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Forest Economics Research at the Pacific Northwest Research Station, to 2000

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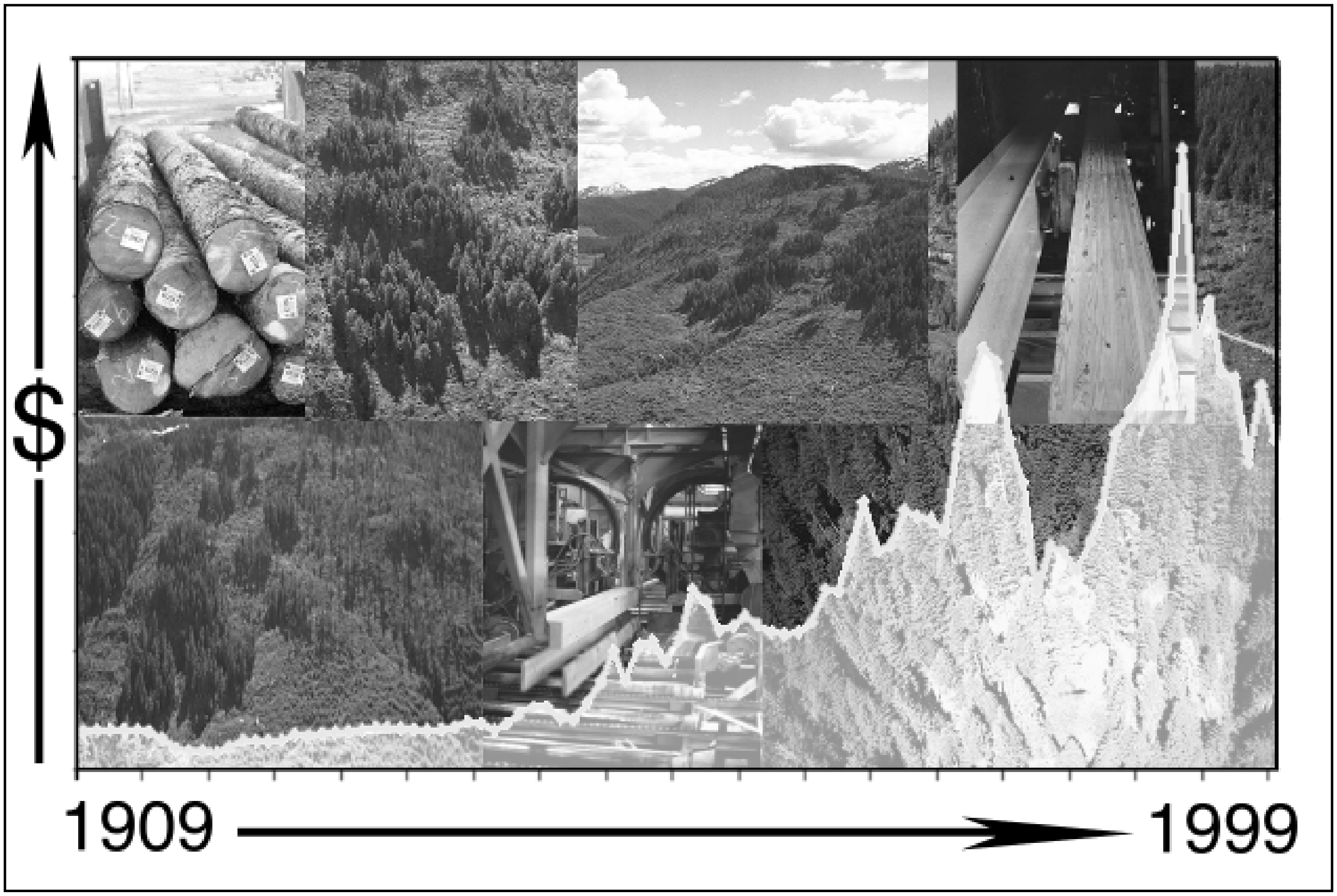

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Abstract

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The contributions for over 80 years by scientists at the Pacific Northwest Research Station to developments in economic theory, economic tools, policies, and economic issues are summarized. This is a story of progressive accomplishments set against a constantly changing background of economic and social events.

Keywords: Forest economics, forest policy, forest management, Pacific Northwest.

Contents

Introduction

Outlined here are PNW's[1] accomplishments in forest economics since the 1920s: contributions to theory, economic tools, and counsel to practicing foresters within and without the agency; and instances in which PNW's economics program made a difference to Western U.S. forestry. The format is roughly chronological. Every scientist and most publications will be mentioned, but the real intent is to portray the evolution of ideas, economic tools, and policy and economic issues to which they were applied.

This is a story built on four forests. Any forester whose working life started in the 1950s at a far corner of the Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) region will have worked among the last of the old growth, measuring trees 10 feet and more in diameter. By then the harvest of the second growth, seeded during logging in the last decades of the 19th century, was well underway. In 2000 it is virtually finished. The triumphs of fire and insect control, the pride of occasional bursts of intensive silviculture, the regrets of over- or under-investment in woods things, all have passed with those mellow, fulsome stands. Trees planted in the 1950s and after are now moving down the highways, 20 and 40 to the truckload. This third forest is the product of myriad economic decisions made and economic events experienced. Even to hold forest land has been an act of economic faith, subject to revision at any time. The fourth forest is outside the door, growing. What will become of it is being influenced by new economic conditions, new information, and new views of the future. That is the stuff of forest economics research.

The Times in Which We Worked

The state of the art in resource economics seemingly depends on a disorderly mix of work done to date, strong personalities, fortuitous meanders, directed effort, treks along arcane technical lines, economic pressures, and screaming land-use conflicts. This section does not deal with what we knew when but, rather, with the changing world around us over eight decades.

The Industrial Twenties

Although federal forestry studies had been underway in the Northwest for some time, PNW was formally commissioned in 1924, a product of politics and persuasion, history and economics. The 1920s blew in as 6 billion board feet of timber blew down in western Washington, and the Capper Report[2] appeared, both of which argued for research. The windstorm of 1921 generated economic questions of utilization, marketing, and export possibilities. The 1920 Capper Report was a Forest Service response to claims of overcutting on industry lands and to a call for regulation. No less than Gifford Pinchot favored corralling cutting in private forests. William B. Greeley, the new Forest Service Chief as of 1920, favored cooperation with the industry in fire control and other areas. The report was a compromise, covering timber depletion, lumber prices, lumber exports, and concentration of timber ownership; in short, the economics of forest resource use. It also called for further study.

Timber supplies in the U.S. South were fading and the Northwest was seen as a last frontier: last but vast. There were some 37 million acres of forest area in the Northwest, of which some 34 million had not been clearcut by 1920.[3] Reserved areas lay mainly in the national forests, astride the mountains, where they were unappealing to loggers. Washington and Oregon had become the Nation's top lumber-producing states, despite a sharp regional recession in 1921. The 1914 opening of the Panama Canal and imports by Japan had been good for the Northwest's primary industry in terms of orders if not net revenues.

Figure 1—A western Oregon clearcut of about 1920, burned then and again in 1932. Forest practices like this, standard for their time, led to the calls for "practical forestry." (Photo taken in 1938 by Wallace Guy, PNW Station.)

Old-growth harvests advanced, in wide swaths. The 1920s were a time of innovation across the spectrum of timbering. During the decade, labor productivity doubled in logging as rail-mounted yarders increased in size, bringing clutches of 40-foot logs flailing down cableways up to a mile long, at 1,000 feet per minute.[4] Immensity and speed were the object. Appearing in the 1880s, logging railroads and steam donkey engines grew quickly in size and number. By 1930, 7,000 miles of track had been laid for logging in the West; in Washington and Oregon, some 1,400 firms had run log trains by 1930, many surviving only briefly.[5]

In the larger mills, workers' productivity grew by a quarter during the 1920s, despite steadily smaller and more defective logs, labor-intensive refinements such as kiln drying, and cutting for grade.[6] New, bigger, faster, and more intricate sawmills appeared, financed to a large extent by capital migrating away from the shrinking resource in the South.[7] Among the innovations was the growing use of hemlock (*Tsuga* spp.), for paper pulp, which vastly increased use of otherwise unwanted trees in coastal forests.

The forest industry was not a happy group. Entry into the industry was easy, but clinging there was hard, with competition and overproduction compelling narrow profit margins. In the 1920s, two new workhorses, a peavey, and a pit saw, could put someone into business, but they would scarcely support a family even in good times. Logging railroads, steam donkey engines, planers, end matchers, resaws, and dry kilns were costly.

The rapid innovations created a steadily more capital-intensive, debt-supported structure within most logging and milling firms. For decades the North American lumber economy regularly fell far and fast into cyclic chasms, climbing back out slowly and leaving many

Figure 2—Staggered settings and a cluster of seed trees, typical of Douglas-fir harvesting in the 1940s and later, although the picture was taken in 1938. The entire area was logged by rail; a trestle is on the right side of the distant clearcut. Whether to burn the area or remove the fire hazard of old-growth slash and present bare soil to descending seed was a major issue at the time. (Photo by Wallace Guy.)

firms lifeless, yet overproducing all along the way. It was a vicious circle: cut faster to pay for the newer, bigger gear that was acquired to cut faster.

Meanwhile, cut-and-get-out timbering was being reconsidered in the Northwest. Timbermen were themselves concerned about overcutting and a long-term future, albeit in a commercial sense. Some owners of cutover land were retaining it rather than letting it revert for taxes. "Practical forestry" (fig. 1) was a phrase that echoed in professional and industry halls. It meant fire protection and property-tax reduction, two rudiments of forestry supported by timbermen and the Forest Service alike; it replaced less cordial earlier agency calls for regulation and federal acquisition of forest land.

One practical result of the practical-forestry initiative was passage of the Clarke-McNary Act of 1924, which provided funds for state forest fire programs and tree nurseries and a nationwide study of the impact of property taxes on reforestation. For a decade, there was research on timber taxation in Oregon and Washington, first undertaken by R.C. Hall in 1929. That work resulted in state laws reducing taxation on forest land. Hall's study was, arguably, PNW's first venture into economics research.

At the same time, fire research became big business at PNW, including a study by Harold Shepard of forest fire insurance.[8] Shepard's suggestions for rating risk became a model for the insurance industry when it considered policies for other industries.

The third leg of "practical forestry," viewed with some skepticism by many landowners, was reforestation, primarily via retention of some trees to promote reseeding (fig. 2). The

Journal of Forestry editorialized that tree planting was dubious on western woodlands because of fire risks and economics.[9] Indeed, in the 1920s only a handful of private owners tried artificial reforestation, and perhaps half of those trials were lost to fire. The other half were ultimately obscured by natural, invading second growth.[10]

To most observers it did not matter: the economics of forestry were preclusive. One wrote, "[In the Douglas fir region] as much as 150 board feet can be grown per year per acre. If stumpage a hundred years hence...could be made to average $10 a thousand... the crop would only be worth $1.50 per year per acre, with nothing for interest on idle investment or to cover insurance for that long, unproductive period...."[11] Remarkably, when pre-1920 cuttings were surveyed in the early 1930s, two-thirds had restocked satisfactorily, despite the harvest practice of "cutting against the face" of the forest.[12] And PNW analysts later would show that young-growth stands grow faster in volume and value than suggested in the quotation.

If there was a fourth leg to "practical forestry," it was reduction of waste, apparent and troublesome to timbermen as well as foresters. In the old stands, half the trees might already be dead or down. Of the live ones, half might be unwanted species such as white fir (*Abies concolor* (Gord. & Glend) Lindl. ex Hidebr.) and hemlock or desirable species but too small to warrant handling. Of those taken, half the woody parts might be left as slash. Clearcuts thus were cluttered with high stumps, snags, breakage, tops, limbs, blowdown, and dead underbrush, usually burned deliberately but often accidentally, what with ember-emitting steam engines powering almost everything.

For economists and foresters "practical forestry" posed obvious questions. Could fires be prevented and controlled at reasonable cost? If they could, were the economics of forest management really that dismal? Where were the best chances, when would they emerge, how extensive were they? If prompt regeneration were economic, how would that affect harvesting and transport planning? Even in the 1920s, economic questions about waste on the land and in the mills were being asked. What could be done differently, perhaps in small ways, that would pay its way? Why weren't Northwestern hardwoods, alder (*Alnus* spp.) and maple (*Acer* spp.), competing with hardwoods elsewhere?

Herman Johnson led analyses of alder and maple use prospects, thereby starting a chain of studies in 1926 that continued to the end of the 20th century. Another chain was work on logging slash and residues disposal and recovery, begun by Richard McArdle.

An early PNW priority was forest inventories, which brought Phil Briegleb, Bob Cowlin (both PNW directors later on), Hoss Andrews, McArdle (Forest Service Chief to be), Donald Bruce, Jim Girard, Elmer Matson, Don Matthews, and Walter Meyer to the Station. Each would become renowned in forest management, mensuration, or economics. They determined that by 1920 about 3.2 million acres in the Douglas-fir region had been cut over; this was about one-sixth of the unreserved conifer sawtimber area. By 1933 one-quarter had been cut. Still the region held half of the Nation's remaining mature softwood timber.[13]

Figure 3—Pre-World War II tie mill burning its waste.

The Interminable Thirties

For at least a century, a few foresters have applied principles of capital efficiency to activities in the woods. A few economists have viewed with interest the special characteristics of forestry: farmlike renewability, minelike exhaustibility, decades-long production periods, and concomitant risks and uncertainty. By the 1930s, a handful of scholars had doctorate-level expertise in both forestry and economics, and the separate field of forest economics was born. Though often distrusted by forestry practitioners and derided by theoretical economists as too "institutional," the first economics specialists found their services heavily demanded, often in addressing problems for which there was not yet a cohesive, generally accepted body of principles.

The 1930s were tough times economically, for the Nation and especially the forest industry. Few barns and fewer buildings were constructed. Tie-consuming railway expansion had stopped with a crunch. Lumber consumption in the United States fell by two-thirds during the three years after 1929. By 1932, half of Washington's sawmills (fig. 3) were closed, most of them forever. Relative to the 1920s, lumber production fell by two-thirds in the Northwest. More than two-thirds of Americans were still employed but at lower wages. Few mortgage lenders could afford to be tolerant, and the national sentiment was fear.

For forestry, though, it was a relatively good time. New Deal programs–CCC and WPA[14] – brought workers to the woods, including some of PNW's research locations. Trees were planted and pruned, counted and measured. Access roads, campgrounds, fences, and research structures were built; fires were fought.

Despite the Great Depression, the 1930s was a time of innovation. The Station worked on new reforestation methods. The industry worked on creating opportunities for reforestation: new logging technology was reducing costs and expanding the harvester's reach. Gasoline power was replacing steam, and crawler tractors, bulldozers, and trucks were being adapted to the woods. E.F. Rapraeger and Axel Brandstrom became point

Figure 4—A southwest Washington clearcut in 1938. Leave strips of uncut trees were becoming common. Clearcutting remained, however, despite the promotion of partial cutting. This was among the last areas logged with railroads, visible at upper left and center. Logs were “swung” by cable from the foreground spar tree to the central spar. (Photo by Wallace Guy.)

men in showing how to economically optimize the use of the new gear. Early in the decade, log transport by truck over highways cost three to five times as much as by rail (fig. 4). In clearcutting, trucks were a poor match for yarders.[15]

By 1937, however, the new economy, dismal as it was, had 70 percent of logging camps using trucks, either totally or as an adjunct to railroad hauling (fig. 5). Truck roads were relatively cheap to construct and could go more directly up hills and down into ravines. Railroads had thrived on large volumes per acre with many contiguous acres. Higher on the hill, the trees were smaller, preferred species were not abundant, partial cutting was in vogue, and in many areas fires had left only pockets of attractive timber. For larger firms, the truck-to-train reload became a key area where logs were sorted among destinations. By the 1960s, perhaps 30 of these remained in the West. Railroaders had shown that they could go almost anywhere. It had been economics, not mechanical infeasibility, that brought tractors and trucks into the woods in the 1930s.

The research staff at PNW was small but growing, and there was economics work on forest taxes, silvicultural systems, and timber supply analyses. Densely worded, fact-filled tomes were the order of the day.[16] Brandstrom intensively studied logging methods and their costs. He and Burt Kirkland joined PNW in 1930 as senior economists, after teaching together at the University of Washington. The Brandstrom-Kirkland proposal to abandon clearcutting for another system is famous still. Kirkland studied timber appraisal methods, flexible rotations, and possibilities for industry-federal harvest planning. Rapraeger analyzed motor trucks in logging, concluded they were around to stay, and suggested their limitations and potential. Don Matthews published a book on forest management. In 1940 and 1942, PNW issued major reports on forests of the west and east sides of the Cascade Range, respectively.[17]

Figure 5—Although this western Washington camp was served by a railroad, the advent of trucks permitted the access grid on the ridge in the background. Individual seed trees were relied on here for regeneration. (1938 photo by Wallace Guy.)

Figure 6—Prescribed fire, a technique assessed by PNW economists in later years in the context of forest health, was applied to this western Oregon area in the late 1930s. (1938 photo by Wallace Guy.)

World War II

Even though timber harvests and wood products manufacture increased in the Northwest during World War II, two decades of mill closures made it clear that, while depression, competition, and technology had played a role, "the overriding, consistent, and fundamental characteristic [affecting timbering was] timber exhaustion."[18] Companies had built mills, first along rivers and tidewater, then inland, and sent legions of loggers fanning outward beyond the old logging-railroad grades. Fire protection was important but so was slash burning (fig. 6). Reforestation had been left mostly to nature, and few had complained about unsightly clearcuts.

The war largely curtailed systematic forestry in the sense of growing more trees, faster. Timber famine was, however, a widely acknowledged future for the Northwest, barring heavier cutting in national forests. The forest industry began active reforestation and wanted public credit for doing so. So began the highly successful tree farm movement. The first one, in 1941, was Weyerhaeuser's Clemons Tree Farm in western Washington. Thousands of schoolboy "junior forest wardens" planted trees on weekends and watched for fires.

The Station did developmental work on products and fire weather research, but economics research stopped. The Station's economists became monitors of industrial production. They also helped product experts look at wartime use of Northwest woods: how to make new and critical products quickly and cheaply with untrained labor and whatever timber was close at hand. That meant Alaska, too, from which the war was not far away. Working 6-day weeks, they ran out of paper clips, paper, ration coupons for gas, and priorities for train rides to the mills and rail yards they were tracking.

After the War

In the Northwest, high pre-War timber production had led to low timber prices, vast clearcuts, and timberland abandonment. During the 1950s, that scenario was replaced by land retention and management of young stands, which now stood on half of all commercial forest land.

Post-War entry into the last unexploited counties in the Douglas-fir region, those of southwest Oregon, had pulled the center of the wood industry toward Portland from Tacoma. Logging also was reaching upward onto long-inaccessible Cascade Range slopes. The national forest share of harvests in the Douglas-fir region rose from 4 percent in 1940 to 25 percent in 1947 to 38 percent in 1960. Annual log production from national forests west of the Cascades increased from about 1 to 2.3 billion board feet in the latter 13-year period.

Harvesting was happening on some of the second-growth lands in the region, partly in response to (federal) stumpage prices that rose fivefold on the west side between 1945 and 1960, this after downscaling for inflation. City people were buying former stump ranches to become tree farmers. Hemlock and other white woods were being used at last, for lumber as well as pulp, but the prospect was still rather dubious for lodgepole pine (*Pinus contorta* Dougl. ex Loud.) and other small east-side non-ponderosa pine (*Pinus* spp.) softwoods.

To the surprise of many, pent-up demand from the War years did not immediately generate a post-War economic resurgence. Styles in cars and clothes and preferences in housing had changed. It took a while for producers to scope out demand and retool accordingly. Industrial production dropped by a quarter and would not fully recover for 6 years. There were waiting lists for cars, and people drove war-surplus jeeps while the auto industry shifted gears. Meanwhile, the inflation that had been resisted with price controls during the War came with a vengeance; consumer prices rose one-third in 3 years. Savings bonds that had earned 3 percent during the War were now worth less in real terms than their face value, and citizens felt cheated. Saving was a joke, so people spent, which of course strengthened price inflation.

Housing was another matter. Shelter magazines were touting simple ranch-style houses with open internal plans: combined kitchen-dining areas, combined dining-living and playroom-living rooms, and so on. Electric kitchens were the mode, as were two-car carports in lieu of one-car garages. Second bathrooms were still luxury elements. Do-it-yourself, a residual from the Depression and from improvising during the War years, affected the design and marketing of building materials. Housing starts doubled between 1945 and 1950 to a record level. Douglas-fir lumber production rose accordingly, remarkably to levels above those of the War years. Wholesale lumber prices climbed 70 percent.

The 1950s were generally a good time for Americans and the wood products sector. New cars were everywhere; there were second cars in some driveways, and second homes appeared on lakes and rivers as they had in the 1920s. Inflation eased and so did lumber prices. National housing starts were robust. Pine-region lumber production trended upward; however, west-side shipments slipped downward and mills consolidated away from tidewater.

Timber questions appeared regularly in even big-city newspapers. This reflected not only the dominant role of wood products in the Northwest economy (aside from Boeing and other former defense activity) but also uncertainties about the 1950s. Would prices continue their rapid climb? (They did not.) Would the Korean War of 1950-51 make a difference? (A little.) Would code officials accept southern pine studs? (They did.) Would water and rail freight rates to the East rise? (They did.) Would plywood displace fir sheathing boards? (It did.) Would Canada displace the Northwest in U.S. lumber markets? Abroad? (Yes, partially but steadily.) Would rising logging costs on steep national forests be absorbed in lower stumpage price? (Yes, partially.)

There were deep questions about the longer term. Would the old growth be cut before second growth and formerly unwanted species could fill the gap? Could they fill the gap, ever? How large would markets in other regions be? Would labor-saving technology, timber depletion, and competition deplete rural areas of jobs and mills? Answers were important: a business decision about forestry might involve $100 million. For a single federal timber sale, a logger might pay $1 million.

Figure 7—The log export issue was a dominant issue in the 1970s. (A) Log sort tagged for export. (B) Ship designed as a log carrier loading logs.

On the ground, the tree farm movement had taken hold. By 1957, there were 9,500 of them in 44 states. As timber cutting proceeded apace, there was talk of conservation and sustained yield, in the same vague sense as foresters used the terms in the 1880s and as sustainability was discussed in the 1990s.[19] The Forest Service established sustained yield units. The industry was criticized for overproduction cycles, but federal rather than private harvests were the more cyclic.

By the late 1950s, Forest Service research administrators, recognizing the need for "critical mass" in economics research, established a significant group of forest economists in Portland. The location reflected the importance of Northwest timber, which provided half of the Nation's softwood lumber and drew on a timber inventory having a value several times that of forests in the rest of the country. It was here that issues usually emerged. And the Forest Service's Pacific Northwest Region generally was the source of, and trial region for, new national timber policies. Economics research was not at this level; it continued to focus almost entirely on timber supply questions, especially for the Douglas-fir region, and on production questions. Typical were thinning-cost and mill recovery studies.[20]

The Robust Sixties

The 1960s were strong for the U.S. economy, continuing the post-War trend. National output grew by 4 percent a year. Lumber prices rose sharply in the late 1960s, driven by a rise in housing starts, and propelled harvest increases on public and private lands. The market surge induced congressional interest in the 1968 Housing Act, which set high targets for home construction, and the Timber Supply Act of 1969, which proposed to increase national forest timber harvests. Whether significant increases could reasonably be made was the focus of PNW's Douglas-fir supply study. Lumber demand receded, however, and the timber act, which would have set up a permanent trust fund for national forest timber sales, died in committee. The Nixon Administration and western governors pressed the Forest Service to raise allowable cuts and build timber access roads. Congress, however, would not fund the additional harvests.

The 1960s confronted PNW with several major timber-supply questions, whose answers the public well knew would have potential social and economic impacts in the Northwest. The old growth was fading from private lands. Could it be replaced from federal lands? From intensive private forestry? From abroad? If from public lands, what would happen to even flow and sustained yield, which were mandates of the time? If from Canada, what would happen to Northwest mills and jobs? How much could timber supply really be increased by using puny thinnings and renaming logging debris "residue"? Indeed, was the Northwest's timber economy starting to decline or at least becoming more insular? And what of log exports (figs. 7a and 7b), a surge triggered by a 1962 windstorm that felled millions of west-side trees? Was this market a good thing or bad, for the near and long terms? If good, could it continue? Would the newly created and seemingly invasive high-country wilderness areas markedly reduce federal timber supplies while raising the scarcity value of private supplies? Would competition for timber push the industry toward the South?

With the industry restructuring in several ways, for what kinds of trees should they tool themselves, and where? In the woods, should high-country roads be truck-oriented boulevards, one-log wide trails, or just landings for Korean War-surplus helicopters? And with Rachel Carson's 1962 *Silent Spring* at hand, what were the economic options for protecting water and other habitats? Would monoculture, with its long lines of trees of a single kind and age, dominate Northwest forests? Did diversity matter? Would nature intervene to produce a variegated forest after all?

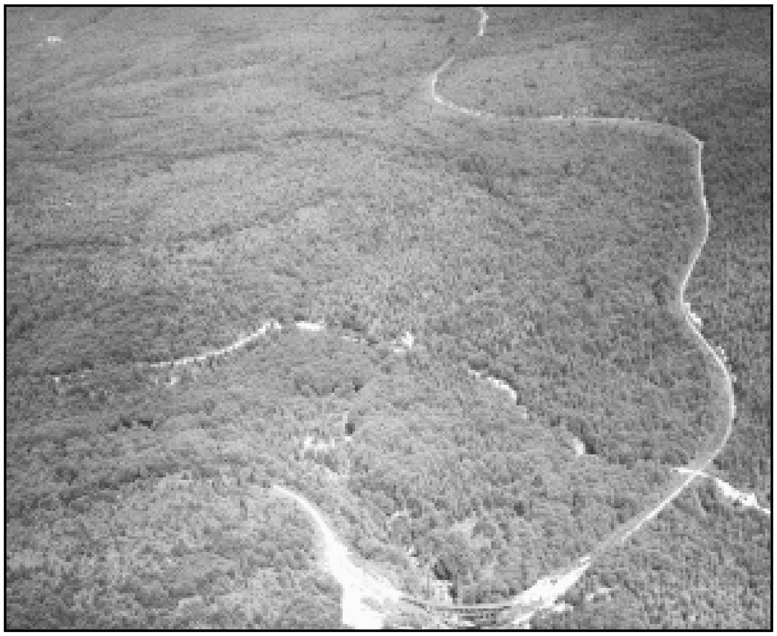


Figure 8—Thinning, prompted by the allowable cut effect, would be employed in the decade following this 1938 picture. The Douglas-fir forest had been clearcut between 1905 and 1910. (Photo by Wallace Guy.)

Timber accounted for half of the region's manufacturing base in the 1960s, so these questions were not trivial. Some non-PNW forecasts had foreseen the plywood industry disappearing with the old growth and the Northwest timber economy fading to near nothing. These concerns gave great relevance to (1) PNW's work on production economics; (2) a pending decline in national forest harvests (the timber trends report is described in its own section under "Regional Resource and Market Projections"); (3) other supply, demand, and price projections; and (4) the "allowable cut effect" (fig. 8) of intensive management on public lands—all topics discussed later. Logging-residue and mortality salvage were seen as significant ways to expand timber supplies without expanding the clearcut acreage. "Advance roading" (building roads well in advance of logging through agency funds, rather than making a road system part of the logger's responsibility) would be needed to get those extra supplies but at immense capital cost. The Station would determine whether the extra wood was worth putting money for roads on the table before the main harvest.

Carl Newport, head of the country's major forest economics group at PNW, was pressed by forestry administrators throughout the West to provide analytical counsel on timber production, protection, and investment questions. The intensity of these inquiries was heightened by growing nationwide interest, especially visible within government, in capital budgeting, investment efficiency, and a number of other roughly equivalent indicators. Funding was a constraining factor, and forestry budgets were unlikely to expand to permit all "needed" management. Spending would have to be directed toward best chances, assuming the economists could persuasively identify them. With the Western world as his oyster, Newport responded by directing effort into problems that seemed to have widest application and could be partly or fully supported with non-Station funding. They included advance roading, protection economics, and agency-shaking work on harvest

Figure 9—A municipal watershed in western Washington, logged in 1937-38. Landscapes like this fostered many economic and ecological questions addressed by the Station in later decades. (Photo by Wallace Guy.)

scheduling and the false promise of sustained yield. “Production economics” remains, after 40 years, a central part of PNW’s economics program, with ever-expanding analytical capability and a continuing need for identifying best economic chances in the face of a constantly changing resource base and convulsing market forces.

