Avenues to EcoSystem Balance In a Human World

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Introduction

Extending reserves for specific endangered species is a monocular view at least as destructive to humankind as an ever-expanding human population growth without regard to adequate food, shelter and quality of life. Harvests from forests and fields are necessary to sustain the human population. To curtail these harvests for wildlife needs most certainly has an impact on the human species depending on these resources. The world is made up of finite resources. It can sustain only a finite population of species.

This paper describes the development of a two-level analytical model as a pilot trial. The objective is to develop an understanding of the relative impacts of varying goals on human, wildlife and ecosystem dynamics assuming limited geographic dispersion and resources. Oregon and Washington in the United States may be considered a macro level in this trial. Nineteen United States National Forests within these two States may be considered micro models at the second level. Sustained yields of forest products and services are simulated for 100-year periods from each micro model. The sustained yields of these forests are affected by the kind of silvicultural systems being applied in order to meet the demands for ecosystem management.

If the geographic extent of the macro model is constrained, then what human population dynamics can be sustained given the outputs from the forest models. The attempt here is to determine what balance is necessary between the human species and its environment within a specific geographic area. Drawing additional resources from outside the model would be depleting someone else's balance.

The objective of this paper is to draw attention to the quantifiable aspects of ecosystem management and what is already known about demands for and production of forest resources.

Pacific Northwest National Forests

Visualize the forests of the United States Pacific Northwest. These forests are made up of mostly intolerant species primarily including Douglas-fir (Pseudotsuga menziesii) and Ponderosa pine (Pinus ponderosa). Associated species include Western white pine (Pinus monticola), Noble fir (Abies nobalis), Western larch (Larix occidentalis) and Lodgepole pine (Pinus contorta).

As these stands advance in time without management or catastrophic events, such as fire or disease, they evolve into mixtures including Pacific silver fir (Abies amabilis), Grand fir (Abies grandis), White fir (Abies concolor) and Sitka spruce (Picea sitchensis). Moist coastal forests develop more tolerant mixtures including Western hemlock (Tsuga heterophylla) and Western red cedar (Thuja plicata).

Tolerance is judged largely by crown density, ability to clean the bole, and the ability of reproduction to take hold and develop under fairly dense crown canopies (Baker, 1950). Prior to the arrival of Europeans to America, native tribes and lightning provided frequent, light fires throughout the forests of the Northwest. As the tribes declined (due to European diseases and invasion) and the U.S. Forest Service developed the Smokey Bear anti-fire campaign (early 1900s), the forests have been allowed to evolve into more tolerant mixtures of species. For these reasons most forests of the Northwest are made of trees less than a few hundred years of age and still contain mostly intolerant species.

While there are many other plant and animal species that live and die in these forests, the mixtures and magnitudes of all species are dependent upon and determined by the primary tree species which characterize each forest. Therefore, the principal silvicultural regime that is chosen for management of these forests will determine the future for all plant and animal species that make up the nature of these forests of the Western United States.

The U.S. Forest Service has divided the public forests of the Northwest into nineteen National Forests averaging approximately 1,200,000 acres (500,000 hectares) each. The databases for these forest inventories were downloaded from the Internet and loaded into Microsoft Access databases. Each database contains the complete, actual tree records from permanent plots distributed systematically across each National Forest. Each cluster of plots were compiled to produce species, age, size, structure tables that now characterize the variety of stand composition and distribution within each National Forest. After setting aside roads, stream buffers (following State regulations by class of stream) and lands not capable of at least 40 feet (12 meters) of height in fifty years (Site Index 40-feet), we have approximately 11.6 million acres (4.7 million hectares) of productive, sustainable forest. These nineteen forest databases are the basis upon which the analyses and comparisons are drawn for this paper (See Table 1.). They range from sea level to over 6,000 feet (2,000 meters) elevation and site productivity from 0 to 130 feet (40 meters) of height in fifty years. Productivity is inversely linear to elevation in this region. This fact increases in significance when we review the databases to find that current age class distributions reflect the impact of extensive, lower-elevation railroad logging in the early 1900s.

