The Economic Benefits of Old-Growth Forests in the Pacific Northwest:

An Overview

Prepared for

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I. BACKGROUND

For many observers, May 29, 1991, marks a turning point in the management of forests in Washington, Oregon, and northern California. On that date in Seattle, Federal District Judge William Dwyer ended almost all logging on 17 national forests in these three states until the U.S. Forest Service (USFS) and other federal resource-management agencies could demonstrate that they had cured logging-related violations of the nation's environmental laws. In particular, Judge Dwyer issued an injunction forbidding the Forest Service from selling more timber in habitat suitable for the northern spotted owl, a species threatened with extinction, until it could provide assurance that it could sell timber without significantly undercutting the species' continued survival.

The injunction stimulated a process that, in 1994, produced the Northwest Forest Plan (NWFP) covering 24.5 million acres of federal lands in western Washington, Oregon, and northern California. Much of the NWFP focuses on providing adequate habitat for northern spotted owls, marbled murrelets, salmon, and other species having a close association with the old-growth forests of this region. Within the confines of the NWFP, the term old-growth forest has a specific definition:

> A forest stand usually at least 180-220 years old with moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; high incidence of large trees, some with broken tops and other indications of old and decaying wood (decadence); numerous large snags; and heavy accumulations of wood, including large logs on the ground.[1]

A common criticism of the NWFP is that its restrictions on logging old-growth forests are bad for the economy. According to this view, forests benefit the economy primarily when they are converted into commodities and, hence, restrictions on logging of old-growth forests deprive American consumers of the lumber, paper, and other commodities that could be produced if old-growth trees were converted into logs.

This view, however, overlooks the economic benefits that residents of the region and other Americans derive from old-growth forests, i.e., from trees left standing rather than cut down. To understand these benefits it is useful to recognize that forests are economically important not just when they produce commodities but also when they provide services, such as providing habitat for at-risk species or producing and regulating the flow of clean water. Over the past several decades, economists and ecological scientists have examined the processes, called ecosystem functions, by which old-growth forests and other ecosystems

[1] Regional Ecosystem Office. 2006. *Northwest Forest Plan (NWFP) Overview.* http://www.reo.gov/general/aboutNWFP.htm (accessed August 30. 2006). To many people, the definition is simpler: an old-growth forest is one with big trees. For the purposes of this report, we blur the distinctions and take a broad perspective on the meaning of old-growth forest.

Table 1. Functions, Goods, and Services of Old-Growth Forest Ecosystems

Functions	Examples of Goods and Services Produced
Production and regulation of water	Forests capture precipitation; filter, retain, and store water; regulate levels and timing of runoff.
Formation & retention of soil	Forests accumulate organic matter, and prevent erosion to help maintain productivity of soils.
Regulation of atmosphere & climate	Forest biota produce oxygen, and help maintain good air quality and a favorable climate.
Regulation of disturbances	Forests reduce flood damage by storing flood waters, and reducing and slowing flooding.
Regulation of nutrients and pollution	Forests improve water quality by trapping pollutants before they reach streams and aquifers.
Provision of habitat	Forests provide habitat for flora and fauna.
Food production	Forests convert solar energy into edible plants and animals.
Production of raw materials	Forests produce wood fiber, mushrooms, streams with energy convertible to electricity.
Pollination	Insects facilitate pollination of wild plants and agricultural crops.
Biological control	Birds, bats, and microorganisms control pests and diseases.
Production of genetic & medicinal resources	Genetic material in forest plants and animals provide potential basis for drugs and pharmaceuticals.
Production of ornamental resources	Products from forest plants and animals provide materials for handicraft, jewelry, worship, decoration, and souvenirs
Production of aesthetic resources	Trees, wetlands, riparian vegetation, and streams provide basis for enjoyment of scenery.
Production of recreational resources	Forests provide basis for outdoor sports, eco-tourism.
Production of spiritual, historic, and cultural resources	Forests serve as basis for group identity, spiritual renewal, folklore.
Production of scientific and educational resources	Forests provide inputs for research and focus for on-site education.