The mobility and affluence of Americans in the 1950s, extended into the 1960s with the latter decade relatively free of unpleasant economic surprises. People were more worldly, more attuned to leisure (and to the atomic bomb), and less dependent on industries with smokestacks and murky waste water. Some, though, were concerned about stockpiling and natural resource scarcity and others with conservation in a less utilitarian sense.

The economics of noncommodity forestry was finding an early home at PNW in the 1960s, which reflected forestry issues swirling around the Northwest. Multiple use had been a first principle of the Forest Service, and an element of industrial forestry, for many years. Implying several uses on the same acre or the same square mile, it had been in practice a Balkanization of uses—timber the key use here, recreation lands there, protected watershed beyond, and so on. Multiple use was codified in the Multiple Use-Sustained Yield Act of 1960, which awarded the agency authority to manage for recreation, wilderness, range, timber, watershed, (fig. 9) and wildlife and fish purposes. Discretion was broad, and the multiple uses remained zoned uses, with timber garnering most of the zones. Each use had its own staff group and a separate budget. If people badly wanted a particular land use—a dam site or wilderness area—they went to Congress, which typically put the Forest Service on the defensive.

This visibly diverse charter led to PNW's landscape economics work of the 1960s and, anticipating the Wilderness Act of 1964, presentation of alternative economic criteria for screening candidate wilderness areas. By 1964, PNW had a project leader for multiple-use economics, Thomas Adams. One of his approaches was organizing meetings of forest economists.

WESTERN FOREST ECONOMISTS

by

Thomas C. Adams

Some time ago a scattering of forest economists felt a need for some sort of "retreat" where they could meet informally with each other and with others in their profession. This was so as to become more acquainted and to exchange ideas relating to their research and to development of their emerging profession. Accordingly, a 3-day conference was called in 1966 with sponsorship by a regional marketing project of the Agricultural Experiment Station of Washington State University and by the USDA Forest Service Pacific Northwest Forest Experiment Station at a small conference center adjacent to the Mt. Hood National Forest in Wemme (now Welches) Oregon.

Informality was stressed, with emphasis on small loosely structured "discussion" groups where participants would feel free to comment "off the record". There were to be no proceedings published.

The invitation list included economists and management-level professionals from federal and state agencies, western universities, and private forest industries from the western United States and Canada. Hoping for attendance of maybe 20 or 30 for a viable meeting, organizers were surprised to find 67 persons registered for this first meeting. It was judged by all a whopping success!

Subsequent meetings were intended to be held each year in a forest setting in different parts of the country to give participants first-hand experience and a "feeling" for conditions on the ground in each area, but this idea was soon dropped in favor of the more or less central location and near-ideal meeting conditions of this first meeting place where these meetings continue to be held each year.

Traditional subject areas have included trends in timber supply and demand, price movements, world trade, and forest planning. Current meetings are giving more attention to competing values and uses such as indirect costs and benefits and public perceptions of intrinsic value and quality of life.

[Tom Adams is regarded as the founder of WFE.]

"Marketing economics" was another arm of PNW's economics research. Originally it was intended to extend the pre-War work on promotion of less used species and residues and to collect market statistics, the roles that similar units had in other Stations. In the Northwest, however, few species were unwanted, and the work moved toward sales

Figure 10—Prospects for Alaska timber has been a perennial issue for Station economists.

arrangements, market structure, and price formation, including interregional market dynamics. The two groups were only lightly separated, and they mingled with each other and with forest survey analysts, especially on large projects that came along and on environmental economics as it evolved. Together they addressed several hundred subjects over the years, not all of which were reflected in publications and not all are mentioned here.

A long series of regional resource and market projections for the Northwest timber economy started in the 1960s at PNW, following several national timber situation reports in the previous three decades. Each answered questions about timber scarcity, the abundance and quality of the resource post-old growth, and implications for employment and the forest environment. Another long research trail that started in the 1960s led through steadily more complex thickets of timber trade interactions. Rather basic work on decision theory and regional analysis was undertaken in that decade and revisited through the 1990s.

Alaska, (fig. 10) with the most valuable and most costly softwood timber in the world, was both isolated from domestic markets and close to the main stream of Pacific Rim timber trade. In its last-in/first-out role during economic cycles, Alaska needed and received supply and, especially, demand analyses from PNW in the 1960s and periodically thereafter. They are described later.

The Environmental Seventies

The 1960s generally had been a time of timber primacy among the multiple uses of forest lands. It was a period of clearcuts, retreating old growth, trails obliterated by logging debris, views framed by snags, and burning slash. For the national forests, it also was a time of multiple use, from building campgrounds to routing the North Cascades Trail, from conservation education to barometer watersheds, from RARE I (roadless area review and evaluation) to the Wilderness Act. By the early 1970s, the Monongahela and Bitterroot clearcutting controversies had halted clearcutting in the

Figure 11—The Rare II process raised interest in the interaction of science with policy discussions.

Southeast and generated Idaho Senator Frank Church's guidelines on clearcutting. Budgets and staffing were growing in support of nontimber activities—but slowly.

The prime directive was multiple use, but the principal pressure was on harvesting. Getting out the cut, raising the level, and getting it out again were the themes for every industry association, numerous academic foresters and economists, and many members of Congress. Harvest scheduling options, all aimed at raising the near-term cut, were pressed. Economic pressures of the time were echoed by Congress and the Administration, into the 1980s. John Crowell, who oversaw the Forest Service as President Reagan's assistant secretary of agriculture, was quoted as saying that departures from even flow were "absolutely necessary."[21] The Forest Service was hard-pressed to maintain a semblance of high sustainable yield and multiple uses, much less even flow. In fact, professional meetings were replete with suggestions that federal forestry was inane, and perhaps it was.

Passage of the National Environmental Policy Act (NEPA) on the first day of 1970 may have cooled the climate for cutting. Here was an early statutory expression of broad environmental concern, echoed 4 months later by the first, and momentous, Earth Day. Little was known as yet, however, about the moderating burden of environmental impact statements on federal and private resource activities. And there was no broad understanding of what Congress had wrought with the Endangered Species Act of 1973.

Clearcutting, wilderness, and large harvests were the reverberating public forestry issues of the 1970s. Congress passed the National Forest Management Act (NFMA) in 1976. RARE II (the second roadless area review and evaluation; fig. 11) occurred during this period as well, accounting for a number of PNW's economic analyses.

Certainly the early 1970s were turbulent economically. Interest rates rose in 1969-70, pulling housing starts down by one-third and lumber prices and Northwest lumber production each down by one-sixth. The economy stabilized in 1971, but wood product prices soared with housing starts, the latter doubling between 1970 and 1972.

Inflation was a fixture of the 1970s. Between 1971 and 1973, producer prices, an indicator of inflation, rose 18 percent while lumber prices climbed 50 percent. These were record levels. To deal with the general inflation, President Nixon undertook an Economic Stabilization Program, but it did not apply to raw materials such as timber. Stumpage prices rose 50 percent between 1972 and 1973. The administration pressed for higher federal harvests, but federal spending caps, set to curtail inflation, precluded additional timber sale funding.

The oil crisis stemming from the Arab-Israeli War started in 1973, and pushed producer prices up another 18 percent in 12 months. This was the first time since World War II that supply rather than aggregate demand caused major price inflation. As always, lumber prices fell as mortgage rates were raised and construction dropped off.

In 1974, interest rates were raised to their highest levels since World War II and inflation eased. The annual climb in producer prices went from 20 to 2 percent. Lumber production headed down again, but the administration still wanted to expand national forest logging. This time Congress provided funds, but the environmental community demanded an environmental impact statement (EIS) under NEPA, and a federal judge agreed.

The EIS matter persisted into 1975, with the possibility that all national forest harvests would be involved. In late 1974, Congress had just passed the Resources Planning Act (RPA), and all agreed that the upcoming 1975 Forest Service RPA documents, including an RPA-based EIS, would suffice.

Americans went on an excellent economic ride during the rest of the 1970s. The economy grew vigorously, so strongly that inflation again dominated domestic economic policy. By 1980, producer and consumer prices were rising 16 percent annually. Housing starts doubled. This time, however, lumber prices and Northwest lumber production did not rise to the occasion. Canadian exports to the United States did instead, doubling in three years to equal the Northwest's whole production.

In this erratic environment Congress became confused. Was the West running out of private timber? Should the Canadians be rebuffed? Could national forest harvests really be expanded without long-term harm to productivity and the environment? Would creation of wilderness areas create a commodity crunch? Should more be done about log exports?

In 1977, the Society of American Foresters (SAF) identified a crisis in federal forest land management. The crisis was the Monongahela court decision, including both a halt to clearcutting and judicial intervention at a level of resource management where the courts had not trod.[22] The combination put an exclamation mark on what everybody knew, that somehow production forestry would have to be blended into a quality environment. "Quality environment" was an undefined but widely used phrase of the time. More sharply understood was that multiple use was not allowing forests to realize their “full potential” (a phrase usually meaning the harvest should be increased). This dilemma was passed by Congress to the agencies via RPA, and the agencies turned to their researchers.

In the mid to late 1970s, PNW economists were responding to a number of nationally raised questions. The timber harvest issues study (THIS) and its effect on the National Forest Management Act of 1976 will be described. The NFMA imposed clearcutting guidelines and made wilderness an explicit multiple use. It endorsed nondeclining even flow in national forest harvest planning, but it allowed departures based on intensified management, thereby embedding PNW’s allowable-cut-effect into law.

Roadless area tradeoff studies, bearing on wilderness-area economics, were done by PNW economists in the late 1970s. They influenced the Forest Service’s nationwide review of roadless areas and thus future wilderness creation and are discussed directly. The Resources Planning Act of 1974 pulled PNW into periodic, comprehensive, model-based demand and supply projections for wood products that continued, with growing sophistication, through the 1990s. They are treated in detail later. The program of timber trade studies begun in the 1960s continued apace as new proposals for import and export constraints emerged. They too will be reviewed, near the end of this history.

Meanwhile, PNW’s production economics group cooperated with the Bureau of Land Management (BLM) in intensive-management studies along the Oregon coast. More work was done on protection economics, and a group of studies centered on forest residues, as both problem and opportunity. These studies are described shortly.

Timber and forest product flows from, and prices in, the Northwest were projected under new assumptions and with new data, which confirmed earlier repeated warnings that harvests were headed downhill. That study will be described, as will PNW’s dealings with strategic concerns, U.S. policy analyses, and Canadian exports to the United States.

Alaska still faced the world of timber commerce from a fragile and unique position. The 1970s brought new PNW studies exploring ways to expand year-round employment in the interior as well as the southeasterly archipelago. Those prospects and what became of them are part of the section on Alaska.

Economics research at PNW during this tumultuous period, and after, was remarkable for its steadfast detachment. Most of the research was about timber but not about timber advocacy. Many others in the profession were drawn into the land-use controversies, either through their employment or their persuasions. Even environmentalists saw the issues as economic and addressed them accordingly. The Station’s economists stuck to testing hypotheses and assessing alternatives, answering questions of what if, how much, how soon, where, and at what price.

The Ecosystem Eighties[23]

Inflation barreled on, bringing high interest rates as always. In 1980-82, individuals could earn 15 percent on Treasury bills. And of course housing starts fell, again by half. These dreary cycles made economic projections difficult and dubious. What credibility could estimated rates of return on forest futures have, when observed rates fluctuated so much? Indeed, what validity could financial maturity and other economic elements of long-term forestry retain? In some quarters, not much. Intensive-forestry studies of the time at PNW tended to include several compound rates for projecting costs and discounting future cash flows.

With the inflation came corrective monetary policy, and the U.S. economy slumped. After the initial recession, the 1980s were, however, somewhat more stable economically than the 1970s. Business economists remark on the decade for its initial deep recession followed by 8 years of strong economic growth. Industrial production climbed by one-third.

Throughout the 1980s, national forest harvests moved with harvests in the Northwest in general, which dipped for the recession and then recovered. If declines were in prospect, it was not apparent from on-the-ground performance, although the big old growth had been gone for 30 years and even small old trees were now largely absent from private lands. The transition to second growth was nearly over, and third growth was the management object of interest on private holdings. The 40-log truckload was becoming common. On national and private forests, problems with roads and streamsides were legion and clear-cutting had not gone away, though slash burning was now largely history and replanting was eminently successful.

Eras probably never come to total closure, but the fury embracing harvest scheduling, even flow, wasted wood, and the like diminished or at least moved to a new venue in the early 1980s. If the 1970s was the decade of forest legislation, the 1980s was the time of litigation. Environmental appeals added 15 to 20 percent to the average time of preparing national forest timber sales. At one time, over 2,000 appeals were in process. Lawsuits and court decisions created management gridlock.[24] This condition did not drive research directly, but it involved many scientists in giving expert opinions and drew attention to the need for a broad range of research information, including economics. Unfortunately, court appearances were creating pop scientists and experts reaching beyond their expertise: enough of this occurred that a backlash of judicial skepticism followed.

In 1971, Forest Service Chief Ed Cliff mandated ecosystem management within the agency.[25] Congress created wilderness areas state by state, each with intense media coverage that included such terms as “pristine” and “save.” Counter language usually included “lost” and “jobs.” Below-cost federal timber sales were pressed as an issue and acknowledged by the Forest Service. In 1988, the agency’s head ordered a major reduction in clearcutting. National forest road construction, in miles, dropped by half. Logging in roadless areas, below-cost or not, became an issue and eventually was stopped by a Chief’s order. Fire losses and then forest health became issues as drought appeared in the West in 1985 and lasted into the 1990s.

Analysis of nontimber objectives and constraints by PNW economists accelerated during the 1980s. Ventures included mathematical programming, a large multiresource

Figure 12—Darius Adams, Dave Darr, and Richard Haynes were part of the group that in 1982 received a USDA Superior Service Award for “innovative research and preparation of a study to provide a basis for timber policies and program benefiting Americans.” Others pictured are Dwaine Van Hooser, George Dutrow, Bob Phelps, Max Peterson, and Dwight Hair.

study for Alaska, social accounting, and economic implications of the national roadless area reviews. Continual expansion of the acreage of young growth, with rising timber values, also drew new and updated economic studies. The needs of RPA and other large-scale resource and market projections continued, and PNW expanded its capability in these areas, including new lines of research on land-use change across the Nation (fig. 12). There were studies of transport economics, means of forecasting housing activity, and methods for region-level stumpage and product price projections. Indicators of and responses to timber scarcity were pursued by research. International work expanded from the Pacific Rim to include Europe, and indeed the globe, more products, and even currency values. And in the 1980s, data—domestic and foreign—became more costly but more complete and, we supposed, more accurate. All these things are discussed later.

The Nineties: Reaping What Was Sown

A national recession early in the 20th century’s last decade was soon forgotten, and feelings of wealth drove housing starts up while pulp and paper prices rose. Building products from trees lost some of their imperative, however, along with other “brick and mortar” materials. Substitutes for wood appeared in almost every use including toilet paper, driven at least partly by higher wood prices and scarcity of high-grade material.

In the rural Northwest, the big news was not markets but rather forest habitats. Running through the wetlands of litigation to catch up with ecosystem management, forestry agencies had tripped over an owl and several salmon. Many previous issues were obscured for a time by habitat management mandates. Meanwhile, the Forest Service was halting logging and roadbuilding in unroaded areas of the national forests. Concerns also grew over forest health (mainly loss of vegetation through insects, disease, and fire, on millions of acres, which was exacerbated by drought in the interior West).

Nondeclining flow became meaningless as federal harvests in the Northwest fell by 85 percent. The relatively good commercial news was that Northwest private harvests dropped by only a quarter during the decade. Mills in the region grew in average size but continued their trend toward sparseness, and wood products employment declined about 20 percent in Washington and Oregon. The decline was offset somewhat by in-migration of retirees and others with outside income, and public controversy developed over subjects like the meaning of basic employment and how one recognizes a resource-dependent community. Research on this subject is covered late in this history.

Economists from PNW were involved in three of the largest multidiscipline, short-term forestry analyses ever conducted. First was the 50-analyst Northwest Forest Plan, related to the spotted owl (*Strix occidentalis*) but with an eye toward other old-growth-dependent organisms. Next was the East Side Forest Health Assessment, head-quartered in Wenatchee, Washington, and involving some 113 scientists. Largest was the interior Columbia basin analysis, involving 145 million acres in several states, a multitude of agencies, and some 300 analysts addressing possibilities for ecosystem management of 164 subbasins. This work was triggered by the salmon, but broadened when salmon habitat was found to be habitat for almost everything else. These ventures are covered in more detail later.

Meanwhile, the 1990s also took PNW economists farther into Alaska, where the forest industry was almost obliterated by closure of its two pulp mills. For Washington, a habitat suitability index was devised by PNW economists. The economics of salmon management and of streamside habitat values were pursued. It was observed that managing for old ecosystems may not coincide with managing for old trees. Ecosystem and habitat strategies had not kept young trees from becoming big trees in the Northwest, and management to make the best of them, with and without new kinds of silviculture and with and without joint production of wildlife and livestock, continued to be crafted by economists. Perceptions of the Northwest's timber future had been trashed by policy developments, and new regional projections came with a new national timber assessment led by PNW. Along a separate track, but with the same expertise and kinds of modeling, came international timber situation studies in cooperation with other countries. Questions about forest sustainability abroad and environmental effects of trade also were addressed. Another new area of attention was carbon sequestration and climate change, on which there were several PNW economics studies.

These lines of economics work are described study by study, albeit briefly, in pages to come. Clearly, this last decade was interesting and, like those before, productive.

In the nineties, the big issues affected all landowners, with consequences reaching far beyond the forest sector. Endangered species and habitat conservation were driving forestry. Key words of the decade became "habitat," "landscape," and "sustainable." Roadbuilding was stopped in the region's national forest roadless areas, and pressure rose to halt cutting altogether. Forest depletion, especially in the tropics, was dramatic and worrisome. What could economists do to aid policymakers and advance their own state of the art in this corrosive climate?

Rather a lot.

Research Accomplishments

This chronicle follows research accomplishments within broad sectors of forest economics. Within subject sections, research is described in the order it occurred. Although the author's memory provides some of the context and commentary, most of the substance comes from the publications. In general, the timing of research is keyed to publication dates. Readers should assume that problem and study selections, data collection, and analyses generally occurred one or two years before the dates recited here.

Of some 500 economic studies done at PNW from 1960 through 1999, about one in eight was specifically useful to federal agencies. Other analyses were about effects on the private sector of proposed government land-use, harvest, or trade policies. Perhaps a third dealt with social and economic circumstances quite apart from governments and policymaking, and a number were arcanely specific to developing the methods of forest economics.

As the authorships will show, cooperative research was common. Universities, other state and federal agencies, companies, and associations participated in economics research at PNW. The rich fabric of cooperation reached from ranchers in John Day to firefighters in the Yukon, from loggers in Tillamook to academicians in Maine. Of 213 researchers named in the text, 110 were cooperators; their affiliations are indicated for the time they worked with us. Not shown at all are the many firms that, assured of confidentiality, shared their data, resources, and insights with us.

First names of researchers are not mentioned again after they first appear, except for people named Adams, Jackson, Johnson, and Mills. In the endnotes, initials are used.

The Forest Problem

When the Station was established in 1925, people were talking about "the forest problem." President Theodore Roosevelt built a keynote speech around it at the forest congress of 1905.[26] In 1926, SAF's national program of forest research gave page one attention to "the forest problem," and proceeded to lay out a research program to solve it, including a major segment in forest economics.[27] In 1933, the Forest Service's oft-cited national plan for American forestry was subtitled, "The report of the Forest Service...on the forest problem of the United States."[28]

The problem was economic: swift timber liquidation. Consequences were flooding and erosion, land abandonment, and reduced timber supplies. "The forest problem must therefore be stated in terms of timber requirements and of forest land use producing this timber, a series of other products, and additional but less tangible economic and social benefits."[29]

An early PNW attack on the forest problem involved forest taxation. Annual property taxes, small on forest land but considerable on standing timber, were widely considered to encourage widespread, untimely harvests. Some large timberland owners declared and demonstrated their intent to cut out holdings in certain counties where tax assessors were considered insensitive. In 1927, the average assessed value of west-side timberland and its (old-growth) timber was $17 to $86 per acre, with the annual tax ranging from 1 to 9 cents per thousand board feet. That's about one-tenth of one percent of the value. Latter-day landowners should be so lucky; however, in a time when wages were $4 a day, and a mature second-growth tree was worth perhaps $1 on the stump, holding onto timber for deferred earnings could be a problem taxwise. Family woodlots, the back forties, suffered less taxwise because they were typically cutover stumpland and considered almost valueless. Data on taxes were collected for Washington and Oregon and other states by forest economists Roy Thomson and Daniel Pingree and several taxation economists, all of whom apparently stayed only briefly in Portland.[30]

The forest problem, like the clearcutting issue, had several facets. Rapid deforestation had been rationalized partly on the premise that cutover lands would be taken over by settlers who were pulled west by inexpensive land and pushed by an immigrant-crowded east. In much of the Midwest and West, good timberland was poor farmland, and poor timberland was even worse. Studied for more than a century, farmland abandonment was a major consequence of the propaganda campaigns to attract settlers to cutover lands in New England, the Lake States, and the Northwest. The "cutover lands problem" generally was attributed by researchers to farmers' laziness, ignorance, and undercapitalization of their farms and rarely to poor land and bad times. In the 1990s, farmland abandonment was seen in more positive terms, at least to the extent that it was encouraged by federal displacement incentives. Federal subsidies of departure, such as the Soil Bank, the Agricultural Conservation Program, and the Conservation Reserve Program, led to significant increases in unfarmed land, especially in the South.[31]

Farmers left the land, but city folk came after World War II, many to live among the trees on former stumpland. Others had always been there, though not necessarily as farmers. Tarp-covered trailers with broken cars in the yard were increasingly common. Many of these folks, rich and poor, did not care much about forest husbandry, and that is still the case. If the trees grew, that was fine, and for the last half of the 20th century trees did, across the Nation. But not often with nurture, and that was the "small woodland problem," descendent of the "forest problem."

Analysts were full of wisdom about the small woodland problem, from finding it no particular problem at all to bemoaning it as a signal of future timber scarcity.[32] In the 1960s, Bob McMahon and I, in separate studies, agreed and disagreed. McMahon compiled from the literature a view of landowners as economically rational, profit-maximizing capital investors using conventional discount rates, whose views of forests' futures were heavily influenced by uncertainty. From interviews of owners of large holdings, whose forest investment behavior seemed irrational, I described utility-maximizing people whose time preference trajectories reflected multiple objectives and alternatives for getting there, relatively certain of their woodlands' futures.[33]

Station analysts revisited the subject starting in the 1990s in the context of climate change. If farmland becomes forest, it might increase carbon sequestration. And if that is good, incentives to leave the farm to natural vegetation may be socially worthwhile. That is the context of studies described in the "Climate change, air pollution, and acidic depositions" section, in "Multiple Objectives...," below.

As this paper was written, global warming was apparent to some analysts, and unproven to others. To some, damage to the ozone layer was becoming worse; to others, the wounds were healing. National policies had been adopted to reduce discharges to the atmosphere, and reduction was occurring; however, U.S. land-use policy was not substantially altered.

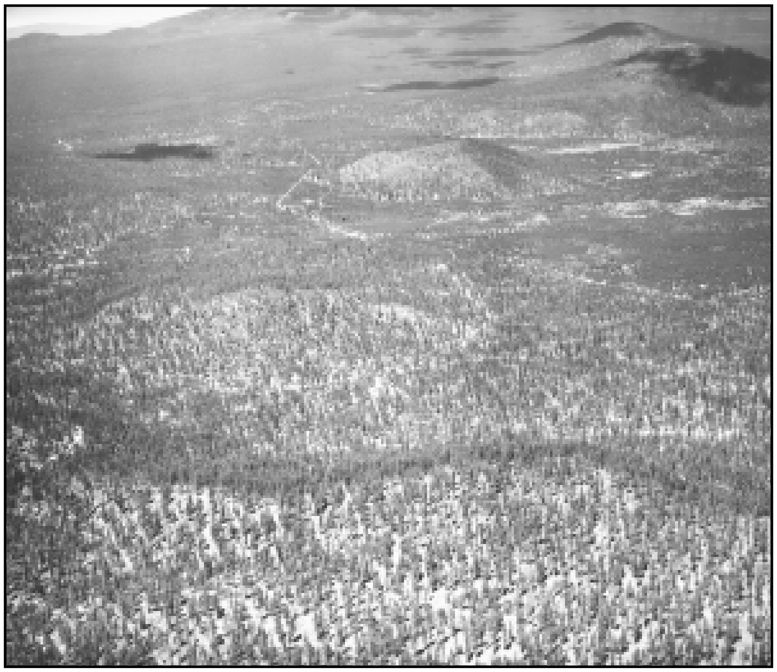


Figure 13—Partial cutting in the ponderosa pine forest of central Oregon in 1937. With about half the (better) trees removed, economic questions emerged about how long the remainder should be held, whether natural regeneration would work in the face of invasion by other species, and how to cope with the risk of fire. (Photo by Wallace Guy.)

The Clearcutting Dilemma

Whole books have been written about the wisdom of clear felling in even-aged, shade-intolerant forests. Others are about the clear stupidity of doing so, given the apparent waste, ugliness, and environmental damage involved. But if not clearcutting, then what?

The issue had already been around a long time when, in 1936, PNW's Axel Brandstrom teamed with Burt Kirkland in a controversial, comprehensive publication advocating selective logging on the west side rather than massive clearcuts. The system would be road rather than rail based, and it would involve what we might now call group selection. The authors included persuasive silvicultural arguments and economic calculations.[34] Their boss, PNW Director Thornton Munger, didn't like the system. He saw it as an excuse for high-grading stands during the Depression era of low prices. After selection logging had failed in practice, mostly because of windthrow and hard times, Munger wrote a "gotcha" article years later. His final words on the subject were, "Let foresters keep to their science of silvics. And let us keep research ahead of practice, so that untested innovations will not get ahead and get off the trail of nature's silvical laws."[35] So there, you economists.

Munger and Brandstrom apparently mended the fence later. In the late 1930s, they joined in discussing the "maturity selection system" (fig. 13) for ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), derided by critics as high-grading.[36]

The ghost of selective logging past returned in the 1990s as a central feature of "new forestry;" however in 1991, Jim Weigand and Richard Haynes pointed out that the objective of partial cutting had changed.[37] Rather than metering out stands to protect the site and ensure reforestation, the aim then was to sustain a legacy of old-growth timber for its own sake. We still know little about the social costs and worth of doing so. Renamed "green tree retention," the practice again "has neither an extensive regional tradition nor a base of empirical data by which to predict economic outcomes."[38] Munger must be chuckling.

Studies in Production Economics

Because he had the country's major forest economics group, PNW's Newport was pressed by forestry administrators throughout the West to provide analytical counsel on timber production, protection, and investment questions. The intensity of these inquiries was heightened by growing nationwide interest, especially visible within government, in capital budgeting, investment efficiency, and a number of other roughly equivalent ideas. They connoted recognition that funding was a constraining factor, forestry budgets were unlikely to expand to permit all "needed" management, and spending would have to be directed toward best chances, assuming that economists could persuasively identify them. Newport responded by directing effort into problems that seemed to have widest application and could be partly or fully supported with non-Station funding.

These production economics studies of the early 1960s brought into common regional use and national forestry literature several major economic principles that together demonstrated that forestry can pay, that in some cases forestry budgets fall far short of exhausting economically attractive opportunities, and that in other instances budgets might well be diverted elsewhere. Among the principles were:

- The time cost of money, rates of return, and present net worth
- The opportunity cost of money and resources: all things have other uses and there is no free lunch
- Fixed versus variable costs
- Distinction between marginal increments and average units of activity
- Emphasis on high net return rather than least-cost management[39]

Estimating the relative economic merit of forestry practices, the stuff of classical forest economics, has evolved greatly at PNW in its sophistication and capacity to deal with complex resource interactions. Rising timber values, changes in the economic and policy worlds around forestry, increases in computing power, and particularly, increasing demand for analytic information have pushed and pulled the Station through three decades of attention to the economics of pruning, thinning, fertilizing, type conversion, harvest technology, residue use, and so forth.