Methods of Analysis

As each database was compiled to develop the species, age, size, density structure of each cluster of plots, a few other indices were also computed. These include a *site productivity index* (dominant height in fifty years) and a *stand clumpiness index*. The stand clumpiness is a measure of the uniformity of stocking among plots in each stand or cluster. Tree dimensions (diameter and height) provide the means to estimate an index to vertical distribution while among plot variation provide the means to estimate an index to horizontal distribution. Plots in an even-aged plantation will produce low clumpiness indices while plots in all-aged, mixed species natural stands will produce high clumpiness indices. Both of these indices were compiled and stored for each cluster of plots in every database.

Each of these nineteen forests were then grown forward for 100 years with summaries produced at each decade (i.e., 2000, 2010, ….2090) written back to each database. The Forest Projection System (FPS Version 5.1) (Arney, 1996-97) was used to project these stands because it contains:

- Most recent and complete calibration against observed permanent growth plots;
- Calibrated for over twenty tree species of the Northwest;
- Uses an Individual Tree, Distant Dependent model driven by Site and Clumpiness;
- Directly reads and writes to Microsoft Access databases;
- Has facility to reflect survival and growth impacts from site preparation, brush control, planting, thinning and fertilization as well as from variation in site productivity and stand clumpiness; and,
- Applies a common tree taper volume function so that all species and forests may be compared on a standard set of merchantability and valuation specifications.

Volumes for all species on all National Forests were computed using 1-foot (0.3-meter) stumps, 32-foot (9.75-meter) logs, 6-inch (15-centimeter) minimum log diameters, 8-inch (20-centimeter) minimum tree diameter at breast height and 5% deductions for hidden defect and breakage. Logs were valued by the following (US$/1000 board feet):

Species	**6-inch logs**	**12-inch logs**	**16-inch logs**
Douglas-fir	$500	$607	$775
Red cedar	525	585	700
Western hemlock	420	505	700
True firs	314	405	620
Hardwoods	314	405	405

Management costs included $75/acre for site preparation, $185/acre for planting, $75/acre for brush control, $150/acre for spacing and $5/acre/year for overhead expenses. Logging costs were $170/Mbf (1000 board feet) for skidders, $200/Mbf for cable systems (over 40% slope) and $390/Mbf for helicopter (over 70% slope).

Four major silvicultural regimes were compared on each National Forest. These regimes are defined (Smith, 1962) and applied as follows:

Even-aged Stand Development

<u>Clearcut Regime</u> – removal of the entire stand in one cutting with reproduction obtained artificially through planting of species and densities defined by Forest and elevation;

<u>Seed Tree Regime</u> – removal of the mature timber in one cutting, except for a small number of seed trees (4-8 per acre or 10-20 per hectare) left singly or in small groups with fill planting to supplement natural seed fall;

Shelterwood Regime – the removal of the mature timber in a series of cuttings, which extend over a relatively short portion of the rotation. This encourages the establishment of essentially even-aged reproduction under the partial shelter (16-32 per acre or 40-80 per hectare) of seed trees through natural seed fall;

Uneven-aged Stand Development

Selection Regime – removal of the mature timber, usually the oldest or largest trees, either as single scattered individuals or in small groups at relatively short intervals (3-6 cuts per 100-years). These cuts are repeated indefinitely, by means of which the continuous establishment of reproduction is encouraged through natural seed fall and an uneven-aged stand is maintained.

In each of the Seed Tree and Shelterwood Regimes the residual seed trees were never included in the total harvested volumes because of the recent insistence from State and Federal wildlife staff that these trees should contribute to standing snags and down woody debris accumulations.

