主要樹種とする高木針葉樹林が広く分布し、乾燥する東側では疎な ponderosa pine 林と広葉樹かん木林とが散在する。

(3) 森林の所有形態は国・公有が60%を占めるが連邦政府林野庁、国立公園局、内務省（インディアン局・土地管理局）およびワシントン州天然資源局に分れて異なった目的で経営されている。私有林の半分は製材工場をも備えた大林業会社でもっぱら木材生産のために経営されている。森林が経営林と非経営林に明らかに区分されているのが特徴で所有形態・経営目的に合わせて人工林割合とその林齢構成に著しい相異が見られる。

(4) 育林と生長をとりあげ基本的な施業タイプとそれに見合う生長予測とを調べた。施業の集約度により収穫量は大幅に異なり、育林投資と木材生産との経済性に強い関心が向けられている。

(5) 森林の利用・経営については19世紀の土地開拓・森林開墾時代、1890～1960年代の木材生産時代、1960年代以降の多目的利用という歴史的な変遷に要約される。その流れの中で多目的な森林の利用のための経営の理念と社会的な価値観とが生じて来た。同時に保続収穫の考え方が明らかになってきた。

(6) 森林計画制度として、国・公有林では国家計画、地域計画そして単位国有林計画の相互調整が行われると同時に、単位国有林ごとに施業計画と環境影響評価について幾つかの代

替案が提示され、森林の公共的役割に対する地元住民および広く国民の意向を計画に反映させることが制度化されている。

(7) 木材収穫予測の試算から今後30年間は現在の水準の木材供給の能力があるが、施業の集約度しだいで森林資源量の将来水準は大きく変化する。

(8) この州の森林の持つ社会的機能については野外レクリエーション、水保全、魚・野生動物管理、牧草供給、鉱山、原生自然保存の役割が大きく経営の重点が置かれている。この州の森林の経済効用として木材生産が漸減するのに対し、レクリエーションおよび河川の魚資源(サケ)の比重が高まり、ワシントン州における産業、就労の場として大きな比重を保ち続ける。