Guiding intensive forestry—In 1933 Brandstrom published a 115-page bulletin on logging costs and methods. It included numerous tables and complex graphs, in detail that would impress a latter-day production economist.[40] Brandstrom's title at PNW was senior forest economist.

During the 1950s and early 1960s, advocates and practitioners of intensive stand management had little economic information with which to select treatments, candidate sites, species, and age classes. It was generally felt that higher sites should have precedence, but in practice traditional treatments and lowest cost opportunities prevailed. Economists were pained to see labor-intensive activities on relatively low sites of the east side and in the Rocky Mountains, while high-site opportunities in the Douglas-fir region languished. Casual economic analyses of public forestry in average circumstances habitually showed that forestry didn't pay, even at the relatively low discount rates (about 3 percent) used at that time. Because forestry was being practiced anyway, in the face of seeming financial folly, several forest economists were more intent on showing the uneconomic nature of forest management than on identifying best opportunities.

During those years, John Fedkiw stirred considerable regional controversy with his advocacy of "financial maturity," a principle that he, Bill Duerr (State University of New York at Syracuse), and others honed in the South.[41] Financial maturity conveyed the idea that forestry could be profitable if stands were harvested when their rate of value growth declined to the current rate of interest. This almost always produced a much shorter rotation than the maximum-average-physical-growth criterion of the time.

In 1960 Fedkiw, then at PNW, and Jim Yoho (Duke University) laid out a financial model for determining the optimum time to thin and reproduce even-aged stands to maximize returns on the owner's capital. This was an extension of financial maturity.[42]

Much of the popularity of the principle lay in Fedkiw's particular attention to well-tended Douglas-fir stands on upper sites and their high rates of return. He commissioned a table of value growth percentages for individual trees that was still being requested 20 years later. He also developed visual guides for estimating growth percentages from bark characteristics of individual trees. That the growth rates of stands might be quite different from those of single trees was considered unimportant, provided that mortality was captured or forestalled by thinning.

Equally popular on the east side were PNW's 1966 guides for ponderosa pine stand management and dwarf mistletoe (*Arceuthobium* Bieb.) control, again because financially attractive opportunities were displayed.[43] The "allowable cut effect" work also triggered controversy and policy changes, discussed later.

Norm Worthington and Fedkiw reported, in 1964, on the economics of large-scale commercial thinning on high sites in western Washington, based on experience at the McCleary (Washington) Experimental Forest. Stumpage prices rose with inflation, from $5 to $10 per thousand board feet from 1949 to 1961. With 3.5 percent interest included, net after-tax cash flows over the 13 years were small; however, they were better than doing no thinning. In one of the two stands, the physical growth was below 2 percent at the end of the period; in the other it was over 4 percent. The future of the low-earning stand would depend on stumpage prices. The authors concluded that "as much attention will have to be given to checking stumpage prices from year to year as to the continued silvicultural care of the stand."[44]

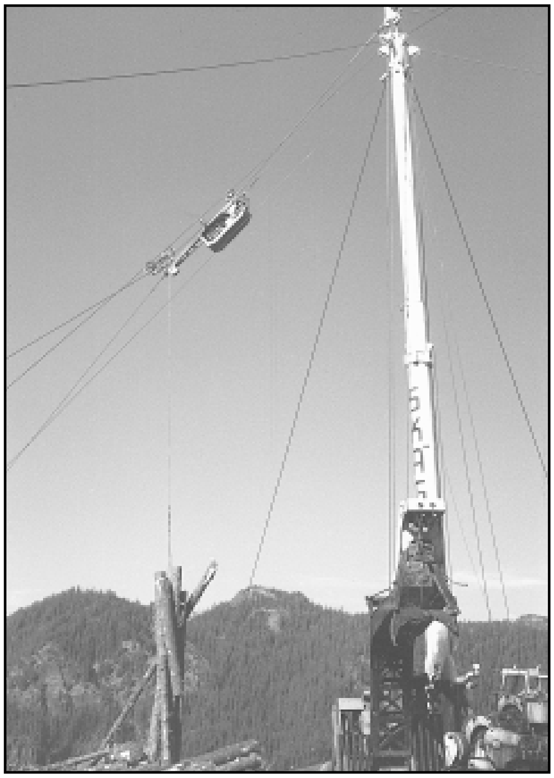


Figure 14—A Skagit tower with a high-lead carriage system being used in steep terrain.

With smallness becoming common among trees slated for harvest, the forest industry and agencies all looked for guidance as to how far down in size the logger could economically reach. "It depends," was not a sufficient answer when millions of dollars of timber transactions were involved. In 1965 Tom Adams developed equations to predict logging and hauling costs (fig. 14). He also compared the costs of "clean" logging when all the trees are removed in one pass, versus "prelogging" in which small logs are removed first to reduce breakage.[45]

Tree planting and seeding, key elements of forest management, expanded rapidly after World War II. By 1960 about 180,000 acres were being reforested artificially each year in the Pacific Northwest, and the trend was still upward. This was about 70 percent of the area burned in wildfires and clearcut. Brian Payne documented the annual areas reforested from 1915 onward and the post-War costs of doing the job. It was not clear whether the backlog of acres needing reforestation was shrinking. Payne recommended concentrating on areas that would provide a good return financially but said that identifying those areas would require information not available then.[46]

More elaborate than the Fedkiw-Yoho investment model of 1960 was another developed by Dan Chappelle in 1969. This was a computer program, IVST, which calculated internal rates of return, present net worth, and benefit-cost ratios—a considerable computational advance at the time. The program was based partly on Chappelle's work for the Douglas-fir supply study, which will be explained later.[47]

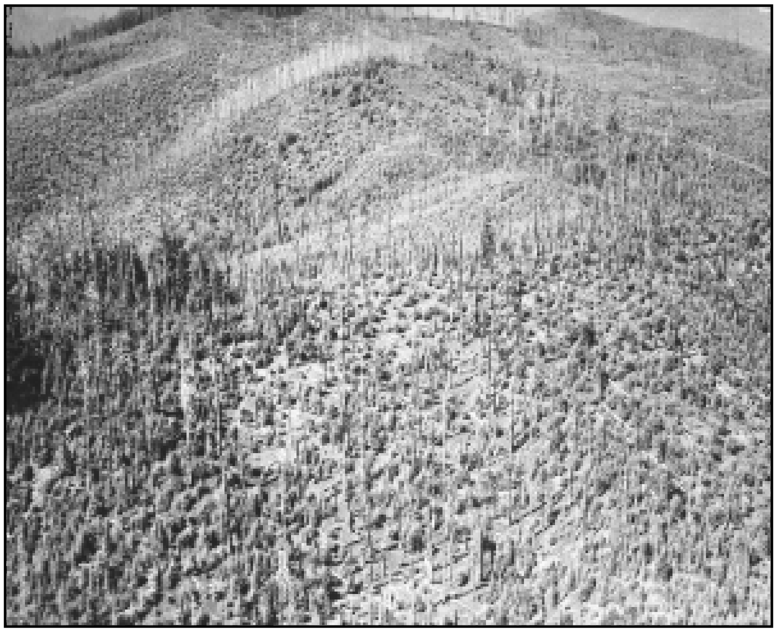


Figure 15—This is natural Douglas-fir regeneration following a burn.

Small-diameter trees were a growing proportion of the timber resource. Notwithstanding computer modeling, it was not clear that commercial thinning could be done on a regular business basis, although many firms had tried it when prices were high, and the USDA published information on the subject in 1961.[48] Tom Adams, in 1967-68, did a systematic market survey and logging-cost analyses to identify how large and accessible thinned material must be in bad times as well as good.[49]

In the early 1970s, David Darr and Tom Fahey compared the value output from three types of mills (Beaver, Chip-N-Saw, and band mills) for typical arrays of log sizes. Both lumber and chips were produced but in different proportions. The analysts showed how total value recovery changed among the mill types as the relative prices of chips and lumber had shifted during the 1960s.[50]

Roger Fight joined silviculturists in 1973-74 in explaining to the harvesting community what intensive culture was all about. They showed how spacing control (thinning) offers a number of production options over time, with different costs and returns. They suggested including fertilization of low-site lands and pointed out that the Northwest's lowest sites were more productive than most areas in the U.S. Lake States and Northeast. They discussed the aesthetics of long versus short rotations, the merits of artificial rather than natural regeneration (fig. 15), and potential gains from genetically improved seedlings.[51]

Interest rates—the cost of capital—have long been considered the bane of economic forestry. But, in a 1974 study of Douglas-fir thinning economics, Bob Randall and Darr found that although time erodes returns, projected returns to thinning were sensitive not only to expected interest rates but also to the assumed relations of stumpage values to average tree diameters. They showed how simplistic value ratios of thinned to residual trees, such as in the Douglas-fir supply study, could skew economic calculations.[52]

How important interest rates can be was emphasized by Randall in 1976 for commercial thinning. Assuming no increase in real prices, stumpage, and various alternative thinning regimes and harvest ages, he showed that a 6-percent interest rate would point toward an early clearcut; 3 percent would support delaying a decade or two after making a thinning, this on a relatively high site.[53]

Another element of intensive management, in the 1970s as well as now, has been the potential production of poles and piling, usually a small but highly valuable product from young stands. Almost invariably, poles are selected preferentially during logging and sorting; they leave the logging site coddled and supreme. In 1974 Randall and Chuck Sutherland (Oregon State University) did one of the few public overviews of this niche market. In a survey, producers worried about future demand but more about the supply of tall, low-taper trees.[54]

Historically, grass had not challenged forest economists, but in 1972 Bob Sassaman provided graphics for gauging the rate of return on investing in forage grass among thinned ponderosa pine trees. It was known that thinning encouraged understory vegetation, and hundreds of thousands of acres of pine were being thinned in the West. It was not known whether opting for grass was worth it. Depending on costs, forage growth rates, and the value per head of livestock grazing time, return on the investment could be rather good.[55]

Sassaman teamed with Fight, Lou Spink, and Bud Twombly (the latter two were with the Pacific Northwest Region, Portland) in 1975 to produce a more elaborate model of forage rates of return after thinning and grass planting, given various rates of grass growth, expressed in AUMs (animal-unit-months of sustainable grazing), including costs of excluding livestock during an initial grass-establishment period. Again the economics appeared generally favorable.[56]

In 1976 Fight and Randall looked at the incremental costs of timber production for different intensities of management in two national forests, one on each side of the Cascade Range. The aim was to assess the investment efficiency and break-even possibilities of intensive-management regimes contemplated in the THIS, described later. Success levels of management were progressively less attractive. There were obvious implications for proposals to offset reduced timber flows caused by, say, roadless-area designations.[57]

In 1977 Randall revisited commercial-thinning economics. Timber values had risen greatly since previous analyses; however, the merit of short-term, out-quickly management over long thinning regimes was still apparent. Conclusions apparently changed little relative to interest rates and prices. Randall pointed out that interest rates in analyses of this sort, in which prices and costs are assumed to be inflation-free, should be stripped of their inflation-expectation component, an adjustment not usually made at the time.[58]

Next, Randall incorporated precommercial thinning into his commercial-thinning computations for Douglas-fir. He found that, given contemporary values and interest rates, "precommercial thinning was justified in most cases and nearly always preferred to regimes which included commercial thinning alone. On lower sites (land of low productivity) precommercial thinning [could] turn an otherwise unattractive management opportunity into a financially feasible one."[59]

In 1977, Sassaman, Jim Barrett, and Twombly developed financial precommercial thinning guides for ponderosa pine. They devised a worksheet useful to readers needing benefit-cost ratios for ranking candidate stands and deciding whether thinning would pay at various discount rates.[60]

Two more examples of joint ventures with silviculturists, in the Fedkiw-Worthington tradition, occurred in 1979. These involved forest fertilization. With perhaps a million forest acres already fertilized on the west side, mostly on industry lands, Dick Miller and Fight presented research results from field plots and the economic implications. The studies indicated a 72-percent chance of increasing growth by at least 10 percent. Fertilizing was expensive, and programs warranted fine tuning to identify best chances, application rates, and schedules over time. Generally these were low sites, large trees, and short waiting periods for returns. The allowable cut effect (discussed shortly) was mentioned; it would apply to fertilizing if flows were regulated over time, as on public lands, and a reserve of mature timber were available to cut.[61]

Randall, working with Bend silviculturist Pat Cochran in 1979, analyzed fertilizing economics for thinned ponderosa pine. They concluded that fertilizing was a questionable investment in central Oregon, assuming prices and costs of the time, and even given somewhat higher returns.[62]

This history is replete with diversions of PNW economists to special engagements. Here is another. In 1975 Fight was asked to join a task force on production economics that was organized by the USDA and western agricultural experiment station directors. The matter of most concern was rapidly rising prices for farm products, including wood, caused at least partially by declining crop reserves and farmland, deteriorating agriculture overseas, and increasing domestic price instability. The group designed lines of research to address the problem.[63]

Unlike price statistics for many commodities, price data for standing timber are not for a standardized material. Timber on the stump is rarely of a single species and quality, and buyers of national forest timber must bid on an entire parcel. Multiple regressions were used to isolate the changes over time of stumpage prices associated with physical quality characteristics. In 1981, Lance Brannman, Joe Buongiorno (both with the University of Wisconsin) and Fight found that the average annual change (trend) in price owing to quality changes from 1968 through 1978 was very small, though year-to-year influence was significant.[64]

Continuing Fight's site-improvement work of the late 1970s, he and George Dutrow (Southeastern Forest Experiment Station, Durham) estimated real rates of return from forest fertilization in 1981 by comparing the Pacific Northwest with the Southeast. Costs in the Northwest were twice those of the Southeast in 1976, but the highest rates of return, on the best opportunities identified, were about 30 percent in both regions.[65]

Fight, Judy Chittester, and Gary Clendenen, in 1983, developed an economic component for DFSIM, then and now a popular computer method of simulating Douglas-fir growth and yield. Costs and prices can be inserted in various ways. The products are discounted net revenue and soil expectation value, the present value of an infinite number of rotations.[66]

The economics of silviculture depends mostly on what it costs, how long one waits for revenue, and the size of that return. In 1984 Fight, Chris LeDoux (Northeastern Forest Experiment Station, Broomall), and Tom Ortman (Pacific Northwest Region, Portland) dealt with the first item. For silvicultural planning on the west side, in 1984 they generated equations for predicting costs of harvesting: cable yarding with large and small yarders; felling, limbing, and bucking; and branding and loading. They also built equations for moving and changing yarding corridors. The yarding costs were for skyline yarders. The form of the data was compatible with the DFSIM model, mentioned above.[67]

Using a wood-strength and value example from the South, Fight and others pointed out in 1986 that highly accelerated growth, from aggressive thinning, may significantly reduce the quality and dollar worth of lumber cut from the managed trees. Whether this could apply to Douglas-fir they did not know, but they pointed out several ways in which one could err badly in pursuing maximum volume. First, the market may not accept material that is below customary standards, though uses might be found if enough were produced. Second, minimizing juvenile (fast-growth) wood production may not be the most cost-effective way to solve the problem. Third, choosing a single view of future quality needs may fall victim to changing technology.[68]

At the same time, Fight and Dave Briggs (University of Washington) showed how greatly tree size and volume, volume per acre, and clearcutting versus thinning can affect harvest and manufacture costs and thus net revenues. Differences could be as much as a factor of two to three.[69]

A more elaborate harvesting system for clearcutting was evaluated in 1990 by Mike Lambert and Jim Howard. A steep-slope feller-buncher, a grapple-skidder for forwarding, a chain-flail debarker-delimber, a chipper, and a shredder were used. Half the output was chips. The shredder received bark, branches, and very small trees for hogged fuel. Used in dense hemlock stands on the Olympic Peninsula, the system was handling about 2,300 trees per 10-hour day, at a cost (1990 dollars) of about $380 per hour.[70]

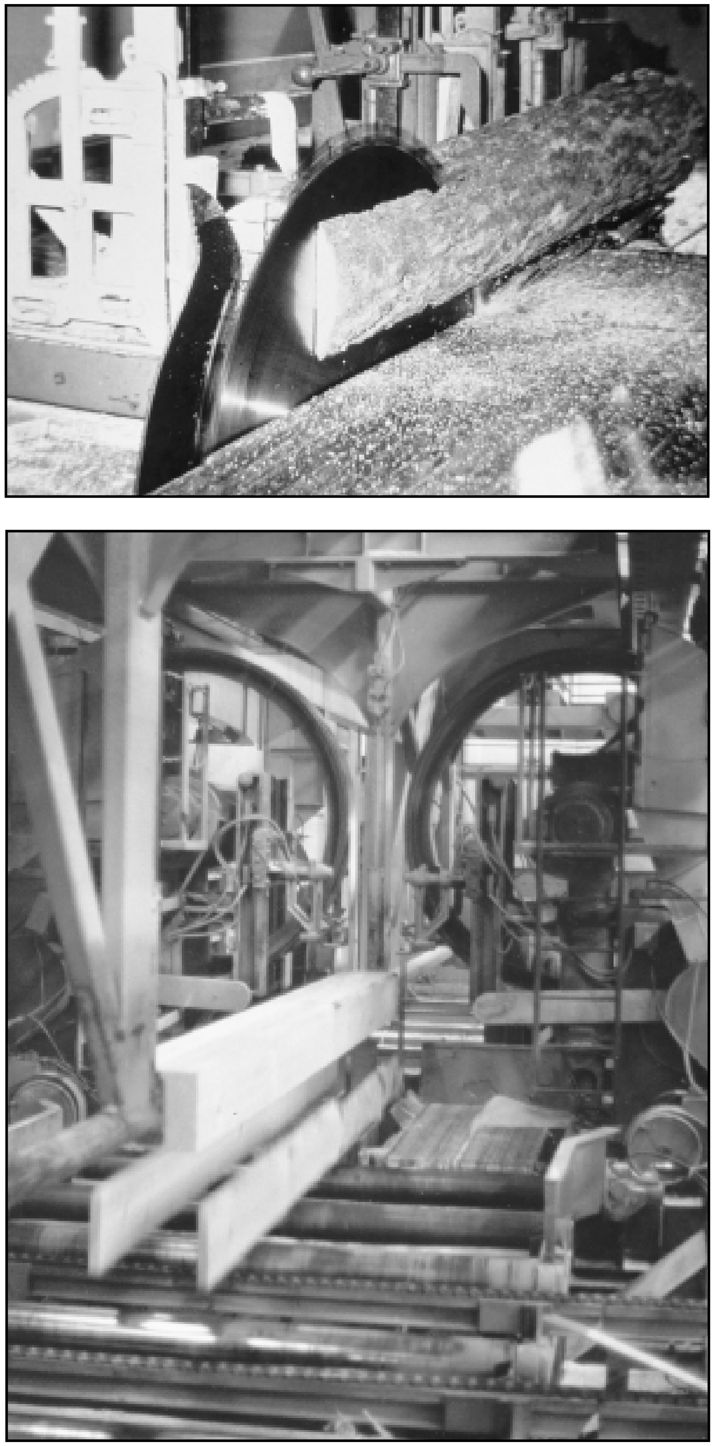


Figure 16—The past 50 years have seen numerous changes in lumber mills in the Northwest: (A) A Pre-World War II circular saw headrig. (B) This double-bandsaw heading with an end-dogging carriage is one example of innovative technology used in western sawmills.

Pruning often has been considered dubious on financial grounds, because it is labor-intensive and it is not always obvious that loggers and mills of the future will "cut for grade" (figs. 16a and 16b). In 1987, Fight, Jim Cahill, Tom Snellgrove, and Fahey found many situations, however, in which pruning coast Douglas-fir would yield more than an 8-percent real rate of return. That rate of return was associated with a 30- to 40-year growth period between pruning and harvest. A 5-year difference in the time of pruning made a substantial financial difference, as did site productivity.[71]

The same people developed a spreadsheet computer program for doing financial analyses of pruning coast Douglas-fir. It used actual mill experience, with pruned and unpruned logs, for both lumber and veneer. Called PRUNE-SIM, it was superseded by DFPRUNE in 1992 (discussed later).[72]

A new product recovery study (in 1987-88) prompted an update of the 1987 financial analysis for pruning coast Douglas-fir. Clearwood offered a substantial premium over unpruned lumber at the time, and comfortably returned 8 percent on the pruning investment on the relatively high-productivity, fertilized land.[73]

The pruning researchers continued their emphasis on holistic planning—in 1988 doing economic accounting from the time and place of planting through tree selection, eventual bucking, and a firm understanding of the product mix and values down the road. Displaying some examples of the economics of thinning, they mentioned TREEVAL, a computer program for economically optimizing bucking decisions for a stand, given tree sizes and taper and end-product options.[74]

Pursuing the holistic theme, Fight proposed an empirical example in 1991 that began with initial spacing, continued with a thinning and pruning regime, and ended with lumber recovery estimates and valuation. This was for potential implementation at the Siuslaw National Forest in western Oregon. It was prepared for two site classes in the forest, with higher returns from the higher (more productive) sites.[75]

In 1992 Fight, Cahill, and Fahey produced DFPRUNE, an update of earlier pruning economics programs that took into account recent product recovery studies for both pruned and unpruned butt logs.[76]

Three more models related to intensive stand management appeared in 1992. One was TREEVAL2, an update of TREEVAL. Another was FIP, which combined the product value estimate with logging and cultural costs to estimate a regime's net present value. Its use mirrored the empirical, whole-system kind of treatment. The third was PP PRUNE, which was a ponderosa pine counterpart to DFPRUNE, mentioned earlier, and incorporated mill recovery results.[77]

Fight, Natalie Bolon, and Cahill used PP PRUNE in 1992 to assess pruning of ponderosa pine. Here they found returns above 4 percent. Clear pine lumber had been a fixture in the moulding and millwork industry for decades, but with a steadily declining resource of old growth, prices of high-grade lumber rose. By the 1990s, the outlook was very poor for upper grades, in terms of prices, proportion of the cut, and absolute volume. Pruning seemed to be the solution. The authors found break-even costs of $2 to $5 per tree in thinned stands; significantly less in unthinned woods. Site was relatively unimportant.

Figure 17—Sue Willits and Roger Fight show two displays on timber stand management to members of the Forest Service Chief and staff morning information session, December 12, 1989. The displays show how proper management improves the quality of Douglas-fir.

Thus lightly stocked stands, even if on low sites, were the best chance. Good wood requires a considerable wait, but not too long: 50 years looked best.[78] Findings like these were significant in that forest managers had written off quality in favor of maximizing volume, mainly because of the cost of pruning.

A synopsis of the financial analyses of pruning both ponderosa pine and Douglas-fir was done in 1993.[79]

The end of old-growth Douglas-fir and continuing demand for clear, close-grained wood products raised questions in the 1980s and 90s about generating such wood by planting trees close together, extending rotations, or pruning (fig. 17). Would any of these approaches really work? Would they pay? Which was best economically? Fight and others answered those questions tentatively in 1995: Yes, they would work; the first two methods were costly; pruning would be cost-effective—all subject to cautions and codicils.[80]

One codicil has long related to continuing preference for clear or close-grained wood. In 1996, Ivan Eastin, Tom Waggener (both with University of Washington), Chris Lane, Fight, and Jamie Barbour explored that preference. They surveyed over 1,700 manufacturers and received 177 responses. Firms were willing to pay a substantial premium for clearwood, but they valued supply reliability and price over quality. Lumber grades were (and are) seen as differing widely in utility for clear products, and there was considerable willingness to search out substitutes and lower grades for clearwood attributes. In another part of the study, trends in clearwood price premiums were investigated. Premiums held up over the 1989-95 data period, though with considerable volatility. Convergence of upper grade prices toward those of lower grades was suspected but not found.[81]

Fight illustrated the complexity of pruning decisions by comparing the clearwood recovered from a small log pruned when the tree was young with a large log pruned when the tree was older and larger. The early pruning won in terms of clear lumber produced, by more than 50 percent, even though the clear shells had the same cross-sectional area.[82]

A cluster of coordinated pruning-related analyses was done by Station economists and others in 1995. Haynes and Fight projected prices to 2040 for lumber of several western species. Trends were expected to be upward until 2020 and then level off. Briggs and Fight described various computer models that would aid whole-system analyses of tree and product quality options. Models, some of them described earlier, were available as decision aids at the log, tree, stand, and forest levels. Fight and Bolon concluded that some of the most promising opportunities for pruning Douglas-fir and ponderosa pine might reasonably produce before-tax real rates of return of around 9 and 7 percent, respectively (fig. 18). They also addressed broader policy issues including employment, forest health, wildlife, and public perceptions.[83]

Meanwhile, in 1990, Helge Eng, Norm Johnson (both at Oregon State University), and Fight looked into the economics of regenerating trees and applying early management on the difficult low sites of southwest Oregon with its dry climate and rapid brush encroachment. Employing the soil expectation value (SEV) approach via present net worths, they used two discount rates and two price levels, which they projected to 2030. They considered areas of high and low reforestation difficulty on three site classes. Treatments analyzed were reforestation, precommercial thinning, and fertilization. The SEVs differed greatly. It clearly was worth emphasizing high sites and adding pre-commercial thinning to the package, sometimes even if management was otherwise a poor choice; however, starting with low stand density was even better. Low sites, long rotations, and low prices were uneconomical when confronted in combination.[84]

Regulatory constraints are generally assumed to push timberland owners toward cut-and get-out decisions, whether the ownerships are large or small. In 1997 Rebecca Johnson (Oregon State University), Ralph Alig, Jeffrey Kline, Eric Moore (Oregon Employment Department, Portland), Robert Moulton (USDA, Forest Service, Washington, DC), and Mark Rickenbach (Oregon State University) examined that proposition in the context of nonindustrial private owners in the Pacific Northwest. There had been a stream of stricter forest practice rules, a log export ban was widely discussed, and harvest levels had doubled on nonindustrial private forest lands in a decade. Only 6 percent of a thousand owners surveyed said that those factors had induced cutting (half of the thousand had harvested during their ownership).[85]

Decision theory—Because key features of forestry are the risks and uncertainty associated with long production horizons, several PNW researchers have aimed publications specifically at these matters. The analysts involved were Alig, Enoch Bell, Jim Cathcart, Fight, Sassaman, Dennis Schweitzer, and me.