Plantations were stocked at 300 trees per acre (740 per hectare) on low site productivity (less than 24m Site Index) and 350 trees per acre (860 per hectare) on all higher sites. Seed Tree Regimes were fill planted to these same densities where natural seed fall was inadequate. Preferred species for planting varied by National Forest and elevation zone as detailed in the following table:

National Forest	Low Zone	Elevation Limit (m)	High Zone
Colville	Douglas-fir		
Deschutes	Ponderosa pine	1500	Douglas-fir
Fremont	Ponderosa pine	1500	Douglas-fir
Gifford Pinchot	Douglas-fir	1200	Noble fir
Mt. Hood	Douglas-fir	1200	Noble fir
Malheur	Ponderosa pine	1500	Douglas-fir
Ochoco	Ponderosa pine	1500	Douglas-fir
Okanogan	Douglas-fir	1400	Noble fir
Olympic	Douglas-fir	900	Noble fir
Rogue	Douglas-fir	1500	Noble fir
Siskiyou	Douglas-fir		
Siuslaw	Douglas-fir		
Snoqualmie	Douglas-fir	900	Noble fir
Umatilla	Ponderosa pine	1200	Douglas-fir
Umpqua	Douglas-fir	1500	Silver fir
Wallowa-Whitman	Ponderosa pine	1200	Douglas-fir
Wenatchee	Douglas-fir	1400	Noble fir
Willamette	Douglas-fir	1200	Noble fir
Winema	Ponderosa pine	1500	Red fir

A 100-year planning period was used in order to evaluate the alternative regimes as influenced by at least a one-third turnover to 2nd rotation yields under the plantation and natural stand development of each regime. This results in a slight, but general, increase in sustainable yield levels as the forest comes under a continuous, full-stocking implementation. Clearcuts were limited to 120 acres (48 hectares); but the average stand size is closer to 25 acres (10 hectares) on these forests with some as small as one acre.

Results

Table 5 and its associated chart show the results of each of the major silvicultural regimes on the Gifford Pinchot National Forest. Table 1 shows the summaries from all nineteen individual forests in cubic meters and hectares. Table 2 displays the same information in Scribner board feet and acres. A *potential sustainable forever,* annual harvest of approximately 3 billion board feet will be reduced by 23% under seed tree regimes, 44% under shelterwood regimes, 59% under selection regimes and over 90% under current USFS practices.

Table 3 presents the accumulative net income from harvests in US dollars from each of the regimes. The *potential sustainable forever,* annual harvest income is approximately $1 billion per year. Moving to a selection-type forestry practice will reduce this by about 58 percent. Current USFS practices and policies have created a net negative cash flow into the US Forest Service rather than any outflow. County school district budgets based on net income from these lands are severely and permanently impacted by these new practices.

Table 4 provides some insight into the trends in major species composition after 100 years if each of these major silvicultural regimes is applied consistently throughout the period. It is quite obvious that moving to a selection-type regime for the intolerant species mixes of the Northwest will result in the end of the Douglas-fir and Ponderosa pine forests. Applying the selection-type thinning treatments will hasten this transition because the larger Douglas-fir and Ponderosa pine will be removed first to make the thinnings viable economically. Neither of these species will re-establish themselves under forest cover at these density levels. The resulting species will be hemlock, spruce, cedar and true fir. All non-tree species and wildlife species common to the Douglas-fir and Ponderosa pine forests will be impacted by this new selection forestry practice. Population densities of these other species will undergo changes to levels for forest types that have never existed in this region in recorded history. To change from clearcut regimes to selection regimes in the Northwest is making a huge change in future non-tree species, wildlife species, insect dynamics, disease potentials and wildfire intensity. Douglas-fir and Ponderosa pine exist here in abundance because they are volunteer species on open ground after fire, volcanoes and clearcuts. The natural (undisturbed) transition is to more tolerant species of hemlock and true fir; but, as observed in the forests that Lewis and Clark found in 1804-6, the major species were Douglas-fir and Ponderosa pine. This is because periodic catastrophic events (fire, weather, earthquakes) throughout Northwest history have resulted in these forests returning to Douglas-fir on a regular basis.

If we have learned anything from observing Northwest natural history, it is that these forests have repeatedly returned to the intolerant species of Douglas-fir and Ponderosa pine on a regular basis. If we chose not to emulate fire by applying small clearcuts throughout the forest, then nature will apply fire over large contiguous areas in its own harvest. We may not be pleased with the result.