Source: Adapted by ECONorthwest from De Groot, R., M. Wilson, and R. Boumans. 2002. "A Typology for the Classification, Description and Valuation of Ecosystem Functions, Goods and Services." *Ecological Economics* 41: 393-408; Kusler, J. 2003. *Assessing Functions and Values.* Institute for Wetland Science and Public Policy and the Association of Wetland Managers, Inc.; and Postel, S. and S. Carpenter. 1997. "Freshwater Ecosystem Services." in *Nature's Services: Societal Dependence on Natural Ecosystems*. Edited by G.C. Daily. Washington, D.C.: Island Press, pgs. 195-214.

produce economically valuable goods and services. They've found it useful to segregate the functions, goods, and services into categories, such as those illustrated in Table 1.[2]

[2] For more about ecosystem goods and services, we recommend: National Research Council of the National Academies. 2004. *Valuing Ecosystem Services: Toward Better Environmental Decision-Making*. National Academies Press.

Determining the value of the services derived from old-growth forests is generally far more difficult than measuring the value of the commodity goods, such as logs and lumber, derived from these forests. Most forest-related services are not easily traded in markets and do not have monetized prices attached to them. This difference does not, however, mean that the services are necessarily less valuable. Instead, it means economists must use a variety of techniques to determine the value of the services. In the remainder of this report we provide an overview of the findings of research regarding several categories of services provided by old-growth forests of the NWFP. We look separately at research findings that substantiate these conclusions:

A. Old Growth Forests Support many Terrestrial and Aquatic Species

B. Old-Growth Forests and the Habitat They Provide Have Economic Value

C. Old Growth Forests Increase Water Supplies and Provide Valuable Water-Regulation Services

D. Old-Growth Forests Provide Valuable Recreational Opportunities

E. Old-Growth Forests Can Strengthen Local Economies

F. Old-Growth Forests Protect Valuable Assets

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A. OLD GROWTH FORESTS SUPPORT MANY TERRESTRIAL AND AQUATIC SPECIES

Many species depend on the old-growth forests of western Washington, Oregon, and northern California to survive. Scientists have looked separately at this relationship for terrestrial species and for those that either live in or depend heavily on streams in old-growth forests.

Habitat for Terrestrial Species

More than 1,000 terrestrial species are closely associated with old-growth forests on federal lands in western Washington, Oregon, and northern California, as shown in Table 2:[3]

Table 2. Terrestrial Species Closely Associated with Old-Growth Forests, by Species Group

Fungi	527
Bryophytes	106
Lichens	157
Vascular Plants	124
Mollusks	102
Amphibians	18
Birds	38
Mammals	26
Total species	1,098

In addition, 15 functional groups of arthropods may contain as many as 7,000 individual species that are closely associated with old-growth forests.

Habitat for Water-Related Species

Within the range of the northern spotted owl in Washington, Oregon, and California, more than 100 stocks of salmon, steelhead, and other anadromous salmonid fish are already extinct, and an estimated 314 stocks are at risk of extinction. Of these, 259

[3] Forest Ecosystem Management Assessment Team (FEMAT). 1993. *Forest Ecosystem Management: An Ecological, Economic, and Social Assessment.* Forest Service, Fish and Wildlife Service, National Marine Fisheries Service, National Park Service, Bureau of Land Management, and Environmental Protection Agency. 794-478. July. pp. IV-19 – IV-20. FEMAT scientists used the term, late-successional forest, rather than old-growth forest, to describe the habitat for these species. We use the broader, more easily recognized term.

stocks depend on federal lands. Anadromous salmonids in these states are especially dependent on having high-quality freshwater in streams because the area has limited amounts of high-quality estuarine and near-shore habitat.[4]

Table 3 shows the number of non-fish species associated with old-growth/late-successional forests that utilize streams, wetlands, and riparian areas. The indicated vascular plants, lichens, mosses, and mollusks are exclusively associated with these areas; the vertebrate species use riparian areas for foraging, roosting, and travel if old-growth conditions are present.

Table 3. Terrestrial Species Closely Associated with Old-Growth/Late-Successional Forests, by Species Group[5]

Vascular Plants	29
Lichens	
Aquatic	3
Riparian	9
Bryophytes (mosses)	
Aquatic	3
Splash zone	5
Floodplain	13
Mollusks	
Freshwater snails	54
Freshwater clams	3
Amphibians	
Salamanders	12
Frogs	1
Birds	38
Mammals	18
Bats	11
Total species	199

[4] FEMAT. 1993. *Forest Ecosystem Management: An Ecological, Economic, and Social Assessment*. July. pp. V-7 and V-10.

[5] FEMAT. 1993. *Forest Ecosystem Management: An Ecological, Economic, and Social Assessment*. 794-478. July. p. V-12.