In 1964, I confronted the conventional view that individuals demand a high premium for investing in long-term ventures, such as forestry, whose outcomes carry several kinds of risk and uncertainty. In fact, capital was flowing into forestry, despite a regional and national history of natural and economic impairments of timber profits. I speculated that

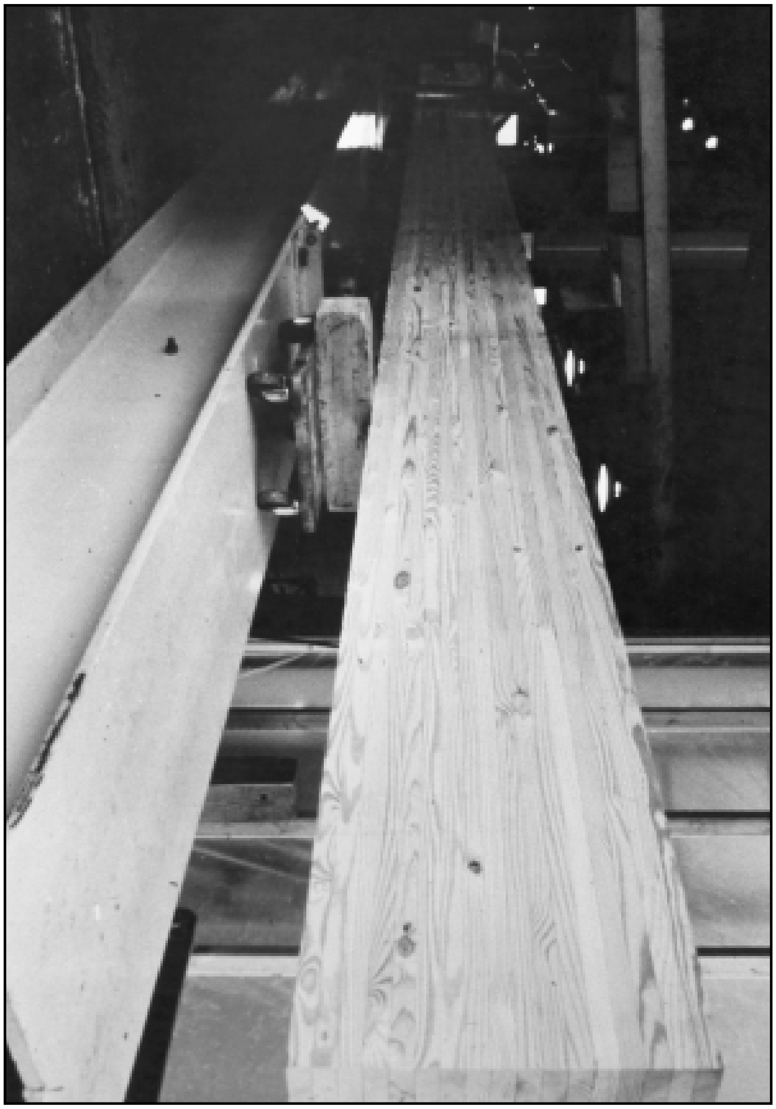


Figure 18—Products like this glulam beam are replacing Douglas-fir heavy framing lumber diminishing the traditional price premium enjoyed by Douglas-fir lumber producers.

persons close to forests, and organizations dependent on them, were making many decisions internal to forestry and of comparable futurity that involved options whose relative riskiness was not perceived to differ much.[86]

In 1970 Schweitzer and Dick Pierson (Washington Department of Natural Resources, Olympia) brought variety to the matter of treating uncertainty when a landowner chooses among leasing, managing, or selling property. They considered several ways of making uncertainty explicit, such as a reasonable range of outcomes, assigning probabilities to outcomes, and standard deviations of probability distributions.[87]

Schweitzer also proposed and demonstrated a way of gauging the sensitivity of present net worth to errors in guessing future costs and incomes. He suggested taking first derivatives of present worth with respect to each of the futurities. He related the math involved, provided a computer program to do the work, and suggested graphing the results.[88]

In 1972 Schweitzer dealt with the conceptual aspects of a practical and indeed urgent matter, that of forest fertilization. The practice was growing rapidly, it was costly, and rather little was known about the outcomes. He suggested probabilistic approaches but also observed that most fertilizing was occurring on properties subject to the allowable-cut effect, where immediate gains in harvests overshadowed time-distant response surprises.[89]

Uncertainty emerged again in 1977 when Fight and Bell dealt with risk and uncertainty in situations in which numbers can be put on future outcomes and also their likelihood. They described a risk management strategy for timber management that used assumed numbers; they pointed out that in the absence of a notion of the numbers, an understanding of the concept still is useful. They also dealt with situations in which new information arrives periodically, and the common situation in which error in one direction, say, the high side, is more costly or unpleasant than the same error on the low side. They reviewed a dozen aspects of timber management planning, finding that planners generally took a liberal stance; that is, they adopted practices or management levels that are risky rather than conservative.[90]

In 1981 Sassaman devised the idea of "threshold of concern" to deal analytically with the fact that public and environmental reaction to timbering is typically at a relatively low and constant level until a threshold of perturbation is reached.[91]

In 1994 there reemerged the subject of risk and risk premiums in required (by lenders) earning rates and expected (by investors) earning rates. This subject had long been a fixture of capital budgeting discussions and theory, especially important in forestry because of the long waiting periods. As Dave Klemperer, Tom Haring (both at Virginia Polytechnic Institute, Blacksburg), Cathcart, and Alig said, "Foresters have long yearned for low interest rates to evaluate forestry investments. But economists have admonished that just because benefits are far in the future is no reason to apply a [low] discount rate." Indeed, the analysts took the addition of a risk premium to discount rates as given and addressed the appropriate size of the premium. At the time, real risk-free rates on government bonds were 1 to 4 percent before taxes, and the federal Office of Management and Budget had recommended 10 percent for government activities, which was intended to reflect a pretax rate in the private sector. The authors dealt with theory, math, and practice related to risk premiums.[92]

Hardwood management—A forest management topic that the Station addressed in the late 1920s and periodically thereafter was hardwood management. Herman Johnson started it with work on red alder (*Alnus rubra* Bong.) that he published in 1926, describing its extent, use, management, and economics.[93] He did the same for bigleaf maple (*Acer macrophyllum* Pursh) in the early 1930s.[94] In 1962 Elmer Matson of the economics group, Worthington, and Bob Ruth did a report on alder management and use.[95] Progress toward alder use in products was slow, and in 1968-69 Yoho, Chappelle, and Schweitzer dealt first with alder marketing opportunities and challenges[96] and then with the economics of converting red alder stands and patches to Douglas-fir.[97] Their general conclusions were that most red alder stands should be converted to Douglas-fir, and most of those immediately. If alder were to be retained, it was suggested that it be on poorer sites, because as one moved toward better sites, the productivity of fir would increase faster than that of alder.

By the late 1970s, conversion was still a relevant economic question. Alder for fiber was on the horizon but clearly not for the vast quantities that kept popping up on the west side. By targeting opportunities, Bell and Randall showed that conversion to Douglas-fir could be economically attractive in some circumstances but should be foregone in others. The analysts found that, although expensive, conversion generally would be financially feasible if adequate conifer stocking was achieved on the first try. The work helped bring economic discipline to at least some of the near-million acres of alder conversion that were in prospect.[98]

By the mid-1990s, landowners were discriminating against alder on sites seen as high for fir and low for hardwoods. One major firm had virtually obliterated alder from its lands, which were mainly high-site. Landowners saw that both prices and volumes per acre were a third of those for softwoods over the same rotations. Terry Raettig, Kent Connaughton, and Glenn Ahrens (Oregon State University) took a comprehensive view in 1995 of Northwest hardwoods, of which alder comprises 87 percent on the ground.[99] Hardwood volumes were the highest ever and increasing, but at a slower rate than during the previous decade. Discrimination against hardwoods in state reforestation rules had diminished. Log and lumber values were rising. While noting that industrial use of alder saw logs was growing, with over 7,000 people employed, they showed that overall growing stock was in decline as the acreage of young alders declined. Over half the commercial hardwoods harvested were chipped. Bob Tarrant, former PNW Director and friend of alders, has suggested that better economic returns may be available from alternating rotations of alder and conifers in areas that would benefit from alder's additions of nitrogen to the soil.

Advance roading—Road construction also attracted considerable attention. Provoked by advocates asserting that it might pay to build forest roads well in advance of the main harvest, to remove thinnings and dying trees,[100] PNW economists analyzed "advance roading" (see "The Robust Sixties" for definition) opportunities. Their findings were a surprise. In 1969 the Douglas-fir supply study (explained later) found that, on average across the west side, completing planned roading in 20 years instead of 40 would generate a negative rate of return on the capital involved.[101] In the same year Brian Payne did a forest-level analysis for the Umpqua National Forest, southern Oregon. He found positive rates of return. But the rate of return was not sufficient to justify additional congressional funding. Inclusion of nontimber benefits and costs did not change matters.[102]

Con Schallau analyzed the merits of advance roading as a means to increase thinning production on BLM second growth in the Tillamook, Oregon, area. His analysis disclosed that advance roading would earn a negative rate of return. He questioned the merits of a Public Land Law Review Commission recommendation calling for advance roading.[103]

Protection economics—In 1962 Newport looked at past and potential economics work on pest outbreaks. He concluded that economic analyses should not be counted on to guide efforts against fast-moving outbreaks or be used to critique such responses. They should be used more, but mainly when long-term preventive strategies were being considered.[104]

My dwarf mistletoe work, the first economic study of insect or disease damage and control except for Robert Marty's work on white pine (*Pinus strobus* L.) in the Northeast, unsettled some foresters because it showed that returns to protection expenditures could be more favorable on low sites than on better soils.[105]

In 1965-66 I worked for 18 months to determine whether a forest-fire danger rating system could be based partly on economic parameters but recognize widely varying economic values at risk and differing resources available for gear and staffing across North America, as well as long-recognized differences in fire behavior and likelihood of occurrence. James Hefner (detailed from the Southern Region, Atlanta) and I concluded that a multifaceted system, ranging from traditional fuel sticks weighed in the field and rules of thumb to computer-run complex algorithms, could be used concurrently to yield remarkably comparable results. This would solve some political as well as technical issues. The effort therefore was expanded to a national fire danger rating unit in Fort Collins, Colorado.

Protection economics got attention again in 1974 when Randall did an unpublished analysis of controlling the Douglas-fir tussock moth (*Orgyia pseudotsuga*), one of the most destructive forest insects in western North America. The insecticide DDT had just been banned and there was question whether an expensive pheromone alternative was worth its cost. Randall, using various assumptions about the number of years required, concluded that benefit-cost ratios likely would be quite high.[106]

BLM cooperative second-growth studies—With strong support of BLM in the early 1970s, Schallau and Randall undertook several protracted studies of the economics of second-growth management. In addition to his analysis of advance roading, Schallau analyzed the tradeoff between road construction costs and road maintenance costs. His findings helped justify construction of more single-lane logging roads. Randall developed an integer programming model for scheduling thinning operations that used the Tillamook second-growth management area as a case study. Then he and Schweitzer set about successfully husbanding implementation of the model.[107]

These studies had immediate, visible implications. The Tillamook fire of 1933 had caused Oregon voters to sell bonds to reforest the vast snag-studded burn. It worked, creating what Forest Service Chief Bill Greeley called "one of the great human achievements in engineered conservation."[108] By the 1970s, the people of northwest Oregon were looking toward the former Tillamook Burn for jobs, and Oregon taxpayers and bond holders wanted a financial return. The slopes were largely tree covered, but was thinning a cost-effective thing to do?

Residues: pain, product, and provender—In the woods, residues were logging slash; in the mills, they were burner waste. In old-growth stands, as many as half the trees were dead. Of those alive, half of the tree was left in the woods to molder away, burn, or be ugly. As much as half of the log became slabs and sawdust. Carbon sequestration hadn't been invented yet, so fire was the slashing solution.

Chief-to-be Richard McArdle in 1930 and Munger and Matthews in 1941 dealt with the perennial questions of burning: Where was the risk of wildfire greatest? Where and when was a controlled burn, with its inevitable risks and uneven results, worth the cost? Was it really needed for reforestation? They concluded that slash reduction was necessary irrespective of the cost, and they did not see relogging and residue usage as reasonable alternatives.[109]

In 1964 Tom Adams judged that the wide variation in logs left in the woods, all termed "residue," might be an opportunity to "high-grade" the left-behind wood, taking it out over roads already built and essentially free to the high-grader. Adams took a hard look at residues in eastern Oregon.[110]

Residues did not remain in the woods. With rising wood values came salvage logging, a subindustry unto itself. Companies enforced their own low-stump rules, and agencies devised sales arrangements to encourage residue removal, such as separate sales of residue and requirements to yard logging remainders and cull logs to landings. Per-acre pricing is discussed below. On all ownerships, bucking was done to smaller tops and whole-tree logging appeared. These things were partly for appearance, partly for fire hazard reduction, and partly to keep rubble from the streams (riparian woody debris was not yet known to be useful). But economics pulled that material as strongly as any yarder.

Keeping mill residues out of the burner was not widely considered until Al Hall found that sawmill waste made wood alcohol—not cheaply, but adequately for the War effort of the early 1940s. By the War's end, there were two plants in the Northwest.

By the 1960s, the western pulp industry had found mill waste cheaper than roundwood, abandoned their woodrooms, and paid enough for chips to encourage sawmills to install chippers and pay attention to careful debarking and chip quality. Then flake-based panels and wood fiber and plastic combinations were devised, and residues became king, often becoming the profit center for a sawmill.

By the early 1970s, the volume of residue left was still equivalent to one-seventh of the reported log harvest; with wood prices rising, there were numerous proposals for moving residue into commerce. In 1970 Tom Adams developed a supply curve for forest residues along the west coast. He used harvest data and recovery and cost data by tree size. He showed a considerable reservoir of residues still unavailable at costs and prices of 1970. On the other hand, he also showed substantial volumes apparently economically available. This was important because of growing dependence by the western pulp industry on mill residues to maintain their comparative advantage.[111]

In 1971 a group of residue articles by PNW authors was commissioned by *Forest Industries*. Howard, Don Gedney, Tom Hamilton, and Brian Wall estimated the volumes of residues generated at the time in logging and manufacturing and their prices in chip form.[112]

In 1972 Tom Adams reported that a whole new log grade had been created to recognize those cull logs that could be chipped. He concluded from a mill study that such logs would have to be at least 80 percent sound and over 14 inches in diameter,[113] criteria that would change greatly over the next decade. In 1976 he found that whole-log chip mills could be economical when integrated marketwise, if not geographically, with other wood processors.

In 1973 John Austin projected west coast mill-residue use by the pulp, paper, and board industries to 1980. His forecasts were based on questionnaire returns and, he felt, were somewhat pessimistic because of the economic climate of the early 1970s. He foresaw, however, a 19-percent increase in wood use by such mills.[114]

The potential for increased lumber production from west coast Douglas-fir cull logs was of obvious interest as the old-growth resource dwindled. The hope was to stretch timber supplies and reduce logging residue. Snellgrove and Darr found that both lumber recovery and lumber grades from cull logs were low. Using prices of the time (mid-1970s), they concluded that only during times of very high prices would lumber manufacture be feasible. These were also times of high prices for pulp and plywood, which competed with lumber for raw material.[115] So, in many places, cull logs went onto the veneer lathe (fig. 19), with the core and other remains going to the chipper.

The energy crunch of 1973 triggered a search for nonpetrol resources. For electricity generation, it was proposed that wood residues, especially those from logging, might be collected. Tom Adams and others concluded in 1974 that transport costs per unit of fuel would be preclusive, although forest industry plants might take advantage of their own residues. Many did, because a hydropower shortage loomed for 1977-78.[116]

Forest Service use of per-acre pricing was assessed by Hamilton, Howard, and Tom Adams in 1975. Would this special sales arrangement move more residue from logging sites than conventionally scaled sales? Thirty-eight sale areas in Washington and Oregon were involved in the comparison. The per-acre sales had a fixed payment per acre, so the stumpage cost borne directly by any particular log would be zero. Thus any piece worth more than its yarding cost might logically be removed. Fewer residues were left behind with per-acre sales than otherwise, but not significantly so.[117]

In 1976 Tom Adams and Richard Smith (University of Missouri at Columbia) dealt with the overabundance, albeit noneconomic supply, of logging residues. They found that novel sales arrangements, specialized chip mills, and chip exporting would, if undertaken on a substantial scale, make a considerable reduction in residues. Separately, Adams added market instability and scaling problems to the challenge list. The industry and agencies followed the advice, one firm even hiring stump inspectors to ensure greater tree utilization. And during strong chip-market years, woods residues faded as an eyesore.[118]

Figure 19—The powered backup roll helps prevent veneer log spin-out by providing torque to the surface of logs. More veneer may be obtained by peeling logs to smaller cores. (Boise Cascade photo.)

In 1980 Tom Adams studied options for leaving residues on the ground for environmental purposes. Could residue "take-and-leave" prescriptions be decided, explained, and executed? Trials suggested that they could. Yarding was inefficient, however, with standard high-lead gear.[119]

By the 1990s, mills closed but chipping plants opened, thereby reflecting the diminished size and quality of trees. Habitat concerns pulled residue out of the woods in some places while leaving it there in others.

In 1999 Haynes considered several explanations for chip price behavior since data had become available in the 1960s. He found some relation between lumber production and chip prices, which reflected the abundance of mill residues for chip making, and he remarked on the stickiness of long-term chip commitments, sometimes requiring that whole logs be chipped. He noted that domestic prices had been about 80 percent of reported export prices. Prices in Japan for U.S. chips had fallen for almost 15 years, despite sharply higher prices in the United States, thereby indicating the rising value of the yen.[120]

Timber Scheduling, Allowable Cut, and the Inevitable Falldown

The premier post-World War II question of Northwest forestry dealt with public old-growth inventories: How fast should they be harvested? Agencies' timber management directives were fairly uniform: (1) maintain even flow over the long run (2) at a maximum level while (3) removing decadent old growth rapidly to make room for thrifty[121] young stands whose growth could be captured in later harvests.[122] Unfortunately these objectives usually conflicted.

Leveling the federal timber flow—Forest Service harvest levels have always been calculated (though not controlled) at the local national forest or working circle level. Until the late 1960s, a simple formula approach was used in figuring the allowable cut. First, a rotation length was chosen for each timber class, or perhaps all of them together; this was widely recognized as the most critical factor controlling timber flows. Next a conversion period, usually equal to the rotation length, was selected, during which timber older than the rotation age would be liquidated in equal annual parts. Next, average annual growth on the non-old-growth acres, and any dead or nongrowing trees among the younger old growth, was forecast for the conversion period. The annual harvest would be the sum of the growth and liquidation (conversion) components. This was a tentative formula, however, because it was unlikely that there could be an even flow of volume **and** a regulated acreage array, at least by the end of the first or even second rotations. Looking at the tradeoffs and striking a balance required some iterative calculations called the area-volume check, a subject in itself.[123]

It was invariably assumed that by the time the conversion component fell to zero, at the end of the conversion period (first rotation), intensive management of young stands would produce offsetting growth rates. Through the mid-60s, however, the calculations never went beyond the first rotation—another subject in itself.

The cut calculation process, repeated every 10 years, obviously had tremendous influence on communities near the forest; yet the figuring was acknowledged to be crude.[124] For instance, at one forest, the planning in 1963 for 15 billion board feet of standing timber, was done on 10 double-spaced pages.

Flow smoothly sweet harvest...to the falls—Nowhere in national forest timber planning during the 1950s and early 1960s was it recognized that when replanning was done every 10 years, credit was being taken for growth increments already achieved, so that no lump of uncredited growth would be left to add in at the end of the conversion period. This was an unforeseen difficulty with traditional approaches to harvest scheduling. Thus, where existing per-acre old-growth volumes were large relative to potential young-growth yields (in some cases, twice as large), there was bound to be a drop in harvesting as the second rotation got underway. Although PNW economists had pointed out the potential difficulty in studies of east-side management (mentioned later), it remained for others in the Station to produce the detailed evidence that would revolutionize timber planning at the national forests.

The allowable cut effect—For those wanting to provide or purchase large and steady flows of national forest old-growth timber, two seemingly arcane notions surfaced uncomfortably in the 1960s. "Falldown" (the prospective sudden drop in harvests) was the bad news presented by PNW economists. "Allowable cut effect" was perhaps the solution, also offered by PNW.

Probably the most controversial notion made prominent by PNW in the 1960s was that of ACE (allowable cut effect), as named at the Station. The idea was simply that, if money is spent making a stand of trees grow faster, the investment will not be recouped until much later, at harvest time. But if annual harvests are based on the average long-term growth of the whole forest, and if there are mature trees being held back from cutting because of, say, an even-flow rule, cutting the old trees may be accelerated by the investment. (ACE also can reduce cutting when, for example, a fire loss occurs somewhere in the forest even if mature trees are standing by). In the late 1950s, foresters at a Canadian timber company had taken advantage of the fact that, by planting trees on old cutover areas, the province would raise the allowable cut for that timber compartment and thus produce an immediate increase in harvesting even though the planted trees would not mature for decades. Cash came out almost as soon as cash went in. I noticed that the same circumstance would occur under the planning system then used for timber on U.S. national forests and applied it in the pine management analyses mentioned earlier.

The concept was elaborated, mostly in the *Journal of Forestry*, by PNW economists. Schweitzer, Sassaman, and Schallau were the first to publish explanations of the physical and economic ramifications of ACE and related consequences of even flow coupled with large old-growth inventories.[125] Controversy erupted immediately over whether it is appropriate to take credit (in some cases, take losses) early in the rotation for distant events. There also was concern that the analytical system usually does not recognize that early harvests come out of old-growth stands whose costs are low or sunk and whose opportunity costs are off the books.

For a decade, Station economists were regularly roasted in academic sessions and applauded in forestry circles. The issue subsided when later work on harvest scheduling, commissioned by Fight, showed that almost any scheduling system alters cash flows and that ACE is an institutional consequence of multiple objectives and inventory policy.

For discount rates and rates of return, in 1980 Schallau and M.E. Wirth (Washington State University) contrasted the IRR (internal rate of return) arising from ACE, with RRR (realizable rate of return), the return on actual cash flow when repeated ACE gains on the same ground are some decades apart. The RRR was lower than IRR in the examples used.[126]

Allowable cut effect, later called EHE, the earned harvest effect, found its way into law. Western members of Congress, looking for ways to increase national forest harvest without doing unpopular violence to sustained yield, built language into the National Forest Management Act of 1976 to "permit increases in harvest levels based on intensified management practices, such as reforestation, thinning, and tree improvement...."[127]

TIMADS, the plunge, and timber streams thereafter—Computers brought an opportunity to adapt linear programming and other mathematical optimization methods to timber management planning and harvest scheduling. Among the first to do so was Randall at PNW, who introduced integer programming to forestry, mentioned earlier in connection with the Tillamook Burn studies. He demonstrated, by using BLM's Tillamook area, that complex scheduling of intermediate cuts could be done quickly and accurately, and that economic returns could be increased in complicated planning situations.[128]

Models of timber scheduling became big business at PNW in an undertaking the Station called TIMADS (timber management decision systems). Chappelle led the effort, with Randall and Sassaman involved. Later, Bell extended the work.

The TIMADS coincided with the availability of computers, so that relatively complex multivariate operations could be run fast and repeatedly. The first TIMADS exploitation of the capability, in 1966, was ARVOL, a simulator that replicated the area-volume check method.[129] Next came AREA, which computed harvests under area control (equal areas harvested annually) without reference to volume regulation.[130] Area control had some attractions because, after the first rotation, the same area would be harvested and reforested each year, in contrast to volume control. Presumably even flow would result.

Extension of ARVOL to multiple rotations, in 1969, became SORAC,[131] which accommodated an assumption that the allowable cut would be recast for each (usually decadal) planning period, a feature that contributed to the falldown finding mentioned in the next section. These models made relatively short work of the formerly cumbersome allowable cut calculations, and they provided a convenient way to explore timber harvesting levels for subsequent rotations. Sassaman and Ed Holt at PNW helped Karl Bergsvik of BLM expedite an extension called SIMAC, which added the ability to display how well the falldown might or might not be filled with management-enhanced growth.[132] It was a cluster of TIMADS runs that convinced timber planners in the Forest Service's Pacific Northwest Region that then-prevailing allowable cut levels could not be sustained.

Another variation, called goal programming, was applied to multiple-use multiple-objective planning by Bell in 1976.[133] Bell also discovered some problems with the approach. He used a 93,000-acre national forest planning unit as an example. It required dealing with 700 subunits, each of which had to be assumed to be homogeneous within itself. The final array involved a table with 7,000 columns and 1,800 rows. For each unit, future production had to be known or assumed. Some things had to be assumed to be linear when in fact they were not. And the rationality of the approach depended on the reality of the goals and their relative weights.[134]

Meanwhile in 1971, Dan Navon (Pacific Southwest Forest and Range Experiment Station, Berkeley) had developed a linear programming approach to harvest scheduling called RAM (resource allocation model).[135] It could accommodate thousands of compartments. Timber planners seized on RAM as an expedient black box, and used it in trial-and-error fashion almost as they had used the old area-volume-check approach. However, RAM had certain limitations, such as invariant rotation lengths, treatment schedules, and yields (rather than inventories and growth functions). Too, constraints required by RAM sometimes negated the volume gains from intensive management. And for at least one sample national forest, RAM produced relatively erratic assignments of harvest to decades.[136] Bell drew the attention of potential users to what the linear programing black box does and certain limitations on its practical use. For instance, linear programming accommodates only one objective, which can be a problem even if applied only to timber scheduling. He offered a generalist's entree to goal programing, mentioned earlier.[137]

In 1976, Chappelle, M. Mang, and R.C. Miley (all by now at Michigan State University) did an influential critique of RAM and a checklist of the features a "best" forest planning model should have.[138] Bell noted two basic types of harvest scheduling models available at the time—those dealing with a single rotation of variable length and those recognizing multiple but invariant rotation lengths.[139] Johnson at Oregon State University made RAM a more flexible tool and developed model I and model II, which led in 1979 to MUSYC,[140] with variable rotations,[141] and then, by 1986, to FORPLAN versions 1 and 2.[142] FORPLAN came into use for multiple-use planning at virtually all national forests.

Douglas-fir supply study—In 1969 a major analysis of national forest harvest-policy alternatives, the Douglas-fir supply study (DFSS), was conducted at PNW.[143] In 1967, the Secretary of Agriculture directed the Forest Service to answer several questions about opportunities to increase timber production from the national forests of the west side of the Cascades. The queries included consideration of accelerated road programs, intensive management, and reduced conversion periods for old growth, as per the Duerr Report,[144] discussed later. At a time when national forest timber planning embraced specific, singular concepts of management generated in regional offices and applied regionwide, DFSS involved 20 combinations of the above-mentioned practices. Although discouraged from considering nontimber outputs, PNW's economists began the Forest Service's first wide-ranging study of environmental effects of timber options. In addition, community and employment effects were gauged and price forecasts, an innovation in resource analyses, were made by PNW's marketing unit.

The work was shared by the Pacific Southwest and Pacific Northwest Regions and economists at PNW. Station participants were Newport, Schallau, Gedney, Hamilton, Payne, Austin, Chappelle, Sassaman, and me.

There was lively discussion about the relative validity of three economic measures in ranking options, particularly because ACE produced immediate returns from intensive management and thus very high cash-flow rates of return. Present net worth was selected. The original DFSS 556-page unpublished report (which had limited distribution) included a preferred alternative chosen by the two regional foresters. It included commercial and some precommercial thinning, the current rate of road construction (not more), and the current rotation length averaging 100 years (not shorter).[145] This decision did not appear in the published, greatly shortened version; however, it was subsequently tested via revision of the management plan for the Gifford Pinchot National Forest in southern Washington. And the approach—ACE with treatments screened via a 5-percent (later 4-percent) discount filter—was adopted nationally by the agency in the late 1970s.[146]

Timber flows from the management alternatives were arrayed for 14 decades, making this the first published look at falldown alternatives at the end of a 100-year old-growth conversion period. A principal product of DFSS was its confirmation of Chappelle's earlier conclusion that, under any kind of timber scheduling, a falldown in timber supply was inevitable for the national forests; only its magnitude and timing could be adjusted. Increasing the level of timber management raised the annual yield in both the first rotation and subsequent decades, but it did not eliminate the eventual falldown in national forest timber availability.

The DFSS was propelled by the newly developed TIMADS machinery, described earlier. TIMADS computations for the DFSS showed falldowns of as much as 45 percent. Fedkiw, looking back 30 years later, said,

> With the help of computer technology and the Douglas-fir supply study..., national forest managers, for the first time, were able to simulate timber harvests, management, and growth, decade by decade, for several decades beyond the first rotation. Unexpectedly, the study results revealed that, under the existing management intensity, current national forest harvest levels could not be sustained after the old-growth inventories had been harvested....The current harvest level could be sustained only if forests were more intensively managed. [The latter a reference to ACE.]
>
> The findings shattered the traditional basis for determining sustainable harvest levels in western old-growth forests....As a result, national forests shifted the determination of allowable cuts to a nondeclining-flow policy based on the potential yields (or harvests) that second-growth forests could produce using existing timber management intensity.[147]

"Shattered" is appropriate. West coast forestry agencies, federal and state, immediately reexamined their harvest scheduling policies. "Sustained yield" had implied even flow forever to the agencies and outsiders. A falldown voided the argument that federal foresters were guarding against industrylike depletion; indeed, an argument for holding federal forests was seemingly destroyed. Were agency foresters, pillars of the natural resource land ethic, conspiring with exploiters via their one-rotation planning myopia? No. One hundred years, the typical rotation, was after all a long time. It is interesting, though, that apparently nobody had looked behind the curtain. Now many folks did. A major analysis was done by the Pacific Northwest Region using the Gifford Pinchot plan for the experiment. The forest's allowable cut dropped 30 percent.[148] The Congressional Budget Office and the General Accounting Office launched investigations. The Forest Service's Washington office issued its famous emergency directive 16 in 1973,[149] which called for a new "nondeclining even flow" policy, under which harvests must be sustainable from year to year at an even or increasing level close to "potential yield." The latter included the effects of intensive forestry. It pushed some of the old-growth cut into the next rotation and in some cases beyond. And it permitted harvest increases only if they could be sustained for a long time through young-growth management (a version of ACE). In fact, the overall harvest could not otherwise rise above the forest's long-term sustained yield level (the maximum mean annual increment [m.a.i.] of earlier planning).