As is observed in these Tables, the tradeoff of moving away from Clearcut regimes in the U.S. Northwest toward Shelterwood and Selection regimes results in the following:
- Major impacts on long-term sustained yield of forest products (59% reduction)
- Major impacts on forest-provided School and Road revenues (58% reduction)
- Major impacts on tree species mixtures and associated wildlife (end of Douglas-fir)

Conclusions

Before we rush off in new directions with regard to managing existing intolerant-species forests, it would be worthy of our time and consideration to evaluate the consequences. In an effort to protect existing plant and animal species by a "kinder and gentler" forestry we may be causing more damage than good.

Using the results from the projection of these nineteen National Forest inventories and a reasonable set of silvicultural specifications, it is quite clear that:

- These impacts of the new silviculture regimes are not generally understood
- Current decisions to do away with clearcutting will have long-term impacts
- These decisions will most likely do away with Douglas-fir as a major species
- Intolerant species forests will be replaced with tolerant species forests
- About $1 billion annual revenue is severely reduced or lost
- More analytical analyses and discussions of impacts are needed

One obvious conclusion is that the U.S. public will continue to use wood products. If these products are not produced locally, then from where will they come? Currently the United States uses about 50.7 billion board feet of wood each year. That is equal to about 208 board feet per person per year. On that basis, the population of Washington and Oregon (7,262,000 persons) demands about 1.5 billion board feet of wood each year. These forests have the capacity to produce about twice that quantity.

Using one-half of the wood products demand per person (100 bdft/yr) of the U.S., it is also obvious that Italy with a population of 57.5 million people requires another 5.7 billion board feet annually forever! Italy provides nearly none of its own wood requirements. Which forests from which country will supply these needs?

As Curtis (1998) summarized so well in a recent Journal of Forestry article, "*Conflicts often arise between political and social pressures, economics, and inherent biological limitations, and compromise is often needed, within the bounds of biological feasibility*." (This author provided the underlining.) As forestry professionals, we must provide the details and range of impacts of making various policy decisions. So far much decision-making has gone on with limited or no analyses of impacts. We have sufficient documented history to know that this is not a logical path to follow. The following summary is taken from the textbook, "The Practice of Silviculture", by David M. Smith.

> *"No account of the selection method would be complete without mention of the half-forgotten attempt to apply the economic-selection method in the virgin forests of the Douglas-fir and associated species in the Northwest. This policy proved disastrous because partial cuttings in these ancient forests opened the way for accelerated deterioration of residual stands under the attacks of insects, fungi, and atmospheric agencies (Munger, 1950; Isaac, 1956). Furthermore, the method was unsuitable for the regeneration of Douglas-fir, which is less tolerant than its competitors in this particular region. The selection method is applicable to Douglas-fir only in dry situations where it grows as a physiographic climax in relatively open stands.*
>
> *The failure of the selection method in West Coast Douglas-fir is an outstanding example of the difficulty of attempting to convert over-mature stands into productive units by selection cutting."* Smith, 1962, page 511-512

Literature Cited

Arney, James D. 1996-97. Calibration of the Forest Projection System for Western Oregon and Western Washington. Forest Biometrics Reports.

Baker, Fredrick S. 1950. Principles of Silviculture. McGraw-Hill Book Company. New York. 414pp.

Curtis, Robert O. 1998. "Selective Cutting" in Douglas-fir, History Revisited. Journal of Forestry. 96(7):40-46.

Isaac, L.A. 1956. Place of partial cutting in old-growth stands of the Douglas-fir region. USDA Forest Service. Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. Research Paper No. 16.

Munger, Thorton T. 1950. A look into selective cutting in Douglas-fir. Journal of Forestry. 48(1):97-99.

Smith, David M. 1962. The Practice of Silviculture. 7th Edition. John Wiley & Sons, New York. 578pp.

Table 1. First Decade Annual Harvest Volume based on a 100-year Planning Period.