Habitat for Species Dependent on High-Quality Streams

Streams in old-growth forests are narrower and exhibit less bank erosion and sediment than those in logged areas.[6] Temperatures are lower and humidity is higher in old-growth forests than in logged areas, and old-growth forests can influence microclimatic conditions in streams far away.[7] Old-growth forests exhibit greater richness than logged forests in the number of amphibian species.[8]

[6] Beechie, T.J., B.D. Collins, and M.M. Pollock, G.R. Pess. 2000. "Watershed-Scale Patterns of Stream Temperature Change in a Puget Sound River Basin." Northwest Fisheries Science Center, National Marine Fisheries Service. http://www.dnr.wa.gov/hcp/type5/authors/beechie_2000.html (accessed August 29, 2006).

[7] Brosofske, K.D., J. Chen, R.J. Naiman, and J.F. Franklin. 1997. "Harvesting Effects on Microclimatic Gradients from Small Streams to Uplands in Western Washington." I. 7(4): 1188-1200. http://www.dnr.wa.gov/hcp/type5/authors/beechie_2000.html (accessed August 29, 2006).

[8] Corn, P.S., R.B. Bury. 1989. "Logging in Western Oregon: Responses of Headwater Habitats and Stream Amphibians." *Forest Ecology and Management*. 29: 39-57; and Lee, Y.M. 1997. Amphibian communities and physical characteristics of intermittent streams in old-growth and young forest stands in western Oregon. Corvallis, OR: Oregon State University. 97p. MS thesis. p. 45-80. http://www.dnr.wa.gov/hcp/type5/authors/beechie_2000.html (accessed August 29, 2006).

B. OLD-GROWTH FORESTS AND THE HABITATS THEY PROVIDE HAVE ECONOMIC VALUE

Americans place economic value on the old-growth forests in this region and their provision of habitats for species, such as the northern spotted owl and marbled murrelet. This value would be lost if old-growth forests were destroyed.

Americans Place an Economic Value on Protecting Old-Growth Forests and Spotted Owl Habitat

Several in-depth studies have quantified the value Americans place on protecting old-growth forests that provide habitat for northern spotted owls.

- A 1987 survey of households in Washington, Oregon, and California found that, on average, they expressed a willingness to pay $35, $37, and $21, respectively, per household per year to protect spotted owls and their old-growth habitat.[9]

- After being told that, on average, 21,000 acres of old-growth forest and spotted owl habitat burns each year, respondents to a nationwide survey were asked to place a value on reducing the acres burned by 3,000 acres per year. Their responses indicate the value of protecting each acre of old-growth and spotted owl habitat is $632,000 – $1,359,000 per acre.[10]

Americans Place a Value on Protecting Spotted Owls

The results of a 1987 survey indicate that the value of protecting the northern spotted owl, measured as households' annual willingness to pay for being 100 percent sure the species will exist in the future was $103 million for households in Washington and Oregon and $1.481 billion for all of the U.S.[11]

Few Americans will ever see or otherwise interact with northern spotted owls. Even so, most Americans place a value on protecting them. A summary of studies that have estimated this value reported that, on average, the value is $22.09 – $95.42 per year per household (in approximately the dollars of 1993) to prevent reductions of 1,150 – 3,500 in the number of owl pairs in the U.S.[12]

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[9] Rubin, J., G. Helfand, and J. Loomis. 1991. "A Benefit-Cost Analysis of the Northern Spotted Owl." *Journal of Forestry* (December): 25-29.

[10] Loomis, J.B. and A. Gonzalez-Caban.1998. "A Willingness-to-Pay Function for Protecting Acres of Spotted Owl Habitat from Fire." *Ecological Economics* 25: 315-322.

[11] Rubin, J., G. Helfand, and J. Loomis. 1991. "A Benefit-Cost Analysis of the Northern Spotted Owl." *Journal of Forestry* (December): 25-29.

[12] Bulte, Erwin and Cornesis Van Kooten. 1999. "Marginal Valuation of Charismatic Species: Implications for Conservation." *Environmental and Resource Economics*: 119-130.