This was the way things stood until after the Station-led timber harvest scheduling issues studies (THIS) and the National Forest Management Act of 1976, both discussed next.

Timber harvest issues study (THIS) — The 1970s were a tense time for forest policy. Presidents Nixon and Carter proposed reorganizing the Forest Service and cutting many more trees from the national forests, a presidential viewpoint that persisted into the early 1980s with President Reagan. A timber association lobbied incessantly for larger federal harvest. This at a time when clearcutting was a national, public issue. RARE I and RARE II identified large areas of national forests where roads had not yet been built and should be quickly, or should not be ever, or something in between, depending on the point of view. Wilderness designations were argued for parts of Eastern U.S. national forests, where there had been none. A habitat-sensitive owl was identified in western Oregon. In the early 1970s, wood product prices rose substantially, partly because of general inflation. The President's advisory panel on timber and the environment (PAPTE) said in 1973 that old-growth harvests [on national forests, presumably] could be increased by 40 to 100 percent, and the change should be studied and then implemented.[150] Congress countered by passing the Humphrey-Rarick bill, which was the Resources Planning Act.[151]

With a plethora of technical and philosophic questions buzzing about, each with stingers, Forest Service Chief John McGuire asked for formation of a Western Resource Policy Economics Research and Development Program at PNW with THIS as its first assignment. Whereas the DFSS had not been received comfortably by senior agency people, THIS was not only commissioned by the Chief but also was to specifically address management options that departed widely from contemporary philosophy and practice. In my view, this license to explore reflected the Chief's own inquisitiveness as much as any political or economic imperatives.

THIS was a cluster of 29 separate studies involving a loose consortium of 34 economists and was organized in 1975-76, before passage of the National Forest Management Act NFMA. Subjects ranged from the conservation ethic, to national strategic objectives, to arcane aspects of harvest scheduling. Almost every technical and empirical issue that had come up in recent decades, relating to public harvest planning, was addressed. All the issues derived from one question: How fast shall we liquidate the national forest old-growth timber inventory?

The audience was specific: Chief McGuire, his staff, and congressional staffers working on national forest timber flow policy. The ultimate product was legislation responding to the Monongahela National Forest (West Virginia) clearcutting debacle and the timber-supply falldown. At the end, the studies were packaged together, and many were published separately. PNW economists assembled a 397-page summary. Some of the contributions became national RPA issue papers.[152]

Many organizations looked over PNW's shoulder at THIS results. Much of the West's economy would be affected by resultant policy, as would remaining old-growth forest environments. Analysts involved in THIS became centers of technical attention and explainers of arcane but critical concepts. An example was a presentation by Randall to the national Indian timber symposium.[153] There were many others.

In late 1976, NFMA was enacted.[154] It stipulated nondeclining even flow, a much tighter harvest trajectory than sustained yield had been. Now the harvest would be a "quantity equal to or less than a quantity which can be removed from a forest annually in perpetuity on a sustained yield basis." This was a harsher master even than the nondeclining yield of the 1973 emergency directive 16. Allowable cuts would be calculated for many decades, not just a rotation, and over that long period, harvests could rise a bit but not fall. No longer was there a question about when to take the falldown; it was now.

There were four reactions. First, harvests dropped; a one-third fall was in prospect in the Umpqua National Forest (southern Oregon), for instance. Second, technical adjustments occurred, including a shift from board feet to cubic feet to measure the inventory. This gave relatively more weight to small trees and so reduced the falldown.[155] Third, pressure arose for departures from even flow. THIS and the "two projections" report, the latter dealing with west coast timber futures,[156] had demonstrated that large gains in near-term harvests could be had without reducing the long-term total; for example, in a sample forest, allowing a 5-percent drop between decades would raise the cut in the first decade by 37 percent. Fourth, a rush of intensive management ensued, which took advantage of ACE. The same studies had shown that, even without a decline option, harvest could rise by half, indefinitely, with high investment in management. One economist remarked that "Congressmen, senators, and governors learned the litany: money for management intensification was the key to higher timber harvests."[157] Together, these steps reduced the immediate falldown to perhaps 5 percent.[158]

Was this the end of it? No. Timberland reserved for wilderness, designated roadless areas, and buffers began making even flow irrelevant. But "falldown" gained new meaning. And in 1979 President Carter ordered USDA to build regulations that would permit limited upward departures (and someday offsetting declines) from even flow to increase lumber supplies, reduce the cost of housing, and thus slow the rate of inflation.[159] THIS had shown the consequences of departures and apparently they were acceptable.

Portrayal of departures was not finished, however. The 1983 RPA assessment update, (discussed later), dealt with departures from even flow via input from Haynes and Darius Adams (Oregon State University). Also, Haynes served on an SAF task force dealing with harvest scheduling issues. He made the first estimate of old-growth inventories by age class, which proved useful in later spotted owl work.

Tools of the Trade

Helicopters are so complex and expensive that designing one specifically for forestry is not feasible. The market is too small. So it is with computers. Forest economics has never received, or really needed, custom-designed computers; however, economists close to forestry have been quick to develop more elegant models and use ever more sophisticated econometric software as computers have advanced in capacity and speed. I recall generating sums and cross products of small data sets with a handful of variables, for regression analysis, in the late 1950s. The machine of choice was either a Monroe or Marchant calculator if one could be borrowed from the boss. Doing and checking the job might take all day (the use of trade or firm names does not imply endorsement by the U.S. Department of Agriculture of any product or service). At PNW in 1960, Dorothy Martin (later Reineke) and I programmed a punchcard-driven mainframe to run the regressions, but data entry still took all day for punching and correcting the cards, and longer if the box of cards was accidentally dropped. Longer yet if a tube burned out in the computer.

Within a decade, the computers had chips and users had keyboards at distant terminals. The change was profound for analysts. Computer programs could be ordered by mail and installed quickly. Computations became faster, of course, so that more detail could be accommodated in the time available to the analysts, and the computations could be more intricate.

Problems specific to forest economics still required special models and, hence, special software. Several are mentioned here. (Discussed elsewhere in this history are AREA, ARVOL, DFSIM, DFPRUNE, FEEMA, FIP, IPASS, IVST, PPHARVST, PP PRUNE, DF PRUNE, PRUNE-SIM, REACTT, SAMM, SIMAC, SORAC, SPATS, TREEVAL, and WAMM).

TAMM—The timber harvest issues studies brought together two lines of market model development for forest products. One was by Darius Adams,[160] whose model, used on impacts of reducing clearcutting, was explained for a nontechnical audience in a THIS background report.[161] Described as a quasi-spatial multimarket model, the model (remarkably, unnamed and bare of an acronym) dealt with prices and flows via demand and supply, with interactions among private and public stumpage, products, and supply regions including Canada. Its particular focus was on estimating long-run price impacts of changes in national forest timber flows.

Some key components of market structure were added as Haynes contributed his fully spatial and dynamic (events in any period are influenced by past events) softwood timber model.[162] Their joint product was called TAMM, the timber assessment market model. It is an interregional, multiproduct model that deals simultaneously with supply and demand for wood products at several levels from the woods to consumers. It was described in 1980 by Adams and Haynes.[163]

TAMM was structured to build the 1980 RPA assessment. The model filled a vacuum between regional supply analyses and national assessments that treated the country either as the sum of its regions or as a few-faceted entity. Neither approach could recognize explicitly the competitive interactions of regions and such factors as interarea differences in wage rates and transport costs. Too, the older approaches could not handle systematically the effects of end-product prices and use levels on raw material supply and demand, or interactions of supply and demand among competing and complementary wood products.

TAMM reflected an analytical philosophy as well as an algorithm. Much of economic theory and research had involved simplifying a complex world by holding other things constant while looking at one or a few factors to assess their effects on each other. TAMM moved the other way, assuming the world of timber and wood products to be interlaced economically, as latter-day ecosystem thinking embraces interwoven biologic entities. In TAMM, markets were assumed to interconnect vertically and geographically, with products jostling each other, affecting and responding to price signals.[164]

TAMM has been employed in hundreds of policy analyses in response to questions posed by the Chief's office, Congress, and industrial and environmental groups. Underlying issues have included the Monongahela clearcutting suit, the roadless area tradeoff study, THIS, alternative log export policies, effects of tariffs on Canadian imports, alternative levels of intensive management, RARE II, response to the industry's various recommended programs, departures from nondeclining even flow, budget levels for state and private forestry and timber management, and every recent round of RPA timber assessments. Because of TAMM runs, the Forest Service has stopped claiming that national forest timber programs greatly benefit consumers by stabilizing product prices. And TAMM has shown that industry claims for stabilizing stumpage prices with national forest timber were overly optimistic.

For the 1993 RPA timber assessment update, a number of changes were made in TAMM. A report[165] captured these and other revisions made over the years by providing a new look at the model's structure. Its performance in reflecting past data was shown through backcasting, and simulations of a future base case and policy variants were discussed and shown graphically.

TRIM and ATLAS—Region-level melding of timber growth and yield models with price-relevant economic structures was an urgent need for RPA-type analyses, which built national aggregates from regional circumstances. In 1981, needing a growth simulator for TAMM, Haynes and Darius Adams called for an improvement on TRAS, which had been the agency's simulation mechanism of choice. This need would influence subsequent work at PNW.[166]

In 1987 a model called TRIM was published by Phil Tedder, Richard La Mont (both with Resource Economics International, Corvallis, Oregon), and Jonna Kincaid (University of Washington).[167] It was a revision of an inventory-projection model developed at Oregon State University. John Mills used TRIM in the South's fourth forest study, discussed later. The study projected a declining resource, and several aspects came under criticism. Mills looked into the TRIM projections. A technical aspect of the model—whether yield tables were based on volume versus growth measurements—accounted for some of the difference between calculated and expected results.[168] Mills also revised TRIM to run on personal computers rather than mainframes.[169] This would affect preparation of the 1989 RPA national timber assessment.

Along the way to RPA, TRIM evolved into ATLAS, which could account for harvests—partial and intermediate cutting as well as final cuts. Partial cutting also could be evaluated as an alternative to clearcutting.[170]

ATLAS would be used, in company with TAMM, in studies of climate-change effects on forests and the Southern timber supply study. An extended version of ATLAS would figure in projections of western Washington forests and in ecosystem modeling of the west side of the Cascades. This version added forest cover changes, harvest scheduling routines, and econometric supply equations.

FASOM—In 1983, Alig, Darius Adams, and Haynes called for a more intensive look at forest area change. The area of woodland was declining nationally, implying a lesser supply of timber and potentially higher prices. That, in turn, would affect financial returns from forestry investments and thus the acreage of intensive management. There were questions, however, about cause and effect. If area change was affecting the economics of forestry, might those economics thereupon affect the area committed to timbering? An explicit, dynamic economic model for forest area change seemed appropriate.[171]

More than a decade later, FASOM appeared, developed by Darius Adams and others. FASOM, the forest and agricultural sector optimization model, selects long-term land-use best chances on the basis of maximizing anticipated consumer and producer surplus (not land price equilibria).[172] It drew in part on the data sets and structure of TAMM and ATLAS. FASOM has played a large role in U.S. carbon-sequestration studies and in long-term projections of land-use shifts within and among regions.

Multiple Objectives and Joint Production in Forest Planning

By the 1950s, industrial foresters were emphasizing efficient production of trees while providing public access, game habitat, and largely unimpeded water flows. Agency foresters had a broader agenda, described as multiple use, which expressed itself as watershed enhancement, wildlife management, recreational facilities, and of course a growing emphasis on timber. Congressional hearings and federal agency budgets emphasized the importance of wood products as harvesting declined on Northwest private lands. In Oregon between 1957 and 1968, private harvests slid 20 percent while national forest cutting doubled. Outsiders pointed to timber primacy and dominant use (for timber) on national forests, calling for special designation of wilderness, wild rivers, scenic areas, national recreation areas, national monuments, and other logging-free zones. Zoning troubled a succession of Forest Service Chiefs, notably John McGuire, a former researcher, who wondered publicly throughout his 1972-78 tenure how to get multiple use without building fences. He said,

> ...our federal land policies are not really typical of the rest of the world....And yet we all do have a common problem. It is the resource allocation problem that bothers the capitalist economies, the mixed economies, and the socialist economies as well.[173]

Taking some liberties with policy history, it might be said that by the 1990s the fencing problem had not been resolved. Too, the multiple-use goal was being treated less as a problem of outputs and more as protection and restoration of forest inputs—soils, riparian areas, forest verdure, and their nonhuman inhabitants.

And PNW's economists were dealing with various parts of these enigmas.

Multiresource analyses in the 1960s—Nontimber objectives entered PNW's economic analyses in the early 1960s, when Wes Rickard, Jay Hughes, and Newport incorporated landscape appearance into simulations of old-growth harvest options and subsequent management. In dealing with aesthetics they presented several criteria: naturalness, meaning (context relative to expected change), and imageability (visual penetration of the scene and sameness). For ranking options they defined "simple betterness," a qualitative measure, and shadow prices.[174]

By 1964 Hughes headed PNW's multiple-use economics. He examined historical concepts of wilderness and identified 15 recurring issues and themes. This was timely because the Forest Service had been declaring informal wilderness and primitive areas for decades, and formal wilderness areas were authorized by Congress in 1964. There were as yet no comprehensive criteria for screening candidate areas, and economics clearly would have a role. Hughes concluded that the true nature of the choice was not between dollar and nondollar value alternatives, but rather between land-use options, all of which had both economic and noneconomic values intertwined. He discussed benefit-cost analysis, least-cost choicemaking, least-opportunity-cost ranking, and joint production analysis.[175]

From multiple use to ecosystem management—Ecosystem management became Forest Service policy in 1971.[176] Never really defined, the phrase presumably carried the longstanding multiple-use mandate from forests to stands, and analytical concern from harvest units to biologic communities. In 1979 Fight also suggested that it would mean changing the meaning of "multiple use" away from dominant-primary-exclusive use to general use of individual forest parcels.[177]

While PNW and others were applying mathematical programming to timber scheduling, Bell was using goal programming to deal with multiple objectives (linear programming can accommodate only one).[178] In the example just cited, recreation and other outputs were regarded as companions to timber rather than subordinate objectives or constraining activities.

The most intensive work on multiple-objective forestry in the 1980s at PNW was by Fight in his management of economic evaluations of fisheries, recreation and recreational facilities, scenic resources, and wildlife. Fight directed two major national efforts aimed at integrating the economics of other resources with those of timber in geographic areas especially valuable for nontimber uses. The first of these was the roadless area-intensive management tradeoff study (RATS), described shortly. Another major multiple-use venture was SAMM, discussed in the Alaska section.

Never mind the difficulty of estimating the value of a campground. Even gauging its cost, in terms relevant to social tradeoffs let alone Congress, can be puzzling. In 1980 Fight showed how social accounting can be different from cash-flow work, and how long-term capital and operating costs can be figured per recreation-visitor-day.[179]

By 1980 the Forest Service had placed 12 percent of its commercial forest land in a special category where emphasis would be on nontimber uses. There and elsewhere, landscape management in the sense of visual quality ("look-nice harvesting") appeared critical to the future of clearcutting. Partial retention, longer rotations, and shaped harvests on small units were among the possibilities. Fight and Randall showed that while the social value of such measures might be elusive, their cost could be considered to be the present value of revenue foregone when visual management replaced business as usual. They used a Mount Hood National Forest example to demonstrate the process. In that instance benefits would have to be $2 or more per acre per year to cover the costs.[180]

Meanwhile, Randall and Sassaman had pursued a THIS problem of gauging effects of timber-flow alternatives on forest ecosystems and nontimber benefits. Randall evaluated five ecosystem elements (water, soils, fish and wildlife, air, and vegetation) by using several criteria for each element.[181] Sassaman identified eight areas of nontimber benefit (coldwater fish, forage, developed and dispersed recreation, natural-landscape viewing, water, instream flow use, deer and elk numbers, and wildlife numbers for viewing).[182]

Randall and Sassaman collaborated on extensions of the THIS work in several directions.[183] In addition, Randall applied these developments to two national forest areas where planning was controversial: the Illinois River in Oregon and the Skagit River in Washington.

In 1982 the *Journal of Forestry* invited Bell and Randall to explore the likelihood of shorter rotations and departures from nondeclining flow on national forests. Using RATS and THIS results, they confirmed that by moving more old growth into the first rotation, via intensive management, ACE, and a flexible-rotation scheduling system, harvests could be increased and shorter rotations might emerge from the scheduling model. Budgets, access limitations, habitat and aesthetic mitigation, and public reaction to unmitigated environmental impacts might well constrain harvest increases, however.[184]

In another outgrowth of THIS, Fight, Steve Calish, and Dennis Teeguarden (the latter two at the University of California at Berkeley) pursued a converse question: rather than asking how rotations affect environmental matters, they asked how nontimber values affect rotations. They demonstrated how fish and game populations, wildlife diversity, visual aesthetics, water yield, and even soil movement are affected by stand age. If, for instance, one wants to maximize m.a.i. of deer, an appropriate stand age can be chosen. And if values are assigned to deer harvests, a soil expectation value can be calculated.[185]

By 1984 linear programming was in wide use for calculating harvest levels for national forests. Linear programming deals with a single objective, so it lends itself to maximizing timber flow while treating other objectives, such as owl production, as constraints. A constraint is a must-do activity that overrides harvesting, so it is powerful, but it mandates a single level for the nontimber activity. To assess tradeoffs between timber and other outputs, a step required by regulations, one alters each constraint a bit to look at the marginal effect of producing another owl. Because there are many constraining outputs on national forests, tradeoff analysis can be intricate. Connaughton and Fight pointed out these things and the high likelihood of arriving at an output mix that is very costly in either dollars or some of the outputs foregone. They also emphasized the importance of tradeoffs at the margin rather than at the mean.[186]

Fight, in 1983, had considered a less deterministic approach to timber management planning: dynamic programing coupled with a simulator. The advantages included avoiding stairstep assumptions about costs and prices and, especially, a better opportunity to tinker with prescriptions that might not be economically optimum from a present-value point of view, but which would embrace nontimber objectives and values.[187]

Working at the other end of the wood products pipeline, Su Alexander and Brian Greber (Oregon State University) traced the environmental effects of using wood versus other materials in construction and manufacture. This was published in 1991, a time when some were rather quick to ascribe negative environmental effects to tree use without looking at the alternatives.[188]

Long-rotation forestry emerged in the 1990s as both a consequence of other agendas and as an end in itself; it resulted from prescriptions for balanced ecosystems over space and time and from a vision of old trees and ancient forests. Weigand and Lynn Burditt (Willamette National Forest, Eugene) looked into the economics of "stand structural retention" in the course of harvesting (fig. 20). This was in 1992. Intended to maintain habitats and thus species diversity, the concept involved keeping three to eight, sometimes a dozen, green trees per acre as well as snags and down wood. Slash burning was precluded. The value of lumber foregone was $100 to $1100 per acre. Logging production per day was reduced by up to one-fourth. The number of bidders for timber sales declined sharply, perhaps because of the economic recession of the time.[189]

In 1993 Haynes pointed out that strategies under discussion at the time could involve doubling the length of traditional rotations on public land. He drew attention to the prospect of higher stumpage prices in the Northwest, with each 100 million board feet of additional harvest reducing prices by nearly 5 percent. Long life would not add much to trees' value—perhaps 8 percent (judged crudely). However, policy alternatives to long-rotation forestry, whatever that turned out to be, offered only harvest reductions.[190]

Weigand and Haynes then argued that aiming for old trees may be quite different from aiming for old ecosystems, with the latter producing a variety of outcomes, some of them surprising. They suggested several lines of research to reduce surprise and guide planning.[191] Whether long rotations coincided with high-quality forestry, they did not say.

Arguably, conservation coincides with using less. In a nation of expanding population and ever-rising projections of consumption, the notion of reduced use of wood products seems unlikely. Yet recycling has clearly had a marked effect on pulp consumption, a development driven more by market forces than by mandate. In 1995 Peter Ince, David McKeever (both with the Forest Products Laboratory, Madison, Wisconsin), and Haynes pointed to recycling and other technology advances as having reduced pulpwood requirements per ton of newsprint by 20 percent. The analysts calculated comparative costs between wood-intensive and alternative technologies for newsprint (recycling saved about 13 percent in total production costs), structural panels (oriented strand board used less wood and cut production costs per unit volume about a quarter), and wood against steel housing construction (a quarter less wood but significant steel). They concluded that the interaction of market forces and technology is an economically efficient route to conservation.[192]

A problem in assessing and projecting forest circumstances is that of choosing spatial and temporal units and bounds that make sense for both the social and biologic analysts. This was not done for Forest Ecosystem Management Assessment Team (FEMAT, see note 211) (the owl-related venture of the early 1990s that led to the Northwest Forest Plan that led to much anguish in timber-dependent communities), but it was for the Columbia River basin work described later. In 1997 Amy Horne and Haynes concluded that the spatial hierarchy devised for ecologic units was not a good fit for economic analyses; the former lent itself to relatively small units of area, while economic analyses are most useful when conducted at higher scales of analysis.[193]

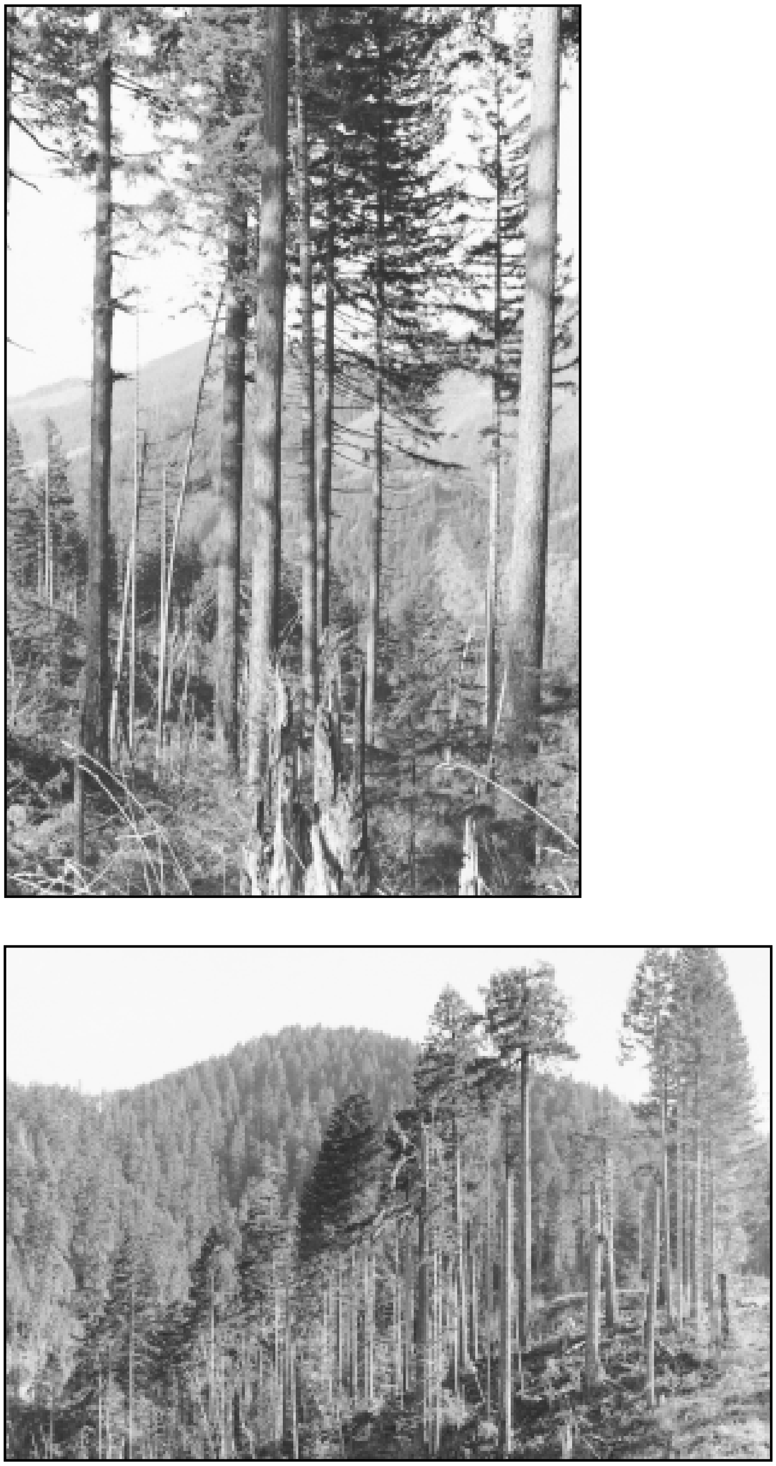


Figure 20—Interest in new ways to apply forest management led to considerable experimentation in the early 1990s as shown in these two pictures from Willamette National Forest. At Dennis #1, the prescription called for possible snags, six green Douglas-fir trees per acre (less than or equal to 24 inches in diameter at breast height), and 240 lineal feet of down woody material. (Photos by Jim Weigand.)

Figure 21—Data being collected for an economic assessment of ungulate herbivory by Judy Mikowski, Jim Weigand, and Richard Haynes at the four corner exclosure near Elgin, Oregon. (Photo taken in 1991 by Art Tiedemann.)

Haynes and Weigand did a considerable essay on the role of economic analysis in ecosystem management in 1997. They concluded that economic methods will not quell land-use controversies, but economic tools are helpful, even necessary, in dealing with opportunity costs, indirect values, tradeoffs, and deciding how much is the right amount, when, and where. Although ecosystem management is a major force within forest management, it is itself propelled and constrained by societal pressures well beyond the forest.[194]

Joint production of cattle, trees, deer, and elk has been studied on the east side of the Cascades for decades, but not often with an eye toward economic impacts, even for timber. In 1993 Weigand and others used data from four ungulate exclosures in eastern Oregon and Washington to look at timber returns with and without grazing and intensive forest management (fig. 21). Whether stumpage values would rise over time determined not only soil expectation values (present value of an infinite series) but also the preferred management regime. It also was found that grazing may either promote or depress tree volume growth.[195]

What if ecosystem management calls for removal of trees that cannot sell, hence a plan that cannot be implemented? To help forestall this possibility, John Chmelik, Fight, and Barbour in the mid-1990s developed the financial evaluation of ecosystem management activities (FEEMA). It is a computer program for assessing financial returns from ecosystem management, with particular reference to small timber that might be removed in the course of maintaining forest health. Given a product price structure, the software advises an operator on best product mixes.[196]

The next year they assembled price data for lumber sizes appropriate to small-diameter timber stands in the interior West. The data were to help planners use FEEMA software in deciding on silvicultural treatments. FEEMA accommodates 34 species-product combinations. Still, the wide range of product options were aggregated. For a given product group, prices were found to be relatively uniform across the region.[197]

The development of FEEMA was a just-in-time invention for the 1996 Colville study, an examination of product output from small-diameter logs in interior Northwest stands where special attention was given to minimizing soil disturbance and damage to the residual stand. This meant cutting logs to length at the stump rather than the landing, quite different from previously conventional tree-length logging. Studied were veneer, lumber, composites, and kraft and thermomechanical pulps. Economic analysis relied on FEEMA.[198]

A comment from the Colville study:

> A complete analysis of the economics of ecosystem management treatments would require estimating the value of ecosystem conditions, wildlife habitat, and other environmental benefits and comparing it to the true cost of management options. However, estimating all ecosystem values is very costly, has seldom been more than modestly successful, and is never comprehensive. The resources available to this project make such efforts out of the question.[199]

Therein, perhaps, lies the nature of future forest economics research.