National Forest	Gross Hectares	Net Hectares	Cubic Meters (x1000) Clearcut	Seed Tree	Shelterwood	Selection
Colville	444,927	359,279	824	653	454	312
Deschutes	649,629	112,212	258	208	143	101
Fremont	449,844	27,803	47	45	29	18
Gifford Pinchot	555,218	428,022	1,929	1,592	1,147	837
Mt. Hood	371,252	293,137	1,378	1,087	784	571
Malheur	590,830	70,050	140	125	84	59
Ochoco	388,086	110,567	117	97	62	49
Okanogan	690,381	267,390	580	443	302	207
Olympic	255,888	195,535	936	759	564	405
Rogue	254,947	205,870	818	642	458	326
Siskiyou	442,819	356,128	1,311	1,067	765	548
Siuslaw	254,940	205,870	1,645	1,267	921	656
Mt. Baker-Snoqualmie	478,287	215,169	968	826	596	428
Umatilla	566,549	227,306	552	438	307	217
Umpqua	398,447	321,093	1,527	1,185	856	627
Wallowa-Whitman	994,072	225,377	521	420	288	205
Wenatchee	630,979	351,162	903	724	518	358
Willamette	678,000	533,976	2,944	2,311	1,661	1,216
Winema	445,145	182,785	340	282	186	121
Totals	**9,540,240**	**4,688,731**	**17,738**	**14,171**	**10,125**	**7,261**
% of Clearcut			**100%**	**80%**	**57%**	**41%**

Table 2. Mean Annual Harvest Removals over a 100-year Planning Period.

			Scibner BdFt	(x1000)		
National Forest	**Gross Acres**	**Net Acres**	**Clearcut**	**Seed Tree**	**Shelterwood**	**Selection**
Colville	1,099,460	887,814	145,481	102,286	74,641	52,200
Deschutes	1,605,297	277,287	42,892	33,318	24,014	17,559
Fremont	1,111,610	68,703	8,488	6,607	4,668	3,440
Gifford Pinchot	1,372,000	1,057,684	331,043	268,297	196,656	146,410
Mt. Hood	917,402	724,372	229,847	179,638	130,658	95,748
Malheur	1,460,000	173,100	23,025	20,143	14,753	10,747
Ochoco	959,000	273,223	22,411	18,223	12,592	10,341
Okanogan	1,706,000	660,747	90,571	70,143	50,821	36,866
Olympic	632,324	483,187	164,678	132,418	100,013	72,002
Rogue	630,000	508,725	143,779	112,698	81,246	59,214
Siskiyou	1,094,250	880,029	237,786	187,846	136,633	100,871
Siuslaw	630,000	508,725	339,812	243,779	175,870	127,818
Mt. Baker-Snoqualmie	1,181,894	531,704	166,511	140,529	102,568	73,462
Umatilla	1,400,000	561,695	89,508	68,356	49,161	35,684
Umpqua	984,602	793,454	276,914	209,038	152,051	111,952
Wallowa-Whitman	2,456,451	556,928	83,801	64,910	46,839	33,825
Wenatchee	1,559,213	867,757	144,190	113,635	81,777	59,022
Willamette	1,675,407	1,319,508	535,274	404,747	293,550	214,968
Winema	1,099,999	451,681	57,402	45,683	32,484	22,862
Totals	**23,574,909**	**11,586,323**	**3,133,413**	**2,422,294**	**1,760,995**	**1,284,991**
% of Clearcut			**100%**	**77%**	**56%**	**41%**

Table 3. First Decade Annual Harvest Income based on a 100-year Planning Period.