The Benefits of Protecting Old-Growth Forests and Spotted Owls Exceed the Costs

The results from a national survey indicate that the benefits of protecting northern spotted owls and old-growth forests in the Pacific Northwest outweigh the costs. Under different assumptions the ratio of benefits to costs ranges from 3.53 to 42.56.[13]

A review of 20 studies of the economic value Americans place on rare, threatened, and endangered species found that, "To date, for even the most expensive endangered species preservation effort (e.g., the northern spotted owl) the costs per household fall well below the benefits per household found in the literature."[14]

The Washington Department of Natural Resources (DNR) compared the costs and benefits of a forest-practices rule that would extend logging restrictions that protect 70 acres of habitat surrounding potential nesting sites for northern spotted owls. The analysis concluded that the benefits of protecting 2,264 acres of Northern Spotted Owl habitat would be $152 – $259 million, or $43,322 – $74,129 per acre. The benefits far outweigh the forgone timber-harvest revenue: $31.7–$45.3 million, or $14,000 – $20,000 per acre.[15]

The Benefits of Protecting Old-Growth Forests and Habitat for Salmon Exceed the Costs

An analysis of forest-practices rules proposed in Washington to protect and enhance salmon habitat found the probable benefits would be $9.1 – $13.3 billion, while the probable costs would be $7.5 – 8.5 billion.[16]

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[13] Hagen, D.A., J.W. Vincent, and P.G. Welle. 1992. "Benefits of Preserving Old-Growth Forests and the Spotted Owl." *Contemporary Policy Issues* X (April): 13-26.

[14] Loomis, J.B. and D.S. White. 1996. "Economic Benefits of Rare and Endangered Species: Summary and Meta-Analysis." Ecological Economics 18 (3): 197-206.

[15] Washington Department of Natural Resources. 2006. *Preliminary Economic Analysis: Forest Practices Rule Making Affecting Northern Spotted Owl Conservation*. January 24. http://www.dnr.wa.gov/forestpractices/rules/activity/owlecon.pdf (accessed August 10, 2006)

[16] Perez-Garcia, J. 2001. *Cost Benefit Analysis for New Proposed Forest Practices Rules Implementing the Forests and Fish Report*. Washington Department of Natural Resources. February 21.

C. OLD GROWTH FORESTS INCREASE WATER SUPPLIES AND PROVIDE VALUABLE WATER-REGULATION SERVICES

Old-growth forests in this region can increase the supply of water in streams and aquifers. They also can improve the quality of the water and slow the runoff from storms, diminishing potential flood damage.

Increased Water Supplies

As fog filters through the old-growth forests of western Washington, Oregon, and northern California the trees often induce water vapor to condense and drop to the earth, increasing supplies of ground and surface water, especially during late summer when stream flows are low. Old-growth forests are especially productive because, compared to younger forests, they have more leaf area on which fog can condense.[17]

- Within the Bull Run watershed that supplies drinking water for the Portland metropolitan area, the precipitation was 25 – 29 percent higher on lands with ancient forests than on adjacent lands that had been clearcut eleven years earlier, and the condensed fog constituted 30 percent of the total precipitation that reached the earth under old-growth trees. Flows in a stream near old-growth forest declined less during late summer than those near logged areas.[18]
- Annual precipitation under old-growth trees near the Oregon coast was 20 inches greater than in a nearby clearing.[19]
- In forests near the Klamath River, fog precipitation constitutes 8 – 34 percent of water used by coastal redwood and 6 – 100 percent of the water used by understory vegetation.[20]

Water Has Economic Value

Past studies indicate that increases in streamflow produced by old-growth forests have the values shown in Table 4.

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[17] Franklin, J.F. and T.A. Spies. 1991. "Composition, Function, and Structure of Old-Growth Forests." In *Wildlife and Vegetation of Unmanaged Douglas-Fir Forests*. Edited by L.F. Ruggiero, K.B. Aubry, A.B. Carey, and M.H. Huff. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

[18] Harr, R.D. 1982. "Fog Drip in the Bull Run Municipal Watershed, Oregon." *Water Resources Bulletin*. 18(5):785:789.

[19] Isaac, L.A. 1946. "Fog Drip and Rain Interception in Coastal Forests. US Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, described in Harr, R.D. 1983. "Potential for Augmenting Water Yield Through Forest Practices in Western Washington and Western Oregon." *Water Resources Bulletin* 19 (3): 383-393.

[20] Research reported in Keppeler, Elizabeth. 1998. "The Summer Flow and Water Yield Response to Timber Harvest." In *Proceedings of the Conference on Coastal Watersheds: The Caspar Creek Story*. Edited by Robert Ziemer. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Pgs. 35-43.

Table 4. Value of Marginal Changes in Streamflow on National Forests (2003 dollars per acre-foot of water per year)

	Pacific Northwest	California
Aggregate marginal value	$24	$66
Hydroelectric generation	$12	$14
Instream recreation	$10	$10
Waste dilution	$1	$1
Ecosystem functions	$21	$64

Source: Brown, T.C. 2004. *The Marginal Economic Value of Streamflow from National Forests*. U.S. Forest Service, Rocky Mountain Research Station. Discussion Paper. DP-04-1, RMRS-4851. December 28.