Detailed harvesting costs were the subject of a 1998 analysis involving Bruce Hartsough, Alex Gicqueau (both with University of California, Davis), and Fight. Numerous equations were developed for elements like turn time, fell-limb-buck productivity, and harvester process time per tree. The objective was to develop stump-to-truck logging cost relations for ponderosa pine plantations. The most crucial situation variables were tree volume and trees removed per acre. This work evolved into a computer program, PPHARVST.[200]

New silvicultural prescriptions for ecosystem management likely will result in a plethora of small trees for processing. A majority of sawtimber harvested in the West goes to sawmills, so the economics of sending small logs to and through stud and random-length sawmills was studied. Francis Wagner (University of Idaho), Chuck Keegan (University of Montana), Fight, and Sue Willits were involved in 1998. Even if only variable costs were covered, trees under 9 inches in diameter could not return 10 percent on investment, and trees under 8 inches could not cover even variable costs.[201]

The roadless area tradeoff study—Wilderness and roads are incompatible. That view was widely held a hundred years ago, and it became urgently relevant in the 1920s as Forest Service Chief Greeley pondered whether wildness should be formalized and figuratively fenced. By the early 1960s, the agency had established, without congressional direction, 9 million acres of wilderness and primitive areas.[202]

The 1964 Wilderness Act halted timber-driven roadbuilding in wilderness areas; however, there remained intense interest in minimizing roads outside formal reserves. A rule of thumb for west-side timbered areas was that 6 miles of logging road per square mile of trees would just about do the job. Four miles would work if the ground lay smooth with no ravines or ridges. Roads were expensive on steep, rocky country; even the loggers wanted fewer of them. The Station launched research on low-impact, low-mileage logging systems. For many people, the correct future road density in roadless areas was zero. That became a national issue.

The Forest Service conducted two assessments of remaining national forest roadless areas to answer how large, where, how timbered, how scenic, and so on. These were the RARE reviews. Both were aimed at identifying candidate wilderness areas. The first, in 1971-72, focused on areas of 5,000 acres and larger in the West. There was vast public involvement, but the Forest Service later acknowledged that in RARE I it had not met some requirements of NEPA, and the agency effectively started over in 1977. RARE II expanded the scope to the whole Nation and included recommendations for wilderness or "release." Sixty-two million acres were studied, about 10 percent more than in RARE I, and attracted comments from some 360,000 people.[203]

RAREs I and II included little economic analysis in their findings. Haynes and Darius Adams stepped into the breach by using the TAMM model (described earlier in "Tools of the Trade") to estimate effects of RARE-induced federal harvest reductions on private harvests, imports from Canada, wood products consumption, and lumber and plywood prices across U.S. regions. With Canadian import offsets, U.S. lumber and plywood consumption would drop 2 to 3 percent and prices would rise 5 to 10 percent. Regional production changes would be more dramatic.[204]

But what if silviculture were intensified on accessible areas to offset (future) harvest foregone in roadless areas? What if that forestry were paid for with money saved by not building roads in the back country? Would the allowable cut effect bring harvests in roaded areas soon enough to offset the foregone timber flows?

With urging from Senator Mark Hatfield (Oregon), Forest Service Chief McGuire asked PNW for answers to those questions. Fight headed the effort, which used as test cases seven western forests in four Forest Service regions. Other PNW participants were Bell, Connaughton, Randall, and Sassaman. They tested the hypothesis that an equal amount of timber could be harvested without entering national forest roadless areas if the resources saved were used for more intensive timber management on the remaining land (ACE again). Then, assuming that such a plan were adopted, they estimated the employment, financial, environmental, and multiple-use implications. For each forest, they considered removal of half and all its roadless area from the timber base, with and without reallocation of road costs attributable to roadless areas.

Their primary finding, published in 1978,[205] was that "the harvest that could be programmed in the first decade with all the roadless area in the land base could not be achieved on any study forest with all of the roadless area withdrawn through reallocation of cost savings to more intensive timber management." Potential yield would be reduced on all forests, even if only half the roadless area were withdrawn. Of 16 environmental and nontimber attributes, 14 would experience significant impacts on at least one forest.

The Journal of Forestry reported on the work. A Journal cartoon captured the findings:

> ...Fewer acres, but more money for timber management. I wonder. . .
>
> In most cases we can't harvest as much timber without the roadless areas even with more money.
>
> Why not?
>
> Well, there is less timber available for harvest...and fewer investment opportunities to increase growth...and besides that, in some cases concentrating the harvest on the reduced land would cause real environmental problems.
>
> Oh.[206]

No roadless area tradeoffs were ever formally executed; however, roadless areas remained an issue throughout the 20th century. In the last days of his tenure, President Clinton froze roadbuilding on 58 million acres of national forest roadless areas, comprising about a third of national forest area, including about 2 million acres each in Washington and Oregon. Concurrently, the Forest Service announced plans to close many-one estimate is half—of the 400,000 miles of existing roads in national forests. This move was not so much to create new roadless areas as to sidestep the costs of road maintenance in a time when road budgets had fallen by a third in 10 years, while logging traffic had dropped by two-thirds, and harvests had declined by three-fourths.

The owl and much more—Much policy has changed in the forest with this creature, first noticed by research in the 1960s. Becoming a proxy for old-growth wildlife and indeed for old growth in the public view, the northern spotted owl first attracted a constituency, then widespread controversy, about cutting of old-growth. The NFMA regulations required maintenance of viable populations of all native vertebrate species in national forest planning areas. Habitat became an agency issue, especially when areas of 1,200 acres were suggested around each owl pair, with a core of 300 acres of old growth.

In the latter 1980s, several factors combined to reduce national forest harvests. Changes in policy and statute (NEPA and NFMA) reduced the harvestable land base. Appeals slowed the sales process, in some cases stopping them and in other instances delaying sales until economic recession drove them under. The harvest high point was 1989.

In 1989 a court appeal of a Fish and Wildlife Service decision not to give the owl an endangered species listing produced the Dwyer decision (U.S. District Judge William Dwyer), which halted national forest sales in owl habitat. Congress directed formation of an interagency scientific committee to develop an owl plan and restarted timber sales. The 1990 "conservation strategy" document was celebrated.[207] Haynes was on the committee and had used TAMM to estimate, for the Wilderness Society, the economic impacts of an owl plan.[208] In a month, an economic team estimated the impact of the scientific committee's plan on harvests and employment. The 38-page report produced headlines: federal harvest reductions would be substantial. About half would be offset by private cutting, but that could not continue past 2000. Short-term job loss would be about 13,000; it would be about 28,000 in the long run.[209]

In 1991 the Forest Service updated the 1990 economic effects report.[210] Haynes was on the update team.

In 1993 President Clinton held a forest conference in Portland, during which he promised $1.3 billion to create 45,000 new jobs (over several years) in the Northwest. Then the Forest Ecosystem Management Assessment Team (FEMAT) was assembled. FEMAT examined forest management options and presented 10 in their report. Their option 9 became famous as the administration's alternative of choice, as announced in 1994. It involved a decline in average annual national forest harvests in the owl's area from 4 to 1.2 billion board feet, or about 70 percent. Haynes was a part of FEMAT and dealt not only in timber flows and prices but also a cluster of forest goods and services.[211] By this time he had already done similar work for east-side salmon habitat analyses, described later in this section. Alig and others at PNW worked on private-timber investment opportunities and trade impacts, both significant because of the immense FEMAT harvest reductions. Haynes, Greber, and Cindy Swanson (Forest Service, Washington, DC) made employment estimates as well. Indeed, a cottage industry sprang up to estimate employment losses, which ranged from 6,000 to 200,000.[212]

There was no vacuum in the intervening 2 years. Court appeals and environmental impact statements were variously advanced and rebuffed. Haynes was subpoenaed to the Dwyer court to describe domestic and offshore economic effects of owl-induced harvest reductions.

Option 9 was renamed the "Northwest Forest Plan." It came close to preserving most of the remaining old growth on federal lands within the owl's range.[213] More litigation ensued, and the Northwest Forest Plan was upheld. A report summarizing impacts of the Northwest Forest Plan was coauthored by Connaughton with a section by Haynes on future (dim) prospects for the timber industry.[214]

Landowners began negotiating for habitat conservation areas with the Fish and Wildlife Service by incorporating adaptive management and promising to produce late-successional forests. Woods and mill workers continued leaving towns. A pivotal role was played by PNW in estimating employment and income impacts, which are described in "Communities, People, and Multipliers," below.

Between 1990 and 1998, Pacific Northwest Region timber sales went from about 5 to about 0.5 billion board feet, a 90-percent decline; regional Forest Service employment fell by about half. The number of spotted owl pairs observed increased greatly.

In 1999 Raettig and Chris Christensen studied the use and effects of the $1.3 billion promised the region in 1993 for economic recovery from habitat-based harvest reductions.[215] The funds did flow, with $800 million spent in 4 years, in a crescent of counties from northern California north along the west side of the Cascades to Canada, and eastward across northern Washington. Not all of these were "owl counties," but all were expecting adverse economic impacts from harvest reductions. The forest industry employment reduction in those counties was 14 percent between 1990 and 1994, while public harvests declined 80 percent and private cutting dropped 23 percent. Infrastructure improvements used half the special funding, perhaps to help the unemployed leave town.

Worsening problems on the east side—Since the start of the 20th century, timbermen and foresters had known that selectively removing big, old ponderosa pine leads to natural regeneration of that species in the openings. But only in some places. After a while, planting was tried, and it worked. But only in some places. Mostly the next round of trees was of different species, notably east-side Douglas fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco) and lodgepole pine. And lots of them. Too, fire protection was exascerbating species conversion because, it was noticed, frequent fires kept competing species out and fuels light, so that fires did little damage to ponderosa pine, a fire-resistant species. Removal of fires removed that species-controlling influence. Complicating the picture was the periodicity of wet years, which seemed to constrain ponderosa pine regeneration while not discouraging lodgepole pine.

Big fire years in the interior West brought attention to the situation as in 1910, the dry years of the early 1930s, and 1993-94. Insect epidemics after fires led to expanses of red then grey conifer foliage across the West, and it was visible from the highways.

By 1930 the forest health problem was being pursued at PNW's Pringle Falls Experimental Forest near Bend, Oregon. It intensified after the Bend Laboratory opened in 1964. The first emphasis was on regeneration. Entire careers of some scientists focused on the ecology of lodgepole pine and other invasive vegetation relative to that of ponderosa pine. By the 1980s, prescribed fire to reduce fuel loadings was being studied and tried at Bend. Similar courses were pursued elsewhere in the West.

In 1993 the Forest Service advanced a forest health initiative to salvage already dead trees, forestall further losses, and cleanse the forest to prevent catastrophic fires. The forest health assessment, headquartered at Wenatchee, Washington, was a large, 113-scientist venture that laid significant ecologic groundwork, including riparian-zone conditions, for the subsequent interior Columbia Basin Ecosystem Management Project, discussed later in this section. In particular, the assessment emphasized the great variety of conditions within and among basins and suggested that prescriptions be developed at the watershed (subbasin) level.

In 1994 Weigand pointed to some key economic issues in restoring forest health (and other ecosystem management). He pointed out that capital and ecosystems are both scarce resources. He discussed uncertainty, suggesting that parsimony of initial investment, motivated by perceived risks ahead, may generate an enduring cost in terms of foregone (sustainable) ecosystem production.[216]

After 2 years of intellectual and technical struggle, in 1994 a six-person team including Weigand assembled a framework for sustainable-ecosystem management of the east side. A principal objective of the work was to fold societal values into ecological capacity—"recognizing the ecological reality that people are beginning to dominate the

Earth's ecosystems" (the authors' summary). They proposed a "lacing model" linking socioeconomic and ecologic domains.[217]

In a companion volume, Haynes and others reinforced the need for such a model to simulate simultaneously multiple agents' dynamics, fire conditions, and plant, wildlife, and fish habitat conditions, all over time. They developed five levels of investment that should be recognized: catastrophe avoidance, catastrophe avoidance involving prevention in high-hazard situations, restoration of high-hazard landscapes and aquatic ecosystems, restoration of moderate-hazard ecosystems, and restoration of ecosystem sustainability. They repeated the need to make the levels of investment congruent with social expectations, values, and economic interests; in short, the no-free-lunch reminder.[218]

An outcome was congressional funding of restoration research on a 1994, 300,000-acre burn near Wenatchee.

PACFISH—Forest health as a venue for regional and microeconomic analysis was overshadowed by PACFISH in 1992-93 and the Interior Columbia Basin Ecosystem Management Project thereafter until 1997.

PACFISH has been a plan for making things better for salmon and steelhead in streams passing through national forests and BLM lands west of the Rocky Mountains, including southeast Alaska. It started with relative modesty: a hurried assessment of the net economic costs of critical habitat designation for two salmon species that spawn in the Snake River basin. Nine areas of economic impact were studied, including flood control, irrigation, salmon fishing, water consumption, and land management. To the extent that forest plans already provided for habitat protection, these costs were incremental. This cost analysis was unique in that it occurred before rather than after planning and critical habitat designation. Bolon, Daniel Hormaechea (Payette National Forest, McCall), and Haynes worked out two economic measures useful in dealing with salmon management alternatives. The measures were variations in employment and the value of a market basket of forest goods and services.[219]

In 1993 BLM joined the venture, which was expanded to all federal lands in the West, including southeast Alaska, that support anadromous fish, plus key tributaries of such streams. Streams within the range of the northern spotted owl (the west side and north coastal California) were not included.

In 1995 physical impacts and costs of mitigating PACFISH impacts over the coming decade were estimated by Bolon, Chris Hansen-Murray (Mount Baker-Snoqualmie National Forest, Seattle), and Haynes.[220] Recreation, range, and timber changes were determined by using the actual current output as the base. Costs were cash costs to the agencies; mitigation meant facilitating the changed land use and restoring outputs where feasible, but not complete restoration. Separate estimates were made on the economic value of output reductions, with and without whatever mitigation might be feasible. These opportunity costs were added to cash costs and compared with the values of the current outputs. If the combined costs were more than the cost of shutting down the programs (that is, more than the value of the pre-PACFISH programs), the programs presumably should die. Recreation and timber programs survived this economic screen, but range programs appeared to warrant scrutiny.

With growing concern about salmon as threatened and endangered species, PACFISH metamorphosed, becoming integral to FEMAT and the Interior Columbia Basin Ecosystem Management Project. The latter program is discussed next.

Salmon and the interior Columbia basin—At some point resource administrators confronted the facts that riparian corridors and salmon habitat did not comprise a plan for regional forestry, and that forest health was running along a parallel track with its own funding and strategies on the ground for dealing with widespread tree mortality caused by insects, disease, and large wildfires. Salmon-related lawsuits against national forests threatened to reduce all activities including recreation. So for the Columbia basin, the recent home range of PACFISH, President Clinton in 1993 mandated a generalized, combined management framework for the east side. This came to mean eastern Washington and Oregon and the upper Columbia River basin, which included 145 million acres in seven states.

There began the geographically largest, most politically turbulent, and likely the most technically complex (and jargon-enshrouded) project in PNW's history. The process and goals for building federal land management plans for large areas was worked out by a group whose final product was led by an economist, PNW's Haynes.[221] Expressed in the ambiguous context of ecosystem management, the planning nonetheless had a mandate for scientific soundness.[222]

The framework was the start of that process. Applying to an area about the size of the original Thirteen American Colonies, it laid out a general planning model, objectives for the model, and a principle that science facilitates decisions and arrays options; choice among options was not the role of science, but rather for the manager or decisionmaker. There had been sensitivity on this subject since the advent of ecosystem management. Similarly, the framework stipulated a distinction between scientific theory and findings versus general ethical values drawn from contemporary views of social behavior. It was apparent that "many of the scientific concepts elevated to the status of principles [were] in fact judgements [sic] reflecting the values of the scientists who define the principles"[223]—another especially sensitive area at the time.

The framework provided what may be a classic description (albeit not a definition) of an ecosystem: it can be as small as the surface of a leaf or as large as the entire planet and beyond.

After a section about the sanctity of ecosystems, a set of goals for ecosystem management was set out, and appropriate nested geographic scales for decisions were defined.

The second major product of the interior basin project was a substantial document characterizing the natural resources of the basin; it described relations within and among ecological, social, cultural, and economic systems there, including emerging issues and technology gaps. Some 300 scientists and specialists were involved. The integrated scientific assessment was published in late 1996 and delivered what was ordered.[224] For instance, resource information from 164 subbasins and 165 cover types and structural stage combinations was assembled. The status of over 8,000 vascular plants and 548 terrestrial vertebrates was reviewed. Integrity and viability ratings were assigned widely and quickly. Some 2,000 pages of material were produced. Tom Quigley and Haynes were two of the three technical editors of the consolidated 300-page product. Along the way, Haynes had shepherded analysts into the framework's fold, with ecosystem integrity as the common denominator. He also led affirmation of several concepts that helped weld biophysical and socioeconomic parts of the work: notions of community, the market basket valuation approach, ecosystem integrity, and socioeconomic resiliency.

In rapid succession several economic studies of communities emerged. Work by Wendy McGinnis, Christensen, Horne, Nick Reyna (Pacific Northwest Region, Portland), Haynes, and others is described below, in "Communities, People, and Multipliers." Intertwined with these studies were supracommunity economic assessments, akin to the mesoeconomic work discussed later but on a larger, transregional level.[225]

Information assembled in the scientific assessment, from literature, historic accounts, and modeling, was employed in environmental impact statements. Their function was as vehicles for agency decisions about future conditions of federal land needed to restore their health and provide a predictable, sustained flow of economic and other benefits.[226]

In 1999 Quigley, Russell Graham (Rocky Mountain Research Station, Fort Collins), and Haynes prepared a retrospective and critique of the interior Columbia basin planning project. Their concluding remarks speak for themselves:

> The overall assignment to develop a scientifically sound, ecosystem-based strategy for management of FS and BLM lands proved to be a task that might very well require several additional years before it will be reality on the ground. Indeed, the writings on ecosystem management have been filled with platitudes that provide no real priorities or ranking of actions to proceed with implementation....Congress has provided no clear statement of goals regarding natural resource management.[227]

Valuing the invaluable resources—In 1985 salmon habitat issues began to involve economics questions—the biologic and hydrologic aspects had been studied at Wenatchee since the 1960s. Fight joined Fred Everest and Daniel Huppert (National Marine Fisheries Service, La Jolla) in reviewing ways to estimate costs and benefits for anadromous fish. Although the gross economic value of salmon harvests was high, low net value was caused by inefficiencies imposed by regulators. Its common-property status causes salmon to be overfished to the point where total revenues fall to equal total costs, well beyond the maximum sustainable yield. The authors discussed ways to limit fishing that would induce some net economic yields.[228]

The value of sport fishing was addressed in a 1988 compilation of papers edited by Darrell Hueth, Elizabeth Strong (both at Oregon State University), and Fight. Three methods in use for valuing recreation were applied. Travel cost, hedonic travel cost, and household-production techniques were used in benefit estimation. This is quite different from using market values for the fish. The resources used in comparisons were Oregon salmon and steelhead. The comparisons showed differences in values not easily accounted for on theoretical grounds.[229]

Because they are migratory, salmon present special population dynamics situations and management enigmas. Among the problems are difficulties with economic valuations and rational economic management given uncertainties about population sizes, cycles, and resiliency after harvesting. In 1991 Huppert and Fight did a broad survey of the economics of salmon management. They looked at costs and returns for commercial and sport fisheries, including income and employment multipliers. They reviewed concepts and applications for both commercial and recreational fisheries.[230]

In 1995, Alexander described some of these issues and some ways to deal with them. Her work exemplified the shift toward nontimber resource economics that was underway at PNW.[231]

Fight was part of a group assembling an annotated bibliography about nontimber products, which was published in 1996. Emphasis was on conservation and development of the products, presumably—but not necessarily—compatible objectives. Several hundred references were found on such things as medicinal and edible plants, their processing, market dynamics, subsistence uses, similar products overseas, management issues, and economic contribution.[232]

In 1998-99, Alexander assembled price trends and values for nontimber forest products, notably mushrooms and game. She noted the considerable volume of "transactions," priced and unpriced. She also showed how their remarkable extent in the Northwest loomed large relative to timber.[233]

In 1999 Kline, Alig, and Rebecca Johnson examined the willingness of forest landowners to forego harvesting along their own riparian areas. The specific issue was 200-foot buffers to provide long-lived trees for coho salmon (*Oncorhynchus kisutch*) habitat. Over 1,700 phone respondents discussed their ownership objectives and priorities, which were analyzed formally by the researchers. Reservation prices, below which owners would refrain from selling, also were determined. Necessary incentive payments to induce nonharvest were twice as high for owners with timber-plus-nontimber objectives as for those with mixed objectives, while those whose primary objective was recreation required significantly fewer payments than the mixed-goal group.[234]

Climate change, air pollution, and acidic depositions—If marginal farmland could be guided deftly back into forest production, there might be some predictable relation between farmland acres foregone and tree biomass generated, between that and carbon sequestration, and between that and global warming. Whether the world should be cloaked in green became the basis for a large share of work by Alig and his cooperators during the 1990s.

In 1990 the American Forestry Association (AFA) examined the premise that if forest growth were increased, more carbon, drawn from the atmosphere, would be incorporated into wood tissues and thus reduce global warming. Alig, in 1992, consolidated the AFA findings for the Climate Institute and covered the question of whether enhancing forest growth made much economic sense. He concluded that it might, substantially, if projections in the 1989 RPA assessment were correct. In particular, the industrial area of planted pine in the South was expected to more than double by 2040. And other private planted forest in the South was projected to increase by 150 percent, from 8 to 20 million acres. On these lands, there would be many opportunities to earn at least 10 percent on treatment investments under the economic assumptions made.[235]

In 1993 Steve Winnett (Environmental Protection Agency, Washington, DC), Haynes, and Bill Hohenstein looked at the economics, including primary costs and secondary impacts, of three greenhouse gas mitigation options. With the TAMM and ATLAS models, used previously in RPA timber projections, they considered two tree-planting alternatives to the 1989 RPA forestry projections, plus a high wood-fiber-recycling scenario. The latter would leave more trees in place to retain and "sequester" more carbon. All options would increase carbon storage while driving down stumpage prices and increasing the supply of commercially available timber, which would adversely affect forest owners.[236]

In 1994 Haynes, Alig, and Moore brought to the carbon matter the combined TAMM-ATLAS model (termed in some quarters TAMM90). The Environmental Protection Agency had asked about forest and market impacts of several carbon dioxide-related scenarios: expanded fuelwood use, increased recycling, tree planting, and habitat-preserving harvest reductions. The largest impacts on forests and harvests occurred in a tree–planting scenario funded at $220 million per year for 10 years. Stumpage prices would drop to token levels. The timing of impacts was estimated explicitly to 2040 for the scenarios singly and in combinations. Of the options assessed, tree planting would store more carbon in the long run, recycling would in the short run.[237]

TAMM was used in concert with physical and biologic models in 1995 to assess four climate-change scenarios. Although the base (1993 RPA) projection yielded declining forest inventories after 2030, the others led to rising inventories followed in a few decades by increased harvests.[238]

In 1994 and 1996, Alig, Darius Adams, and Haynes pursued the land-use shift history and rationale between agriculture and farming.[239] In 1998 that tradeoff received economic analysis by Alig, Adams, and Bruce McCarl (Texas A&M University) with FASOM, a model mentioned earlier. In 1982-92, 90 percent of the 115 million acres of nonfederal land-use changes involved shifts between agriculture and forestry, mainly in the South. This first analytical link in the farmland-to-climate chain considered the underlying and consequent economics, including the tie between land allocation and land management. Impacts of various federal policies on the land-use balance were explored, including a situation in which land could not be returned to farming even if farm prices rose.[240] It was found that owners' uncertainty about policy outcomes, or limits on investment, could affect prices more than forest acreage. Under a minimum harvest age restriction or a reduced public harvest policy, habitats could change if less hardwood land were converted to softwoods because of softwood planting on farmland; this is only one of several unintended consequences uncovered through FASOM.[241] Another of those wayward consequences is the possibility that farmland diversions to forests will raise prices of the remaining farmland and thus discourage diversion.[242]

Extending the chain to carbon concentration within the forest took further effort, in both modeling and analysis. In 1996 and 1997, Alig, Darius Adams, McCarl, and others estimated that the U.S. carbon stock will increase by one-fourth to one-third by 2050, depending on the forestry situation, relative to 1990.[243]

Given carbon-storage targets, What would be the best means of getting there? Using FASOM still, and assuming that economically best meant least cost, in 1999 the same group estimated least cost under alternative policies to (primary) consumers as well as landowners by using the optimum mix of land transfers from farming, management input, and afforestation.[244]

In 1996 the role of the Northwest in engaging carbon ions by the ton was taken up. Mark and Janice Harmon and Bill Ferrell (all at Oregon State University), with David Brooks, extended the usual terrestrial analysis to (transient) carbon retention by forest products and subsequent disposal. They estimated that of the carbon harvested in Washington and Oregon, about 23 percent moves into forest products. About 0.4 percent of carbon harvested actually is added to the enduring stock of products.[245]

The final link, readily apparent to economists, is the worth of warmth, negative though it may be. At the margin, How much harm might the green cloak prevent? In 1996 Diana Burton (Texas A&M University), McCarl, Darius Adams, Alig, Mac Callaway (Risoe National Laboratory, Denmark), and Winnett approached this difficult subject. Their particular focus was the impact of warming on Southern U.S. forests. The interaction—that forests planted to reduce warming might be impaired by temperature as they induced cooling—had scarcely been explored.[246]

In 1997 Brent Sohngen (Yale University) and Haynes wondered how much a reduction in forest fires would reduce carbon loss to the atmosphere. They used a model of postfire forest mortality and TAMM to conclude that the carbon impact would be greatest in the West, but the largest economic impact would be in the South, given equal reductions in fire frequency.[247]

The flip side of carbon dioxide and other additions to the atmosphere is that from whatever goes up, some comes down. In 1990 Haynes, Darius Adams, and Fred Kaiser (Forest Service, Washington, DC) looked at the down part, acid rain. Haynes and Kaiser described the latest version of TAMM and its companion ATLAS forest projection model. They showed that, if acid rain were to reduce forest growth by 5 to 10 percent across the country, economic effects would range from nil to a 50-percent increase in stumpage prices, the latter in 50 years for softwoods in the Northeast. Softwood lumber consumption would fall by 3 percent nationally by 2040.[248]

Regional Resource and Market Projections

For a hundred years, questions have been raised about the timber supply outlook for the Pacific coast, particularly the Douglas-fir region. Steadily increasing timber values, cyclic economic developments, and changing multiple-use circumstances have required not only updated projections but also changes in the questions being asked and greater sophistication in the answers. All three Portland economics-research units have participated in various resource analyses. For example the Duerr report, discussed in this section, involved virtually the whole economics staff, for many months.

Timber and its products: production outlook analyses—Early reports addressing timber scarcity and conservation largely treated timber as a stock resource. Running out, regionally and across the Nation, was seen as distinctly possible. How soon it would happen depended primarily on how fast the trees were cut.

Post-World War II timber outlook studies looked not only at old-growth exhaustion but also the emergence of a replacement resource. Regeneration rates, age-class inventories, stand tables, and the like became urgent forecasting matters.

Regional projections of timber output, described in this section, were oriented to trends rather than year-to-year forecasts, although the underlying calculations might be annualized. It was generally assumed that rising or at least robust demand would prevail to encourage innovation and pull timber out of the woods. Price behavior was not made explicit, however.

Timber trends report—Faced with a paucity of graduate forest economists, in 1960 Newport acquired the temporary services of William Duerr, mentioned earlier in connection with Fedkiw and financial maturity. A key issue then was the opportunity to enhance the diminishing supply of old-growth timber with intensive management of young stands. Rising timber values during the 1950s had made tree farming an attractive investment for many, and extrapolations of price trends boded well for the future. It also was apparent, though, that the emerging second-growth forest would benefit from and might require, heavy investments in hardwood control, thinning, and perhaps fertilization.

The economic prospects had been calculated privately but only for individual holdings and case-study stands; there was little public information about the economics of individual treatments, the mechanics and economics of small-log harvesting, and even the accounting principles to use in reckoning the profitability of tree farming. Additionally, the economics of timber supply from public lands were not only virtually unknown but also viewed as largely irrelevant by many, if not most, foresters.

Into this environment in 1960-61 came H.R. (Joe) Josephson (Forest Service, Washington, DC), Newport, and Duerr with a plan to assess economic opportunities for forestry on all ownerships in the Douglas-fir region.[249] The calculations, for site-stocking-age classes by owner group, were formidable in the absence of computers. In addition, the study required that economists become mensurationists for a time to generate needed managed-yield tables, a circumstance that would be repeated several times in the next two decades and had involved PNW economists since the 1920s. For instance, projections of yields from thinning, salvage, reforestation, and protection fully occupied Tom Adams for many months.