			US$ Values (x1000)			
National Forest	**Gross Acres**	**Net Acres**	**Clearcut**	**Seed Tree**	**Shelterwood**	**Selection**
Colville	1,099,460	887,814	31,828	25,032	17,399	12,445
Deschutes	1,605,297	277,287	19,213	15,263	10,661	7,766
Fremont	1,111,610	68,703	2,708	2,534	1,737	1,063
Gifford Pinchot	1,372,000	1,057,684	103,341	84,469	60,948	43,938
Mt. Hood	917,402	724,372	75,463	60,524	43,653	30,883
Malheur	1,460,000	173,100	5,564	4,970	3,351	2,348
Ochoco	959,000	273,223	5,182	4,403	2,952	2,526
Okanogan	1,706,000	660,747	20,094	15,808	10,672	8,008
Olympic	632,324	483,187	48,837	39,894	29,260	21,560
Rogue	630,000	508,725	51,848	41,697	30,403	22,689
Siskiyou	1,094,250	880,029	79,738	64,405	46,684	36,208
Siuslaw	630,000	508,725	132,064	103,084	74,269	59,191
Mt. Baker-Snoqualmie	1,181,894	531,704	45,696	39,182	28,348	18,990
Umatilla	1,400,000	561,695	22,092	17,719	12,446	8,763
Umpqua	984,602	793,454	102,529	79,941	57,769	41,063
Wallowa-Whitman	2,456,451	556,928	21,772	17,811	12,419	8,957
Wenatchee	1,559,213	867,757	39,001	31,845	22,738	16,054
Willamette	1,675,407	1,319,508	184,230	142,872	102,611	73,487
Winema	1,099,999	451,681	13,568	11,085	7,668	5,543
Totals	**23,574,909**	**11,586,323**	**$1,004,768**	**$802,538**	**$575,988**	**$421,482**
% of Clearcut			**100%**	**80%**	**57%**	**42%**

Table 4. Ending Major Species Composition based on a 100-year Planning Period.

National Forest	Gross Hect.	Net Hectares	Major Species Clearcut	Major Species Seed Tree	Major Species Shelterwood	Major Species Selection
Colville	444,927	359,279	DF	DF / PP	DF / GF	GF / WH
Deschutes	649,629	112,212	PP / DF	PP / DF	DF / GF	GF / WH
Fremont	449,844	27,803	PP / SF	PP / SF	PP / SF	SF / PP
Gifford Pinchot	555,218	428,022	DF / NF	DF / SF	SF / DF	SF / WH
Mt. Hood	371,252	293,137	DF / NF	DF / SF	WH / DF	WH /SF
Malheur	590,830	70,050	PP / DF	PP / DF	DF / GF	DF / GF
Ochoco	388,086	110,567	PP / DF	PP / DF	DF / PP	DF / GF
Okanogan	690,381	267,390	DF / NF	DF / SF	DF / GF	GF / WH
Olympic	255,888	195,535	DF / NF	DF / WH	DF / WH	WH / RC
Rogue	254,947	205,870	DF / NF	DF / SF	SF / DF	SF / WH
Siskiyou	442,819	356,128	DF	DF / WH	DF / SF	SF / WH
Siuslaw	254,940	205,870	DF	DF / WH	DF / WH	WH / SS
Mt. Baker-Snoqualmie	478,287	215,169	DF / NF	DF / SF	DF / WH	WH / SF
Umatilla	566,549	227,306	PP / DF	DF / PP	DF / GF	GF / DF
Umpqua	398,447	321,093	DF / SF	DF / SF	DF / WH	WH / SF
Wallowa-Whitman	994,072	225,377	PP / DF	PP / DF	DF / GF	GF / DF
Wenatchee	630,979	351,162	DF / NF	DF / WH	DF / WH	WH / SF
Willamette	678,000	533,976	DF / NF	DF / WH	WH / DF	WH / SF
Winema	445,145	182,785	PP / RF	PP / SF	PP / SF	SF / WH
Totals	**9,540,240**	**4,688,731**				

Table 5. Mean Annual Harvest Removals on the Gifford Pinchot NF

		Scribner BdFt	(x1000)	
Period	Clearcut	Seed Tree	Shelterwood	Selection
2000	314,218	259,908	187,126	138,936
2010	317,490	261,581	188,921	140,615
2020	320,445	263,870	191,586	142,674
2030	325,950	266,001	194,268	144,804
2040	330,024	269,194	196,986	145,381
2050	334,982	270,697	199,104	147,018
2060	335,117	271,261	201,351	149,739
2070	339,303	272,636	201,913	151,061
2080	337,368	273,373	202,626	151,604
2090	355,532	274,445	202,671	152,261
Average	**331,043**	**268,297**	**196,655**	**146,409**
	100%	**81%**	**59%**	**44%**