Improved Water Quality in Streams and Clean Water for Municipal-Industrial Use

Algal biomass in headwater streams in old-growth forests are 7 – 14 percent of the algal biomass in headwater streams in logged areas.[21]

Many cities and industries in the region obtain water from rivers whose waters are sufficiently clean that they require minimal treatment before being distributed to consumers. The watersheds of these rivers typically are forested and exhibit little disturbance. A study of the North Santiam River, which proves water for the City of Salem, Oregon, found the savings for consumers were $18 – 34 per capita per year, and the water supply naturally meets the high quality standards of silicon-chip manufacturing.[22]

Controlled Runoff and Reduced Flood Risk

Studies near Puget Sound show that, in natural forests, less than one percent of rainfall becomes surface runoff. In contrast, in urban areas 84 percent of the rainfall becomes surface runoff.[23]

Old-growth forests diminish the peak flows of streams following storms by 33 – 50 percent, relative to logged forests.[24]

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[21] Kiffney, P.M, and J.P. Bull. 2000. "Factors Controlling Periphyton Accrual during Summer in Headwater Streams of Southwestern British Columbia, Canada." *Journal of Freshwater Ecology*. 15(3): 339-351. http://www.dnr.wa.gov/hcp/type5/authors/beechie_2000.html (accessed August 29, 2006).

[22] Hulse, D., G. Grant, E. Niemi, A. Branscomb, D. Diethelm, R. Ulrich, and E. Whitelaw. 2002. *Muddy Waters: how floods clarify evolving relationships among landscape processes and resource management decision-making in municipal watersheds*. National Council on Environmental Research and Quality Assurance, U.S. EPA GAD # R825822.

[23] Beyerlein, D. and J. Brascher. 1998. "Traditional Alternatives: Will More Detention Work?" Presented at Salmon in the City (Can Habitat in the Path of Development be Saved) in Mount Vernon, WA.

[24] Jones, J.A. and G.E. Grant. 2001. "Comment on 'Peak Flow Responses to Clear-Cutting and Roads in Small and Large Basins, Western Cascades, Oregon: a Second Opinion' by R.B. Thomas and W.F. Megahan." *Water Resources Research*. 37(1): 175-178.

D. OLD-GROWTH FORESTS PROVIDE VALUABLE RECREATIONAL OPPORTUNITIES

The forests of this region provide many, valuable opportunities for recreation. The recreational opportunities in old-growth forests have greater economic value than those in other forests.

Unroaded Forests Have Greater Recreational Value than Those that Have Been Logged

Studies from throughout the western U.S. indicate that the value of unroaded areas with the characteristics of wilderness increase the value of recreational activities by nearly $42 (dollars of 1999) per person per day. In addition, many Americans place a value on protecting areas with the characteristics of wilderness, even though they will not visit or otherwise interact with them. This value, which economists call the nonuse value of wilderness is about $6.72 per acre (1999 dollars).[25]

Research in 1990 found that the recreational value of additional hiking trails in old-growth forests of the region was $1,254 per mile.[26]

Recreational Opportunities and Unroaded Areas on Federal Lands Provide Services Move Valuable than Logging

Forest Service researchers extensively analyzed the relative value of different goods and services provided by federal lands in the Interior Columbia River Basin, between the Cascades and the Rockies. Even though they were unable to estimate values for many ecosystem services, such as providing high-quality water and habitat for at-risk species, they still determined that the federal lands' ability to produce services, such as recreational opportunities, has greater value than its ability to produce timber and other commodities. Table 5 shows their findings for three Ecological Reporting Units on the east side of the Cascades. In 1995, recreational activities accounted for 30.22 – 73.36 percent of the total. The researchers also found that the value of unroaded areas warrants special distinction because, all else equal, recreational activities in them are more valuable than those elsewhere, and these areas have highly valued characteristics, such as the existence of wild places. Unroaded areas accounted for 20.66 – 59.83 percent of the total value of all goods and services.

Together, recreation and unroaded areas accounted for 50.88 – 92.15 percent of the total in 1995. The researchers predicted that the value of these services would increase in the

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[25] Loomis, J. and R. Richardson. 2000. *Economic Values of Protecting Roadless Areas in the United States*. The Wilderness Society and Heritage Forests Campaign. June.