Two years in production, the report contained in its appendix the most comprehensive managed-yield tables ever produced for western softwoods. But, interest in the early drafts focused on the economic methodology, which included assumptions that owners, including federal agencies, would choose rotations and management regimes on the basis of compound interest, and that public agencies would countenance fluctuations in public timber supply over time. Expurgation of a key draft chapter suggesting the economic rationality of a falldown in public timber harvest led to a congressional request for release of the excised material. Although the author's name was dropped out at his request, the final publication quickly became known as the Duerr Report.

Almost overlooked publicly were Duerr's projections of decline in public and private timber harvests across the Douglas-fir region. In projecting a 10-percent fall over 20 years, Duerr necessarily employed many assumptions and subanalyses about forest management. However, this decline conclusion followed from both a projection of present trends and an alternative soil-rent-based projection.

The eastern Oregon study—Published at the same time as the timber trends report, in 1963, Gedney's assessment, specific to eastern Oregon,[250] did not employ the concept of financial maturity. It looked instead at typical stand behavior and physical targets deemed reasonable at the species-type-owner level. A novel, exponential forest model was developed for stand table projection, in which each 2-inch diameter class would have 1.4 times as many trees as the next larger class. Two projections were made, the first one assuming current cutting rates and forestry practices. The 30-year outcome was that, overall, forests would not trend away from their then-ratty condition. In the second projection, it was assumed that a primary objective would be to convert stands to a fully regulated[251] condition, which would take 145 years. Over time, though, the harvest could be increased about 30 percent in the short term and about 65 percent in the long term, assuming no large shifts of forests away from timbering.

This may have been the first regional timber supply study that, on the one hand, evaluated specific species and management strategies and, on the other hand, made projections well beyond the present "rotation." In 1965 Newport reported that the assessment had been instrumental in attracting several plywood plants to eastern Oregon.[252]

The Bonneville report—In 1966, Gedney, Newport, and Dwight Hair (Forest Service, Washington, DC) produced a major work on future economic developments that might be generated by timber in the Northwest and affect power demand.[253] This was a key report in that a similar one for the Bonneville Power Administration (BPA), prepared by a different organization, had concluded that the demise of Northwest timber would eliminate the forest industry in the region.

The Columbia-North Pacific analysis—Wall, in 1969, authored a 50-year outlook for the entire Columbia River drainage, including parts of Wyoming and Montana.[254] In addition to projecting trends in timber and harvests (from 1869), he forecast levels of industrial use of forests by product group and thence employment. The work was commissioned by the Water Resources Council, for use in river basin planning.

Wall judged that employment would decline while payrolls would rise, a conclusion met with skepticism but borne out over the next 30 years. He foresaw log exports increasing, then dropping in the 1980s, which occurred. And he expected that changing manufacture costs and technology would generate offsetting growth and decline in plywood and lumber production, respectively, with pulp and paper expanding, which also occurred.

Two projections—Six years later, PNW researchers Gedney, Dan Oswald, and Fight did another set of projections to set the federal timber situation into an all-owner, coast-wide context.[255] They used data provided by the forest survey unit for "Timber Trends in the United States" (see note 276), in which Gedney and Newport had participated, but didn't assume widespread adoption of purely economic forestry. Gedney and others confirmed that a dip in timber harvests was in prospect for private as well as public lands, with the falldown unlikely to be affected as much by changes in scheduling as by the harvest of remaining old growth.

Gedney and others estimated a 16-percent decline in sawtimber supplies by 2000 owing to lower harvests on industrial lands. Assumptions behind this conclusion were that 1960s timber management practices, processing, and marketing patterns would continue unchanged. The second projection did not toy with rotation lengths, but rather with a 10-year program of intensified management (and ACE) and increased use of logging residues, embracing only treatments that would return at least 5 percent on costs. The program converted the base-level decline to a static level of output until a 13-percent increase would appear in 2020.

As has happened with other unpopular Forest Service research results, the report met disbelief, attempts to discredit its methodology, pointed remarks to PNW's Director about the political vulnerability of economics research, and an industry association's offer of funds to a university to do a counter analysis (the university refused). Washington's land commissioner ordered a series of studies that he publicly announced would refute the Forest Service findings. The studies were done; they didn't. A prominent university forest economist announced that, by calculating harvests in cubic instead of board feet, the falldown could be avoided (on paper at least). Sassaman and Schallau, and Fight and Schweitzer, published calculations that showed otherwise.[256]

In retrospect, because of its forthright forecast of west-wide decline in harvests, the Gedney report may have been the most controversial work in the Station's history to that point. By the time the decline arrived in the late 1970s, however, the analysis and its extensive publicity were forgotten, and the private-sector falldown was greeted with widespread surprise. Some of those who had objected to the Station's forecast on the grounds that it would discourage investment in the region now used the imminence of timber scarcity as a reason to press for increased harvests from the national forests.

Regional supply, demand, and price projections—More complicated but informative are market projections in which prices figure explicitly rather than lurking in the background. In these analyses, supply and demand interact to establish, for a particular date or time, the volume produced and consumed, thus sold and purchased, and the associated price.[257]

The RPA was a national mandate for national compilations and analyses. The Nation is the sum of its regions, though, and in any case audiences provide an imperative for down-home perspectives. Too, most timber and wood product transactions are local.

Portions of the 1989 RPA timber assessment pertinent to the west coast were discussed by John Mills and Haynes in 1991. Although national softwood harvests were expected to increase 19 percent by 2010, along the Pacific coast they were expected to decline 16 percent because of shrinking private inventories and restrictions on public lands. Stumpage prices would double over that period. By 2040 there would be a young generation of trees on private lands but with smaller trees than left the land earlier, and harvests thus would not return to 1990 levels.[258]

Completion of the 1993 RPA timber assessment update led Haynes to lay out its particulars for the three Pacific coast analysis regions to 2040. In the Douglas-fir region, lumber production was expected to fall two-fifths by 2010 relative to 1991, mostly because of competition from reconstituted-wood panels. Industry harvests were expected to fall until 2010, then rise, while other private cutting would move up then down, and public harvests were assumed to remain constant. The Northwest would face continuing competition from Canada, growing long-term supplies from the South (albeit tightness there in the short run), and important displacements by recycling. Stumpage prices were expected to rise, in real terms, until 2010.[259]

Haynes pointed out that timber supply and forestry options in the Northwest were "essentially limited to the rate and timing of reductions." However, given rising stumpage values for a while, nonindustrial private owners with maturing young growth might prosper.[260]

In 1990 Darius Adams and Haynes generated a byproduct of the 1989 national assessment: projections for the Douglas-fir region to 2040. They ran three scenarios: (1) public harvests continuing at the average level of the two past decades, (2) national forest harvests falling 42 percent within 5 years, and (3) expanded private forest management in response to scenario (2). The authors concluded that boosting private investments would have little effect, at least within 50 years, despite a projected doubling of stumpage prices. In fact, private lands could not sustain the harvest levels of the late 1980s. Most of the price increase over the several decades would be driven by reduced supplies from the South; only one-fifth of the projected increase was attributed to federal harvest declines.[261]

John Mills disaggregated the 1989 national assessment to private lands in the West which indicated that by 2020 softwood harvests would increase 17 percent, albeit with smaller tree sizes, harvest ages, and volumes removed from industry lands. Stumpage prices were expected to double. In the Northwest, private growth and harvests would be climbing by the start of the 21st century.[262]

These conclusions were drawn before the full impacts of public harvest constraints were known. Between 1986 and 1990 the national public cut fell 24 percent, partly offset by a 10-percent rise in private harvests. By 1992 John Mills and others were foreseeing another 10-percent public-cut decline by 2000 because of general replanning on public lands, plus another 14-percent decline associated with owl habitat. These would exacerbate expected harvest declines in the South.[263]

Dwane Van Hooser, Ronald Tymcio (both with the Intermountain Research Station, Ogden), Karen Waddell, and John Mills used the 1989 national assessment to formulate an outlook for interior Douglas-fir, which accounts for nearly one-fourth of the timber volume of the Rocky Mountain States and the Washington-Oregon east side. Once scorned, this species is now a principal component of spruce-pine-fir lumber production. Assuming that Douglas-fir's share of future harvests would mirror current inventories, and using the RPA assessment projections for species groups, it appeared that public inventories would fall a third by 2000, while growth would decline and harvest would rise, both by about 60 percent. Stability was indicated for other owners to 2000, and for later years on all ownerships.[264]

Price projections derive from either separate projections of supply and demand and perhaps their determinants, or direct projections along trajectories embedded in the past. The latter route was used by Weigand in 1998, in projecting lumber prices to 2020; he used as a base the past average prices of grade groups. The 1971-95 prices were shown for various Western U.S. grades by species. Regression equations were used to project the west-side lumber prices forward.[265]

In 1992 the traditional timber orientation of many research customers led Darius Adams, Alig, and Jim Stevens into a projection of softwood timber supplies in western Washington to 2085. This was triggered by the Washington state legislature, which was concerned about impacts of habitat preservation policies that were coming into force. The projections were done for five multicounty timbersheds by using ATLAS and assuming a fixed rotation age for harvest planning, which shifted forward every decade. It was estimated that a 70-percent reduction in national forest harvests might reduce total harvests by less than 10 percent. Uncertainty about the future of nonindustrial private lands and certain inventory disparities led the analysts to consider a 20-percent decline to be plausible.[266]

The nonindustrial part of that disclaimer was elaborated by Pete Bettinger (Oregon State University) and Alig in 1996. Although western Washington's nonindustrial private land is on relatively easy, productive ground, this owner group may be highly susceptible to regulatory and land-use pressures. In a survey, almost one-fifth of nonindustrial private owners said they planned to commercially develop or subdivide their land. On average, the age of forests on nonindustrial private lands was greater than on industrial lands, implying more frequent cutting, shorter rotations, and perhaps lower volumes per acre on industrial holdings. Too, rising stumpage prices might induce nonindustrial private owners to continue using timberland for timber production, giving up timber.[267]

Multiregional Analyses and the Long Reach of RPA

National timber situation reports have a long and respected history in the Forest Service. Early ones focused on timber devastation, high lumber prices, and remaining timber stocks. In 1896 the USDA Division of Forestry concluded that, at current cutting rates, only a 58-year supply remained.[268] In 1907 the division said there would be timber for 71 years.[269]

How could we gain 24 years of timber future while mowing the forests at a good clip? The analysts involved were bright, astute observers. They could convert recent lumber production by region to acres cut, estimate the acreage left, and do the division on an envelope, all before lunch—in concept; in practice, it was laborious. What changed so greatly over time were the analysts' perceptions and the market reality about the nature of timber and commercial forest land. As time moved on, more species were being harvested, more of the tree was being used, and technology was taking loggers onto more difficult lands.

But, 1907 marked a national financial panic. By the end of the year, west-side harvests were down by half.[270] The economy recovered (there was great prosperity between 1910 and the start of World War I), but U.S. lumber production never returned to its 1907 level. In 1923 two Forest Service analysts, R.V. Reynolds and Albert H. Pierson, concluded that forest exhaustion was already at hand.[271] National lumber output had declined for 13 years. Population had grown and prices had risen, so slack demand was not a reason for shrinking production. Rather, lumbermen had pursued big trees into the mountains of the West, their last refuge. There were fewer and smaller trees to harvest, said the analysts, and it cost more to log in the high country. This may have been the first, if intuitive, use of supply and demand analysis in national timber studies.

There also was the matter of how much usable volume to ascribe to small trees in a time when only large trees left the woods. In 1899 a remarkably foresighted analyst who had estimated Washington's timber volume said, "An estimate....made twenty-five years hence, when timber will have become scarce and the lumberman's standard lowered, will doubtless show twice as much timber in the same area as if made today."[272] He was right.[273]

Forest forecasting gradually became more detailed. In 1946 a set of reports, called the reappraisal report[274] was issued by the Forest Service. It began the practice of distinguishing between future requirements and prospective forest growth, then proposing growth goals to fill the gap. It noted that between 1938 and 1945, private sawtimber in the Northwest declined by a third, and that two-thirds of remaining sawtimber in the West was still old growth. It did not speculate on the horizon for timber exhaustion.

The gap-and-growth approach was carried forward to "Timber Resources for America's Future" (TRR),[275] which was based on 1952 data and published in 1958. Forests and forestry were laid out in unprecedented detail. Three levels of future "demand" (actually consumption) were estimated. It was concluded that, if very intensive management were practiced, the midlevel consumption trajectory could be met. Otherwise a large gap would appear by 2000.

Next was a report called internally the "1962 timber appraisal"; it was published in 1965 as "Timber Trends in the United States" (TTUS).[276] PNW's Gedney and Newport were acknowledged in the report. The report found the U.S. timber situation "considerably improved" over 10 years before. Timber growth exceeded the cut. Quality was in decline, however, because old growth was being replaced by small trees of less preferred species. In particular, softwood cut was expected to exceed net growth—the gap again. Wood consumption, in cubic-foot terms, was expected to double by 2000. As in TRR, TTUS had a detailed appendix of state-level forest statistics.

"The Outlook for Timber in the United States"[277] introduced explicit price trajectories and produced three pairs of production and consumption forecasts. The middle combination had lumber and plywood prices rising 50 to 60 percent by 2000, with stumpage prices about doubling. This was consistent with previous product price trends and with significantly falling private softwood harvests in the West. Fight, Gedney, Hamilton, and Oswald participated in this review. Inventory field data from the forest survey group was the underlying source.[278]

That view of rising prices was alarming as seen by the President's advisory panel on timber and the environment in 1973.[279] The Nation faced a critical situation. "Instead of timber being a glut on the market, it has become one of the Nation's scarcest commodities in relation to demand," it said.[280] This conclusion was based on a long history of rising real timber prices. The report proclaimed that the old-growth cutting rate should be increased 50 to 100 percent. Economic supply and demand curves were displayed, which set a precedent for future national timber studies. Environmental matters were relegated to 4 of the 16 appendices.

Congress passed the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) to procure from the Forest Service decadal reports like the timber reviews of the past but that would include nontimber resources as well. The RPA provided for multi-resource planning, exposure of the tradeoffs involved, and portrayal of the effects of alternative budget levels.[281] This meant inventories, demand and supply projections, and laying out possibilities for expanding tangible and intangible goods and services. Each 10-year round of RPA analyses had two parts: an assessment laid out the resource situation and potential trends, and its companion contained alternative programs for meeting resource management objectives and recommended one of the programs.

That Congress trusted the agency to do these things objectively is interesting, considering industry's intense criticism of earlier timber studies. For instance, disliking the projections of falling sawtimber production in the West, some called for halting all projection work by the Forest Service.[282]

An organizational dilemma of the time was whether to make RPA a new staff function in Washington, divide it among existing staff groups, or create a line function involving the field. The answer was all three, which brings the RPA story to PNW.

Only a few months remained before the first RPA assessment was due. Other field people and I were detailed to Washington, and there was heavy reliance on the just-issued outlook report (see note 277). Treatment of supply and demand were the same as in the outlook; even whole paragraphs were carried over. The share of text on nontimber resources was more comprehensive, however, than in the TRR, the previous all-resource report. Included was a discussion of environmental effects of rising relative timber prices. Tom Mills, who would come later to PNW as Director, pointed out that multi-resource interactions and joint production of timber and nontimber products had received little study. Economists or alumni from PNW acknowledged in the report were Gary Lindell, Payne, Schweitzer, and Charles Van Sickle. This 1975 assessment[283] was sent to Congress in early 1976; it was published in 1977.

The next major timber supply analysis was the timber situation report for the United States published in 1982.[284] It was issued as an elaboration of a timber chapter in the 1980 RPA assessment.[285] The advent of computerized interregional market modeling, TAMM, described earlier, made it relatively easy to centralize supply and demand projections to study effects of changing flows from any region of the country on prices, production, and consumption in other areas. Two sets of projections were made, one with assumed base-level prices over time, the other using TAMM to estimate prices.

There were perhaps 50 participants. Station analysts acknowledged were (in order mentioned) Darr, Lindell, Chuck Bolsinger, Gedney, Wall, Haynes, Patricia Bassett, Florence Ruderman, Jim LaBau, Oswald, Van Sickle, and Hamilton, as were Alig and Tom Mills, who both came to PNW later.

Haynes and Darius Adams led the supply-demand work. As indicated later, this was a major departure in methodology, with interdependence of prices and flows, regions, and stumpage with products. For the Douglas-fir region, the projections indicated steadily diminishing softwood sawtimber supplies through 2030. These projections excited resignation rather than hostility, and the industry rather than the agency publicized the consequences of a declining resource base.

Haynes and Darius Adams also modeled timber supplies with different assumptions about forest management. In response to industry concerns that private-forest management was being underforecast, and to THIS findings that departures from federal even flow could be done without compromising long-term yields in some cases, they made corresponding projections. They concluded that even with departures and intensive management, Northwest lumber production would decline for at least two decades, through 2000.[286]

The 1980 assessment's 1983 update[287] was accompanied by yet more sophisticated demand and supply projections, again prepared by Haynes and Darius Adams. This time a variety of scenarios were analyzed, including alternative assumptions about housing starts, export restrictions and tariffs, processing efficiency, forest management, and national forest departures from even flow. These projections, the most intricate ever, again projected a supply decline in the Douglas-fir region through 2030.

This round of timber supply and demand projections raised some questions about traditional perceptions of the national timber situation. Earlier studies had indicated strong growth in demand, with consumption exceeding domestic production, that would lead to higher prices and increased imports. Economic developments of the early 1980s and emerging results from the Southern timber supply study, which included a national perspective, suggested movement away from that perspective, although the South's situation was in the tradition of American forests.[288]

In 1988 PNW economists participated in "The South's Fourth Forest," in response to a rapidly changing resource situation in the South. The third forest was in hand, visible and operable. The key questions were, given that development of the fourth forest could be managed, in what form was it emerging, and what kind of forest would be best for the economy and society of the South. The latter question was not answered, but implications of various forest scenarios were displayed. Timber growth was declining in this immense region, while harvests were increasing. Private harvests were expected to level out by 2000 after climbing substantially since 1960. The changed trajectory was expected to be caused by an age-class gap. Stumpage prices were expected to rise sharply until 2015 and then decline. Economic opportunities to increase the quantity and character of the timber flow were expected to be numerous. The PNW people involved were Haynes, Kincaid, and John Mills.[289] Alig, who came to PNW later, made land-use and cover projections.

Completion of the southern study with its national context reinforced Haynes' earlier sense that the North American timber scene was changing, with more abundant timber supplies if hardwoods were included and relatively flat real prices for hardwoods.[290] The prospect that pine plantation areas would increase in the South had implications for the whole Nation's wood products markets.

The 1989 RPA assessment yielded another timber situation report, which Haynes coordinated.[291] The group this time included PNW analysts and alumni (again in the order acknowledged) Darr, Oswald, Waddell, Ted Setzer, LaBau, John Teply, me, Brooks, John Mills, Alig, Howard, Kincaid, Alexander, Lisa Haven, Penn Peters, Mick Gonsior, Chuck Mann, Bob McGaughey, and Kristine Jackson. The summary is copied in its entirety:

> This study projects rising demands for timber products, as have previous assessments. The study, however, has identified three potential sources of structural change in the supply situation that could shift the outlook.
>
> - Continuation of establishment of pine plantations in the South will affect the outlook and this is reflected in the Assessment projection. If these plantations are not established, the Nation faces prolonged increases in prices of timber products.
>
> - Concerns over the global environment have stimulated interest in planting trees as a way to sequester carbon. Large tree planting programs in addition to the plantations in the Assessment projection could further affect the supply outlook after 2020. If global warming occurs, it could either increase tree growth or reduce it, depending on rainfall and other characteristics of the environment at that time.
>
> - Increased recycling of paper and paperboard could shift the outlook during the next decade.
>
> These sources of structural change are not reflected in historical data except for the establishment of pine plantations in the South. Global change and recycling of paper and paperboard are developing issues. They should be monitored closely for their potential effects on the outlook.

This timber review had the most ambitious section on international developments yet done for the RPA, an indication of growing U.S. interest in forest changes abroad.

In 1990 Alig addressed the role that nonindustrial private owners might play in future U.S. timber supplies. Relying on several regional and national studies, he concluded that this owner group was a wild card, albeit a potentially important one. Nonindustrial owners were not visibly responding to price signals as they made forest management decisions, an understandable product of the long waiting periods involved in forestry investments. For whatever reasons, these owners were, however, rapidly increasing the number of trees they planted.[292]

The 1993 RPA timber assessment update, authored by Haynes, Darius Adams, and John Mills, took wood projections in a new direction.[293] The year 2010 appeared to be a turning point, with upward wood-product consumption trends of the past turning downward a bit, and with historically rising solid-wood prices stabilizing as a downward trend in private timber inventories turned upward. A base projection set found private forests having stable total volume by 2040, with rapid growth balancing harvests, especially in the South. On average, private forests would be younger than in the 1990s. Public forests would grow older with larger inventories and rising growth. Neither wood exports nor imports would change much.

Ten alternative futures were portrayed, of which six represented policy changes. For RPA timber assessments, though not for PNW, policy analysis was a new departure. The alternatives were lower Canadian production, expanded regulation of private timberlands, reduced pine plantations in the South, higher rates of recycling, a slower economic-growth scenario, subsidized tree planting, higher national forest harvests, government-induced increase in use of wood for energy, global climate change, and a combination of environmental cum energy policies. Kincaid (University of Washington) worked on this analysis.

A supporting document on international forestry was done by Brooks. He summarized global forest data and compared circumstances abroad with those of the United States. Fuelwood accounted for over half of the world timber harvest. He discussed the "greenness" of U.S. wood products versus those from overseas, doubting any difference, at least as seen by U.S. consumers. He concluded that, although the United States is the largest consumer and producer of wood products, we may not have a lot to teach the world about prudent forest husbandry.[294]

Land use changes—Through the first four decades of the 20th century, the nationwide so-called forest problem was seen as land abandonment after unsuccessful farming that followed the first round of logging. The stump ranches of the west side were a case in point.[295] The companion farmland problem was addressed in various New Deal programs of the 1930s with the aim of making farming worthwhile to the farmer. *Five Acres and Independence*... was a widely read book of the 1930s and beyond, with 25 printings by the end of the war.[296] It appealed to servicemen awaiting their chance to prosper on the land they were fighting for. By the late 1940s, however, the notion of the successful small farmstead was fading. Successful agriculture was concentrating among fewer owners in fewer places. This left forestry as the best chance for much of the 185 million acres of U.S. farm woodland.[297]

The relevant land area for forestry is always hard to define and devious to discover on the ground. Early national timber situation reports started, of course, with an assessment of the land base. The key portion was called commercial forest land (CFL) for many years, until PNW analysts replaced it with *timberland*, and pointed out that commercial was an ephemeral concept that parts of the private sector resented. Who were we to tell them what was and would be economic?

Those national reports, 11 of them produced by the Forest Service between 1946 and 1995, showed how timberland acreage changed over time and among regions. In 1981 Wall laid out the state-level increases (in some states) and decreases (in others) from 1952 to 1977, and made projections to 2030.[298]

In 1987 Alig, Brooks, and Denise Ingram (Southeastern Forest Experiment Station, Research Triangle Park) looked into fitting land-use changes into global trade and forest development modeling, or vice versa. They suggested that a common approach would fit nations approaching timber situation modeling for the first time as well as familiar kinds of analyses for the United States.[299]

The RPA analysts responded in a part of the 1989 assessment cycle. Ecosystems and forest types were joined in the analysis, which dealt with the major ecotypes of each region. Land resources were covered, from minerals to wetlands. Land cover and use changes were projected to 2040. Relevant words (except ecosystem) were in a glossary.[300] The principal PNW participants were Oswald, Waddell, Bolsinger, Bill van Hees, and Alig. The detailed data for 1987 were published separately by Waddell, Oswald, and Douglas Powell (Northeastern Forest Experiment Station, Broomall).[301]

After participating in the 1989 Forest Service RPA assessment[302] and a number of land-use studies, Alig assembled some conclusions about nonindustrial private forest land and their owners that seemed almost universal within the United States. This was a key group, providing about two-thirds of timber harvests and controlling about three-fifths of U.S. timberland and half the national timber inventory. Alig found the owners to be not much different from other Americans except they owned forest land. Their intentions and practices differed widely and their land changed hands frequently. Timber production did not drive their days, and they accepted federal financial assistance for forestry gracefully. They responded to stumpage price signals but, absent payments, did little to their woods in the way of forestry.[303]

In 1996 Darius Adams, Alig, and others projected impacts of public timber harvest policies on private timber production. They anticipated large acreage shifts from hardwoods to softwoods and large investments in private forest management induced by public harvest reductions. They expected slightly falling sawtimber prices from 2000 through 2040. The price outlook contrasted with rising price projections from other studies of the time. This was an early use of FASOM.[304]

For 1961 through 1994 in western Oregon, Daolan Zheng (Oregon State University) and Alig found that the rate of conversion from forest land to other uses had slowed greatly, from about 6 percent to about 1.3 percent per decade. Urbanization was rapid and concentrated in the flatlands. From 1960 to 1990, population growth was almost linear, though it slowed a bit during the third decade.[305]

A Northwest question highly relevant to the times related to land-use planning, which was especially vigorous in Oregon and Washington after the mid-1970s. An analytical model yielded puzzling conclusions: the likelihood of conversion of resource lands to developed uses was not measurably different between lands outside urban growth boundaries and those within. Perhaps people were establishing hobby farms on the minimum-sized units of nonurban land. More likely, Kline and Alig concluded, was that the growth boundaries originally were drawn somewhat outside the extant urban areas to allow some expansion into the countryside, which then occurred.[306]

A different timber production question was posed by Alig and others for the Northwest west side: What happens to forest land after clearcutting? Or for that matter, without harvest? Alig, Zheng, Tom Spies, and Brett Butler made projections for privately owned forest cover types on the Northwest west side to 2040. They used probabilities of disturbance and change based on land use and forest manipulation. They pointed out that previous modeling of forest type change had been based either on ecological disturbance, prescribed or optimal forest management, or a combination. They compared successive conditions of forest inventory plots and found that, over the approximate decade between visits, about one-fifth of plots had been disturbed by harvesting. Nonindustrial land was more likely to be partially cut; clearcutting was more frequent on industry lands. Alder stands had a 13-percent chance of changing to the Douglas-fir type on nonindustrial lands and a 30-percent chance on industry lands. Although the area of harvesting rose, the volume removed from private lands remained stable. These authors concluded that timberland's share of the land would be relatively constant, rising perhaps by a quarter for industry. The alder component of these lands would decline in all cases ("cases" alludes to three options: recent trends, no human-caused disturbance, and partial harvesting).[307]

In 1999 Alig reached beyond the Northwest to trace the history and project the future of land use in the Lake States region and, separately, for Maine. The workers included Thomas Mauldin and Andrew Plantinga (both at the University of Maine). They made projections based on past trends influenced by changing land rents and quality.[308]

Alaska: the Economics of Far Places and Big and Little Sticks

Even before the Northern Experiment Station was merged into PNW in 1966, Portland-based economists, utilization, and marketing people were being asked for counsel by Alaskans. Economically Alaska was both different from (Alaskans' viewpoint) and much like the rest of the Northwest (perception of outsiders). High operating costs in Alaska made it a last-in first-out region during economic cycles. There, cycles are felt sooner, last longer, and are deeper, though upside euphoria can be considerable. Similarities include the kinds of trees, tough country, and worldwide markets. Another difference was that, as harvestable old growth diminished to the south, it lingered in southeast Alaska, for a while.

Alaska as a different supply region—Early questions from Alaska were about manufacture: treatability, drying schedules, and machining properties of Alaska species. Next came a series of feasibility studies, largely done by Jack Grantham and me on possibilities for greater use of Alaska wood within Alaska and manufactures that might be economic. There was hope that the very seasonal economy of Alaska could be lifted in winter months with more in-state manufacturing. Some of the obstacles were high labor costs, monopoly power within the Alaska timber industry, Forest Service rules governing export, and Jones Act prohibition of shipments between U.S. ports in non-U.S. ships.

In 1967 I analyzed Alaska's primary-processing rule and laid out a conceptual framework from trade theory and estimated stumpage income foregone. In 1968 I arrayed and assessed special pricing structures to encourage use of cull logs and cedar. In 1969 I estimated that exporting of chips would be feasible and would reduce the area in Alaska considered economically inaccessible.