[26] Englin, J. and R. Mendelsohn. 1991. "A Hedonic Travel Cost Analysis for Valuation of Multiple Components of Site Quality: The Recreation Value of Forest Management." *Journal of Environmental Economics and Management* 21: 275-290.

future, relative to the value of commodities derived from federal lands. By 2045, they predicted recreation and unroaded areas, combined, would account for 79 – 98 percent of the total value.

Table 5: Contribution of Recreation, Other Activities, and Unroaded Areas to the Total Value of Goods and Services Derived from Federal Lands[a] in Three Ecological Reporting Units on the East Side of the Cascades, 1995

	Contribution (percent)		
Activity	**Northern Cascades**	**Southern Cascades**	**Upper Klamath**
Logging	7.76	13.86	48.96
Grazing	0.09	0.03	0.15
Recreation			
Camping	5.87	5.18	8.46
Day Use	4.20	10.48	4.78
Fishing	1.22	19.30	6.21
Hunting	3.22	5.70	4.35
Motor Boating	0.04	0.16	0.69
Motor Viewing	1.88	4.44	1.09
Non-Motor Boating	0.05	0.99	0.19
ORV	0.34	0.11	0.07
Snowmobiling	0.16	0.12	0.12
Trail Use	9.29	4.42	2.18
Viewing Wildlife	0.60	10.02	1.17
Winter Sports	5.43	12.18	0.93
Total Recreation	32.32	73.36	30.22
Unroaded Existence	59.83	13.01	20.66
Total	**100.0**	**100.0**	**100.0**

[a] Includes primarily lands administered by the Forest Service and Bureau of Land Management. Does not include values for production of other goods and services, such as production clean water, provision of habitat for at-risk species, modulation of flooding, and sequestration of carbon. Numbers may not sum to 100 percent due to rounding.

E. OLD-GROWTH FORESTS CAN STRENGTHEN LOCAL ECONOMIES

When logging of old-growth forests on federal lands was restricted in the early 1990s, many feared the economy of the entire region would collapse, with tens of thousands of workers becoming permanently unemployed. The predictions were wrong. Although some workers and communities saw their immediate economic prospects diminish, the regional economy, as a whole experienced robust economic growth. Evidence indicates that the robust growth occurred not despite the logging curtailment but because of it.[27]

Federal Lands, Including Old-Growth Forests, that Are Managed to Provide Services Rather than Commodities Boost the Economies of Local Communities

Many studies document the positive impacts that federal lands managed for their natural amenities, rather than for timber and other commodities, have on local economies.

- A study of roadless areas on federal lands in Washington concluded that, rather than causing impoverishment of nearby communities, "roadless area protection strengthens their current and future economic base and the sectors of the economy that will be the source of additional jobs and income."[28]

- A study of 250 rural counties in western states found that those counties adjacent to a national park experienced more rapid population growth than other counties, and the designation of wilderness had no negative impact on employment or income. [29] A related examination of all 333 non-metropolitan counties in eleven western states found that the listing of species as threatened or endangered under the Endangered Species Act had no statistically significant, negative effect on growth in employment between 1980 and 1990.[30] Another study found that, between 1969 and 2000, rural counties adjacent to wilderness areas experienced faster growth in population, jobs, and income than those more distant from wilderness.[31]

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[27] Niemi, E., E.W. Whitelaw, and A. Johnston. 1999. *The Sky Did NOT Fall: The Pacific Northwest's Response to Logging Reductions*. ECONorthwest. April.

[28] Power, T. 2000. *The Economic Impact of Preserving Washington's Roadless National Forests*. University of Montana. June 13.

[29] Duffy-Deno, K. 1998. "The Effect of Federal Wilderness on County Growth in the Intermountain Western United States." *Journal of Regional Science* 38 (1): 109-136.

[30] Duffy-Deno, K.T. 1997. "Economic Effect of Endangered Species Preservation in the Non-Metropolitan West." *Growth and Change* 28 (3): 263-288.

[31] Holmes, F. Patrick and Walter E. Hecox. 2004. "Does Wilderness Impoverish Rural Regions?" *International Journal of Wilderness* 10 (3): 34-39.

- Natural-resource amenities, such as those provided by forested federal lands protected against logging, can stimulate growth in population, employment, and income in nearby communities.[32]

- The influence that natural-resource amenities exert on economic development in local communities appears to be increasing.[33]

- Although the presence of protected federal lands is correlated with growth in employment, data from Oregon's counties shows that logging levels are not correlated with changes in employment in those counties.[34]

- In a retrospective look at how the economy responded to the protection of old-growth forests that provide habitat for northern spotted owl, marbled murrelets, and other species, economists with the Forest Service concluded that the predictions of economic catastrophe failed to materialize.[35]

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[32] Clark, D.E. and W.J. Hunter. 1992. "The Impact of Economic Opportunity, Amenities and Fiscal Factors on Age-Specific Migration Rates." *Journal of Regional Science* 32 (3): 349-365; McGranahan, D.A. 1999. *Natural Amenities Drive Rural Population Change*. U.S. Department of Agriculture, Economic Research Service, Food and Rural Economics Division. Agricultural Economic Report No. 781. September; Rudzitis, G. and R. Johnson. 2000. "The Impact of Wilderness and Other Wildlands on Local Economies and Regional Development Trends." In *Wilderness Science in a Time of Change Conference-- Volume 2: Wilderness Within the Context of Larger Systems*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station; Rudzitis, G. 1999. "Amenities Increasingly Draw People to the Rural West." *Rural Development Perspectives* 14 (2): 9-13; and von Reichert, C. and G. Rudzitis. 1994. "Rent and Wage Effects on the Choice of Amenity Destinations of Labor Force and Nonlabor Force Migrants: A Note." *Journal of Regional Science* 34 (3): 445-455.

[33] Vias, Alexander. 1999. "Jobs Follow People in the Rural Rocky Mountain West." *Rural Development Perspectives* 14 (2): 14-23.

[34] Power, T. and P. Ruder. 2003. *Economic Realities in the Tillamook and Clatsop State Forests*. Tillamook Rainforest Coalition. January.

[35] Diaz, N. and R. Haynes. 2002. *Highlights of Science Contributions to Implementing the Northwest Forest Plan: 1994 to 1998*. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

F. OLD-GROWTH FORESTS PROTECT VALUABLE ASSETS

Old-growth forests in this region conserve valuable assets, such as soil and the genetic legacy of species that, absent the habitat provided by old-growth forests, would face a greater risk of extinction. By reducing sediment in streams and the risk of flooding, old-growth forests also maintain the value of public infrastructure, such as roads, and private property. Old-growth forests also contain large amounts of carbon, both above and below the surface of the ground.

Protect Productive Soils and Infrastructure

Building roads and logging trees in old-growth forests can increase the amount of soil lost through erosion and sedimentation of streams. A summary of research concluded: "Sediment yields from logging and roads are widely documented … and studies generally show a 2- to 50-fold increase over background levels, with most of the increase associated with roads." Sedimentation remains higher than background rates more than 5 years after logging.[36]

A 1988 study of the Siuslaw National Forest found that logging on 87,000 acres would increase sediment in streams, which would increase by $770,000 the costs local government would incur during the period to remove the sediment from municipal water supplies and roadside drainage ditches.[37]

Protect Habitat for Valuable Species

The 1988 study of the Siuslaw National Forest also found that the logging would reduce the populations of adult fish in the area by 84,000 salmon and 24,000 steelhead over a thirty-year period. The estimated commercial and recreational value of these fish losses was $1.8 million dollars.

Even logging of forests that contain large trees, but do not yet have all the characteristics of old-growth forests, can destroy valuable habitat and reduce the populations of salmon and steelhead. Managing such a watershed tributary to Tillamook Bay to produce annual salmon populations at historical levels would generate annual benefits of $26.2 million – $52.4 million. The value of the salmon produced in coastal watersheds not damaged by logging may be as high as $4,500 per stream mile per year.[38]

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[36] Reid, L.M. 1993. *Research and Cumulative Watershed Effects*. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. General Technical Report. PSW-GTR-141. p. 69.

[37] Loomis, J. 1988. *Economic Benefits of Pristine Watersheds: The Economic Effects of Timber Harvesting on Recreational and Commercial Fisheries and Municipal Watersheds*. American Wilderness Alliance. December.

[38] Radtke, H.D. and S.W. Davis. 1997. *Economic Considerations of the Future Use of the Tillamook State Forest with Emphasis on the Trask River Basin*. Oregon Trout. August.

A recent study summarized and augmented research on the economic benefits of restoring salmon populations or, alternatively, of avoiding further declines in salmon populations. It reported that, for incremental changes in population, the value per fish is approximately $872 for Washington Coastal Chum Salmon, Oregon Coastal Coho Salmon, Rogue River Coastal Coho Salmon, and Puget Sound Chinook Salmon.[39]

One survey of the relevant literature compared the economic benefits U.S. households derive from different rare, threatened, and endangered species.[40] It found the annual economic benefits of protecting Pacific salmon/steelhead are $31 – $88 per U.S. household. These numbers, when applied to the approximately 100 million households, indicates the total annual benefits are $3.1 – $8.8 billion. The researchers concluded the economic benefits of actions taken under the Endangered Species Act to conserve the species outweigh the costs.

Protect Sequestered Carbon

Forests store carbon in both live and dead organic matter, both above ground and in the soil. The concentration of carbon (quantity of carbon per unit of land area) stored in old-growth forests in the Pacific Northwest is among the highest in the world for lands other than tropical forests.

Some have suggested that the amount of carbon sequestered by the region's forests could be increased by logging old-growth trees and replacing them with faster-growing seedlings.[41] Recent, careful research indicates that the reverse is true, however. The forest-replacement proposals arise from a view of the forests that focuses on the woody material in the stems of growing trees. This material typically grows more rapidly in younger trees than in the mature trees of an old-growth forest. Old-growth forests, however, exhibit greater stores of carbon: in tree stems, tree roots, organisms other than trees, and dead organic matter. Much of this carbon would be released to the atmosphere if an old-growth forest were logged, and the replacement seedlings would not grow fast enough to replace it fully.[42] Research also indicates that old-growth forests

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[39] Goodstein, E. and L. Matson. 2005. "Climate Change in the Pacific Northwest: Valuing Snowpack Loss for Agriculture and Salmon." In *Frontiers in Environmental Valuation and Policy*. Edited by J. D. Erickson and J. M. Gowdy. Cheltenham, UK: Edward Elgar.

[40] Loomis, J.B. and D.S. White. 1996. "Economic Benefits of Rare and Endangered Species: Summary and Meta-Analysis." *Ecological Economics* 18: 197-206.

[41] Banuri, T., Barker, T., Bashmakov, I., Black, K., Christensen, J., Davidson, O., Grubb, M., Jepma, C., Jochem, E., Kauppi, P., Krankina, O., Krupnick, A., Kuijpers, L., Kverndokk, S., Markandya, A., Metz, B., Moomaw, W.R., Moreira, J.R., Morita, T., Pan, J., Price, L., Richels, R., Borinson, J., Sathaye, J., Swart, R., Tanaka, K., Taniguichi, T., Toth, F., Taylor, T., Weyant, J. 2001. *Technical Summary. Climate Change 2001: Mitigation.* Working Group III of the Intergovernmental Panel on Climate Change. p 41.

[42] Schulze, E.-D., C. Wirth, and M. Heimann. "Managing Forests after Kyoto." *Science*. 289: 2058-2059; and research reported in Keppeler, Elizabeth. 1998. "The Summer Flow and Water Yield Response to Timber Harvest." In *Proceedings of the Conference on Coastal Watersheds: The Caspar Creek Story*. Edited by Robert Ziemer. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Pgs. 35-43.

in this region can store additional carbon annually at rates that are intermediate when compared to those of younger trees.[43]

Therefore, when one looks to the future and accounts for a forest's overall carbon content—both above ground and in the soil—the amount of carbon stored by sustaining an old-growth forest probably would exceed the amount that would be stored by logging the mature trees and replacing them with seedlings. This conclusion is supported by the authors of a summary of research conducted at an old-growth forest in Washington, who observed that forest-management schemes other than protecting old-growth forests "never match old-growth" in the "total carbon in live and dead organic matter" that would be stored over time.[44]

Protect Ecosystems and their Functions

Old-growth forests maintain a hydrological and ecological balance. Loss of the forest can result in the loss of biomass and soils, and of the nutrients they contain. It also can result in the conversion of a moist, cool, forested ecosystem into a more drought prone, and warmer ecosystem.[45]

[43] Buchanan, N. and E.-D. Schulze. 1999. "Net CO2 and H2O Fluxes of Terrestrial Ecosystems." *Global Biogeochemical Cycles*. 13:751-60, cited in Suchanek, T.H., H.A. Mooney, J.F. Franklin, H. Gucinski, and S.L. Ustin. 2004. "Carbon Dynamics of an Old-Growth Forest." *Ecosystems* 7:421-426.

[44] Field, C.B. and J. Kaduk. 2004. "The Carbon Balance of an Old-Growth Forest: Building Across Approaches." *Ecosystems*. 7 (June). pp. 525-533.

[45] Research reported in Keppeler, Elizabeth. 1998. "The Summer Flow and Water Yield Response to Timber Harvest." In *Proceedings of the Conference on Coastal Watersheds: The Caspar Creek Story*. Edited by Robert Ziemer. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Pgs. 35-43.