In 1974 Grantham explored the economics of using barges in southeast Alaska to reduce supposed environmental damage in log raft storage areas. Barges would work but would be expensive. He also considered the economics of barging hemlock and spruce (*Picea* spp.) cants to Puget Sound for remanufacture at lower cost. It was feasible but resisted by Alaskans. I repeated that exercise in 1975, during a recession. By then spruce barging was feasible but hemlock transport was not.

In 1976 I assessed sending whole logs to Puget Sound and then studied chips in the same context. Both possibilities seemed financially feasible.

In the mid-1970s, there was much interest in the Anchorage-Fairbanks railbelt and points northward to the Yukon as a timber source region for offshore manufacturers, and questions were being raised about possibilities for local milling for the Anchorage market. Japanese interests were negotiating with the State for a billion-board-foot sale. Grantham and I worried about the consequences of a bold startup followed by recession-borne disaster. In 1977 Grantham and others looked into the feasibility of structural particleboard manufacture in Anchorage and Fairbanks for sale to Asia. They found that high production costs in Alaska would not be offset by the lower shipping cost, Pacific Rim markets were not yet attracted to composite panels, and there was only a small backup market in Alaska. In that year, I evaluated export of green veneer (not competitive with the west coast), and Darr and others, in the cluster of Fast Alaska Rescue Team studies mentioned below, again considered the possibility of exporting chips (still not competitive with other North American sources). Was PNW wrong? Why so many negatives?

Within a few years, a facility for making and exporting chips was built on the Kenai Peninsula in south-central Alaska. A fine plant, it faltered during the next recession.

The Fast Alaska Rescue Team—The Grantham-Flora studies were followed by Darr's 1977 series of analyses of a variety of strategies that might enhance Alaska's competitive advantage and employment. As mentioned elsewhere, Darr and associates (they were called the Fast Alaska Rescue Team) looked at 22 alternatives that could be implemented by the Forest Service.[309] The options included export and primary manufacture alternatives, contract administration and sales arrangement changes, and adjustments to meet non-commodity concerns. In connection with this, Bell did a collateral study dealing with the theoretical implications of the existing bilateral-monopoly stumpage economy in southeast Alaska.[310]

The study was requested by Congress at a time when both the lumber and pulp markets were depressed. The underlying hypothesis was that marketing constraints or institutional deterrents might be identified and eased to increase timber sales and restore employment. The analyses were not optimistic absent a worldwide economic upturn. The most accessible timber in Alaska already had been cut, and much of what was left would not be competitive given its quality and Alaska's remoteness and labor costs, the latter among the highest in the world. Most of Alaska's unique store of old-growth spruce and hemlock was already committed to two large pulp concessions.

One significant result of the study was termination of the export embargo on wood chips; they now would be considered to have had primary manufacture, a threshold criterion in Alaska.[311] This was especially important to small sawmill firms that had been stonewalled in selling chips to pulp mills, a circumstance that made them uncompetitive in buying logs.

Darr followed the analyses with an intensive study of market structure in Japan and Alaska, PNW's first major attempt to explore and explain Japanese demand. He pointed out that advocates of unimpaired log exports from Alaska, in the interest of increasing stumpage revenues, had overlooked the possibility that prices in Japan might be pushed down by the increased supply. He emphasized Bell's point that the demand for Alaska timber was a duopsony (an industry in which there are only two buyers for whatever commodity is being produced). He discussed markets in other Pacific Rim countries. Assuming price-inelastic supplies for non-U.S. regions and using an assumed supply elasticity for the United States, he showed how the supplies, interacting with inelastic demand, could have substantial price effects. He also estimated the grade mix of logs remaining in Alaska after the export market had taken the best. He mentioned a further complication: Japan's increased imports of logs might displace existing imports of cants from Alaska.[312]

The southeast Alaska multiresource model—In 1982 Fight undertook development of the southeast Alaska multiresource model (SAMM). Its purpose was to develop an understanding of the interaction of key forest resources in southeast Alaska and to illustrate the economic tradeoffs involved in forest policy choices. An informal team of about 30 scientists, periodically assisted by consultants, developed the model over 6 years.

The model included effects of forest harvest and regrowth on aquatic and terrestrial conditions. Within the model, aquatic factors, soils, and weather determined the habitat and population dynamics of pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), and coho salmon. Terrestrial conditions and weather, especially snow, determined the habitat and population dynamics of Sitka blacktail deer (*Odocoileus hemionus sitkensis*). Together, elements of the model dealt with interactions among timber, water, fish, and deer, all of them key forest products in southeast Alaska.

In the model, annual timber growth depended on site class and age. Timber removals included mortality and thinning. Overstory management and road building figured in a hydrology and soils submodel. Fish and deer habitat were driven by that submodel plus precipitation, hydrology including sediment, and air and water temperature, the last for subunits within watersheds. Individual salmon species were tracked, including spawning and rearing. Deer populations reflected energy intake and its cost and population drivers including vegetative manipulation, snowfall, and hunting. The model's detail was evident in, for example, the relation of old-growth level to coho salmon populations through the quantity of rearing ponds created by large organic debris. Economics appeared in job counts, user days of recreation, and timber revenues and costs.

The effort was instrumental in establishing and improving links between research and staff scientists in four agencies—relations that had been distant. And because development of SAMM involved many of the most knowledgeable scientists in southeast Alaska, the development of interaction hypotheses as well as the strength of some of the submodels had enduring influence on forest planning.

The model was developed for watershed areas of 5,000 to 20,000 acres. At the level of national forest planning units, Fight's SAMM enterprise began integrating fisheries and deer habitat into resource planning with a degree of synthesis that had never been achieved in the fractious Alaska planning environment.[313]

World perspectives, of and from Alaska—Like many resource-rich regions around the world, Alaska wishes not to be exploited for its raw materials but wants to play an international role in manufactures. Such has not generally been Alaska's lot. Lacking a significant internal market for wood products, Alaska must look abroad, to Pacific Rim customers (and the lower 48 states) having either cheaper labor, parochial product standards, their own processing industry to protect, or their own timber. Because of high labor costs and tough operating conditions on the ground, Alaska has needed a niche; PNW has helped with that as well as bearing unwelcome market facts from abroad.

In 1983-84, Schallau, Douglas Olson, and Wilbur Maki (University of Minnesota) dealt with employment and income effects of forest management scenarios for southeast Alaska. They used an impact-analysis model called IPASS (described below in "Communities, People, and Multipliers"). Year-to-year links were driven by production and investment. Estimated were local and nonlocal impacts of the closure of Alaska's two pulp mills and potential tourism increases. The authors concluded that if sales to tourists equaled lost pulp-mill sales, tourism would more than compensate for lost pulp-related employment and earnings.[314]

Other economists and I did two studies that recognized expressly the remarkable breadth of values in Alaska forests. Alaska has the most valuable and some of the least valuable softwood trees in the world. Similarly broad is the spectrum of access and logging conditions. The best Alaska timber has unique economic promise in all seasons. A 1986 study of small-log values around the Pacific Rim indicated that Alaska's lower grade material could be expected to rise in value slowly over the next 20 years and gradually move into world markets, but being ever sensitive to business cycles. This trend was not considered promising for residual stands of small timber in Alaska.[315]

A later analysis with McGinnis in 1989 showed why midrange material fluctuated greatly in value depending on world market cycles, and why it would continue to do so.[316] Alaskans had imputed to small and midgrade logs the unique character and value of their big, old spruce and hemlock.

Another round of economic studies for Alaska began in 1988. George Sampson, van Hees, Setzer, and Dick Smith revisited the prospects for forest products in interior Alaska. In the 1980s, shiploads of logs were leaving south-central Alaska, ownership had stabilized including creation of a 1.6-million-acre state forest, Native corporations were selling timber, and the Anchorage-Fairbanks lumber market had expanded to about 100 million board feet of consumption annually. Construction programs rivaled the rebuilding of San Francisco after its 1850 fire. Yearly production in the interior, however, had been below 20 million board feet. Poor access and the dispersion of sawtimber-sized trees (white spruce [*Picea glauca* (Moench) Voss]) were seen as major obstacles. Drying, planing, and grading facilities did not exist in the interior, and a small-mill economy would need them. The state's allowable cut was far below the level needed to support a big mill. The conclusion: little could be done to improve interior Alaska's competitive position in softwood lumber in the short run.[317]

Much has been written about Alaska's remoteness from some places and closeness to others. Many Alaskans see themselves as a northerly crossroads from which planes drop southward to various parts of the world. Those who must ship by water are less sanguine. For them, port facilities matter as much as distance. So the timbered parts of Alaska may or may not be economically close to, say, Asia, relative to competing regions. Harold Wisdom (Virginia Polytechnic Institute) addressed this question in the context of Alaska versus Puget Sound.[318] He found that Alaska's shorter distance to South Korea, Taiwan, and Hong Kong did not generally offset other factors such as weather, trade volume, and backhaul opportunities. Distance seemed to matter for rates from Puget Sound but not from Alaska.

Competition between cants and logs has long perplexed Alaskans. The advent of major log exporting by Alaska Native corporations in the late 1970s coincided remarkably with a trend of decline in lumber exports. By 1990 it appeared that log exports would have to decline soon. It seemed logical that (overseas) customers would resume their imports of Alaska lumber; however, analysts found a number of reasons to question this scenario. Eight explanations for the difference between cant and log market behavior were explored. The conclusions were that the flush of private logs explained the rise in log shipments, and declining offshore demand for cants **and** logs explained the fall in cant flows. An exception was select grades of cants and logs, where direct displacement may have occurred. In short, it would be well to consider cant and log markets as rather independent in the future.[319]

The prospect of an early-1990s decline in Alaska Native harvests was supported by Gunnar Knapp (University of Alaska, Anchorage), who in 1990 traced Native timberland selection and timber policy and estimated the harvests. (There are 12 village corporations and 1 regional corporation [Sealaska]). At the time, it appeared that Native corporation timber would soon be exhausted, while Sealaska inventories might endure for a decade or so. This would have important implications for Alaska log exports, because more than half the state's harvest was from Native lands and almost all of that was exported as logs.[320]

In 1994 Christine Lane and I did a paper distributed in Ketchikan without formal publication. It was requested by the University of Alaska to alert residents to likely futures, including closure of their pulp mill, on which the area was heavily dependent. This was shortly after the Sitka mill had closed (in 1993). Company officials insisted the Ketchikan mill would endure. At a Ketchikan conference, we did not argue otherwise but presented information the community evidently had not heard, about weakening world markets for dissolving pulp, the different outlooks for high- and low-grade timber markets, and looming intense competition from abroad. We said, “Alaskan industry's comparative advantage is in its timber. To understand your opportunities, look to your trees. Their volume, their variety, their warts." Ketchikan may or may not have done that; the company did. The mill closed in 1997.[321]

Alaska has been well served by PNW with explanations of their unique place in world wood markets and forecasts of their situation. In addition to studies mentioned, three rounds of special analyses were begun by Brooks and Haynes in 1990 to provide assumptions for use in Tongass National Forest land management plans, the latter mandated by the Alaska National Interest Lands Conservation Act. The first report set the pace, in a climate of fluctuating federal timber harvests, sharply rising Native harvests, and the near-total export of Native logs. Assuming elastic overseas demand facing Alaska, harvest requirements were derived from forecast product output, with a near-term near-collapse of Native corporation harvests. The harvest projection was carried forward 20 years, to 2010.[322]

Brooks and Haynes revisited the subject in 1994, with the same target date (2010) for their projections. The same derived-demand format was used as in 1990 but a number of particulars were revised in response to new data. Closure of the Sitka pulp mill also caused some new harvest trajectories to be made. Price projections were included this time but were generated outside the model and with an eye toward rising prices in Washington and Oregon from logging reductions in spotted owl forests. There also was attention to the sharp decline in Japan's economy, still the principal outlet for Alaska log and cant exports.[323]

The next in the series came in 1997, still with a 2010 horizon. In this report,[324] the concept of derived log consumption from national forests reached out from Alaska's manufacturing industry to offshore markets and distant competitors. Three demand scenarios were developed this time because of uncertainty about disposition of timber available through closure of the two pulp mills, which had accounted for much of the national forest harvest. Cant shipments from Alaska to Japan fell by nearly 90 percent while exports from the lower 48 and British Columbia together increased 30 percent, both during the first half of the 1990s. The Japanese market had changed, with scarcity and high prices for lumber and chips inducing a turn away from cant imports. Reflecting another change, it was assumed that 15 to 35 percent of Alaska's lumber production would be shipped to the lower 48.

As before, prices were projected separately from timber consumption. Alaska stumpage prices were developed from national forest stumpage prices in the Pacific Northwest Region and world pulp prices. The expected trend was for near-term rise, brief decline, and then a rise culminating in stability after 2010.

Thirty PNW economic studies across four decades have consistently conveyed a message: Alaska has been different in its store of old-growth whitewoods and also in its high costs. With the end of the former, Alaska must compete with a mixed resource bag in a difficult market world.

Communities, People, and Multipliers

Community stability has been, within the world of timber, as strong a driver of opinion and policy as has ecological diversity in the latter-day sphere of sustainable ecosystems. In 1933 a national plan for American forestry[325] called for "...a continuous supply of timber...for each dependent community; that is, under the principle of sustained yield by comparatively small economic units." The national plan was concerned as much about boom developments as about ghost towns. However, nobody has been quite sure what the words meant, and those who guess are challenged. Stability is considered a nice thing, if attainable, though close study suggests it is improbable and unnatural. Communities mean people (if not plants), variously reckoned at town or county or state levels, often counted within occupations.

Much of PNW's economics work has been denominated in costs, prices, and quantities. There has been significant attention, however, to the effects of forest management on the people who work near the forests and on the people who work for the people who work there. Local economic well-being had long been a hallowed cornerstone for regional forest policy on several levels. For example, federal sustained-yield units, initiated in the 1940s, and Forest Service working circles were aimed at sustaining specific local communities, largely through locale-oriented even flows of stumpage.

In 1965 Gedney and Dick Smith provided the first analysis of labor productivity in the Northwest wood products industry in terms of labor used per unit of logs processed. Previous studies had dealt with labor per unit of end product.[326] That research started decades of attention by PNW to defining, then measuring, community-level economic health.

Also in 1965, Tom Adams and Hamilton estimated employment and incomes created by the rapidly growing log export industry.[327] Although moving logs overseas was not especially capital intensive at the time, it generated high revenues per staff-hour.

During the 1960s, the center of gravity of timber markets moved not only toward the coast but also toward southwest Oregon. By 1970 harvests in Douglas County had already turned downward. With input-output analysis it was possible for Darr, Fight, and others to estimate the degree to which changes in purchases of goods and services and sales of products by forest products industries would radiate through other economic activities in the county.[328] In 1974 Darr and Fight found that timber-using elements of the economy accounted for two-thirds of the county's economic base. Per dollar of change in federal timber sales, total sales in the county could be expected to change by $7.50 to $10.[329]

In 1968 Maki, Schallau, and John Beuter defined 15 multicounty economic areas along the west side of the Cascade Range including northern California. They assigned to the economic base of each area any industry whose percentage of the local employment total exceeded the national norm for that industry. Where timber was among the excess-employment industries, they used its percentage of the total area's excess as a timber-dependency indicator. Nine of the areas had indicators exceeding 70 percent; the indicator was 45 percent for the region as a whole. They also found that high indicators in peripheral areas could propel central metropolitan areas into high dependency via support to the periphery. They confirmed the principle of economic growth centers by identifying communities whose superior size and vitality destined them to grow even if the surrounding resource base were constant.[330]

In 1973 Maki and Schweitzer examined the 14 non-California economic areas of the west side, and found that, from 1959 to 1971, timber-dependent employment matched national gains in only three of the areas. In almost every case, timbering accounted for a declining share of basic employment. Lumber and wood products employment had reversed its upward trend of the 1960s, more abruptly than national trends in the industry and more sharply than employment in service or noncommodity fields.[331]

An outlook for timber in the United States, issued in 1973,[332] projected a one-third decline by 2000 in timber harvests in the Douglas-fir region. Wall estimated the consequent employment impacts through the use of labor productivity and industry mix assumptions for each of 12 subregions that he had developed for the 1969 Columbia-North Pacific report (see note 254). He concluded that forest-based employment would fall by nearly half, driven by declining timber production, log exports, and especially downward-trending employment-wood consumption ratios.

In 1974 Schallau followed up on Wall's point about employment-wood consumption ratios by relating it to community stability; he concluded that correlation between the two was imperfect.[333]

In 1975 Darr revisited the employment and revenues generated by log exports. This was 10 years after the Adams-Hamilton study (see note 327). Exporting had become a major Northwest industry accounting for one-sixth of Northwest harvests. Although west-side harvests had begun to decline, as mentioned above, log exports were rising sharply. While the amount of labor needed per unit of logs in domestic processing had fallen as much as 13 percent over a decade, export-log loading efficiencies had reduced export labor needs by a quarter. Lumber-making required more than twice as much labor as exporting; veneer and plywood manufacture used four times as much.[334]

Employment data for Darr's 1975 report were provided by Wall and Oswald from their employment projection techniques report.[335] For 1950-71, they collected employment and wood consumption data for the several forest industries in six west coast regions and fitted equations to the employment-consumption ratios over time. The technique was unusual in using wood input rather than product output. It was a useful change because timber supply was a constraining factor in rural development in many counties. Employment-consumption ratios had trended downward in every forest industry, evidently reflecting labor-saving technology. Seasonality was examined and found to be significant, even in the pulp, paper, and paperboard industry. Wall updated the data for 10 subareas within Washington and Oregon for 1976.[336] There were significant differences among the subareas, presumably because of different product mixes and intensities of manufacture.

Bell, in 1977, estimated the effect of harvest changes on employment in Western States, to illustrate measures of community stability and some difficulties in using them. He discussed the ratio of primary employment to log input, the distinction between basic and nonbasic employment, the problem of whether those hired or fired are as productive on average as the others (if not, the ratio assigned to such people would be too low). He described the location quotient and export-base methods of estimating secondary employment, whose existence depends on serving workers in the primary industry. He concluded that community development impacts were not handled consistently, if at all, in federal decisionmaking processes and environmental impact statements.[337]

Fight and Douglas YoungDay (University of Montana) explored the possibility of tracing the incidence of wood product price changes among consumers. This was in 1977, a time of rapid and significant changes in the cost of lumber and other wood-based consumer goods. The authors used a model of the U.S. economy to gauge the effects of log prices on costs of consumer goods and services. They followed these effects into differential impacts among low-, medium-, and high-income groups. They concluded that a program to lower wood costs would benefit low-income households, but families with three times as much income would get twice as much expenditure benefit.[338]

In 1978 Beuter and Schallau explored the interaction between stability in forestry and stability of communities and dealt with basic versus residentiary activities and with stages in the evolution of a community.[339] Basic industries were taken as the foundation of the community, because they bring in new money. The researchers appraised four developmental stages: takeoff, proliferation, maturity, and decline. Each stage might have a different ratio of basic to total employment and economic activity. The analysts noted that stability in a social sense also requires infrastructure and a sense of community. They concluded that constant physical or dollar flows from the forestry sector were unlikely to ensure stable communities, even in insular forest-bound places, and that in any case natural, political, and economic circumstances were apt to shake the continuity tree.

In 1979 Connaughton and Bill McKillop (University of California, Berkeley) estimated community-level multipliers for California by using income and employment, with community defined as a county. They used an econometric approach to move between the multisector input-output multiplier and an aggregate economic base multiplier.[340]

In 1980 Schallau examined the stages-of-growth concept against money movements from commercial banks in two western Oregon communities noted for their timber orientation. Theory indicated that capital would come into the communities during the takeoff period and move away as the towns became economically independent, or at least as local earnings exceeded investment needs. The places were Roseburg and Medford, both of which were net exporters of capital from 1953 to 1977. The implication was that these were economically mature communities during that period, when other indicators of stagnation would probably not be apparent.[341]

In 1983 Schallau and Paul Polzin (University of Montana) considered whether departures from even flow, an acute issue of the time, would make a significant difference to four timber-dependent communities in Montana and Oregon. Forest Service regulations permitted such departures when “implementation of base harvest schedules would cause a substantial adverse impact upon a community.” The analysts pursued four matters they considered relevant: future timber supply, timber dependency, long-term feasibility of alternatives to current harvest schedules, and whether growth of nontimber industries might compensate for timber shortages. The four communities differed somewhat in their economic prospects, but none was rosy. Retirement incomes were growing rapidly. All four were trade centers for rather large areas. The strongest growth factor in the judgment of the analysts was that all four places had universities.[342]

In 1983-84 Olson, Schallau, and Maki developed IPASS, a computer-based method of linking input-output analysis to other simulation steps to project the socioeconomic effects of local changes in investment and demand. It was a more comprehensive and complex way of getting at multipliers, from household activity to interindustry activity, government spending, and exports from the area; conversely, it could trace changes backward through those sectors. To do all this, it expanded on an input-output model already developed by Darr and Fight in 1974, described earlier.[343]

In 1985 Connaughton, Polzin, and Schallau defined basic activity in local economies as activity in industries producing for export that affects but is not affected by derivative activity.[344] Concerned about static economic multipliers, which compared total with basic activity data from the same period, the analysts used causality analysis, in which activity in one period is theorized to result from activity in previous periods. One variable "causes" another if the second can be better predicted than not by using past information on the first. Using data on wages and salaries from Flathead County, Montana, the authors rejected the assumption that changes in the basic sector are independent of changes in the derivative sector. Employment data, on the other hand, yielded no relation between basic and derivative activity.

In 1986 Debbie Salazar, Bob Lee (both University of Washington), and Schallau estimated the impact of retirement income in timber-dependent communities. They found that from 1969 to 1978, government pension payments to people over age 65 rose significantly in three of the five Northwest counties they studied. This reflected a marked change from earlier rural-to-urban migration.[345]

The next year, Polzin, Connaughton, Schallau, and James Sylvester (University of Montana) estimated the role of transfer payments and property income as part of the economic base. These were considered sources of economic growth.[346]

Interregional competition, implicit in the TAMM-based RPA analyses described earlier, occupies a large share of economic base theory. In the 1980s, it also engaged much attention in the Northwest as Canada and the South appeared to be taking market shares away from Northwest forest industries. Would displacement continue? What would drive it? What timber legislation or trade policy could improve the Northwest's comparative advantage? Would timber remain a premier driver of the Northwest's overall economy? How much would these things matter?

In 1986 Schallau and Maki put some numbers on the situation. Between 1970 and 1980, the Northwest's share of U.S. forest products employment declined substantially; however, this industry continued to be a major source of export dollars from the region. In 1980 timbering was still the largest basic industry in Oregon and the second largest in Washington. Meanwhile the South increased its share of U.S. employment in the forest products industries. Imports from Canada impinged on both the South and the Northwest; however, they forestalled use of wood substitutes, held down lumber prices, and the analysts suggested, may have resulted in higher future U.S. employment in wood products.[347]

In the mid-1980s, Schallau and Maki extended their intraregional analyses to the South by showing how timber economies had differed among states in that region.[348]

In the late 1940s and early 1950s, several federal sustained yield units were established by the Forest Service to orient national forest timber harvests to particular communities, for the long-term welfare of those communities. Timber from the Quinault Ranger District, northwest Washington, was sold exclusively for processing in Grays Harbor County. This raised some lively equity questions. In 1949 the unit accounted for a third of logs consumed in the county (the rest were from the Quinault Indian Reservation or from private lands). By the early 1980s, the unit provided only 8 to 15 percent. Using the excess-employment method of identifying the Grays Harbor economic base (it was timber), Schallau and Maki concluded that the county's economic performance was better than that of neighboring counties. The local-processing rules were relaxed, and by 1985 only half the logs from the unit were consigned to Grays Harbor.[349]

For people employed in logging and milling towns, community stability has been a simple, direct, we-have-it-or-we-don't circumstance. How difficult a concept this can be, at least for social scientists, was shown in a followup analysis after the Interior Columbia Basin Ecosystem Management Project in 1996. Haynes, Horne, Steve McCool, and Jim Birchfield [Burchfield] (the latter two at University of Montana) enumerated the problems. *Community* and *stability* are hard to define at a distance. Stability of timber flows may not sustain per-capita incomes. The analysts noted a negative relation between wood products activity and per-capita income in places, and a positive relation between poverty and trees. The latter factor, measured in Georgia, is quite apparent along the west coast including British Columbia. Community well-being may transcend incomes, and incomes may come in the mail from afar. Superimposed on all this is the flexible concept of economic resiliency, a community's capacity to rebound from economic adversity (perhaps tending toward a steady state).[350]

Beyond these issues is that of economic welfare in communities. Within the forest industry, for example, are wealthy small towns and poor large ones. How can that be? What happens to communities when timber harvests are constant, or go to zero? How much is a job worth, and how much do social programs cost to sustain a job or replace it somewhere else? As private harvests declined in the Northwest, how much employment and income could be regained by increasing public harvests? And how much would be lost in areas where public lands were withdrawn from cutting? These questions were as timely in the 1990s as they had been in the 1960s when the center of gravity shifted for industries using timber.

In 1993 Fight assisted Keegan and others at the University of Montana in estimating employment and wage multipliers per unit volume of timber or wood fiber processed in Montana. This was done for segments of the wood-using industry. Employment ranged from a high of 117 workers per million cubic feet at log home manufacturers to a low of 12 at stud mills. Mill residues from processing added substantially to employment. Wages paid per million cubic feet of wood used ranged from $273,000 at stud mills to nearly $2 million at log home manufacturers.[351]

Raettig and McGinnis made a projection of wood products employment in the Pacific Northwest. This work was cited in the Northwest Forest Plan of 1996.[352]

Using range and timber effects of interior Columbia basin management changes in northeast Oregon as an example, Edward Waters, David Holland, and Haynes looked at multiplier implications for employment. They used a multiequation model (different from conventional multiplier work in which invariant prices are either assumed or are necessary to model solutions). As resource supplies fade, the model estimates demand-driven price increases that presumably discourage purchases, thus reducing next levels of economic activity and associated employment. The overall effect is lower multipliers than estimated formerly. The analysts also projected the effects of time on employment, income, and revenue impacts. In general, time allows greater adjustment to shocks, thus raising the multipliers.[353]

The Columbia basin synthesis of the 1990s involved McGinnis in tabulations and mapping of county economic and demographic data across the Pacific West. She considered a wide array of social indicators from population, education, and ethnicity to employment and poverty, various kinds of income, and their components, generally for 1990 and in some cases showing change since 1980. Her maps included land ownership, wildland, timber, and recreation dependency. The mapping embraced Alaska and some were for the Nation.[354]

Then McGinnis, Christensen, Erv Schuster (Intermountain Research Station, Missoula), and Walter Stewart (Southwestern Region, Albuquerque) explored the significance of the numbers in terms of change, interaction, and trends into the future.[355] Populations, employment, and incomes were growing more quickly in metro than nonmetro areas. Destination retirement counties had had rapid population growth for two decades but with low per capita incomes. The population of the basin was becoming more racially and ethnically diverse.

Population flux in a region is driven by “multiplying” employment factors, such as resource use and industrial expansion, that pull people in. It also is affected by livability and external factors that push people toward the region, quite independent of the regional economic base. In 1996 McCool and Haynes dealt with natural rates of increase in the resident population plus migration, based on Department of Commerce estimates of regional trends over the 1990-2040 forecast period. They distinguished among recreational, metropolitan, and other counties and generated high and low projections, both considered possible. For the interior Columbia basin, 50 years out, the high projection was about 7 million persons; the low mark was about half that many.[356]

Socioeconomic resilience, like biotic resilience, alludes to the capacity of presumably sustainable populations and yields to bounce back from disturbances such as harvest reductions and fires. Horne and Haynes pursued the premise that diversity within social and natural systems reduces the effects of and speeds recovery from a sudden, sharp upswing in amount of noxious change. In 1999 they pointed out that the goal for ecosystem management sustainability may obscure the more usual fact of community change. They proposed an index of diversity (hence resilience) based on the proportion of total employment in each of an area’s industries. Next they computed population density and lifestyle diversity for each county in the interior Columbia basin. Lifestyle was based on education, affluence, family life cycle (presence or absence of children, etc.), mobility, race, ethnicity, and degree of urbanization—all from census data. “Socioeconomic resilience” was a composite of the other indexes. They mapped resilience and dependence on federal forage and timber. They concluded that humans are among the most adaptable creatures in the basin.[357]

Community resilience figured also in a 1998 assessment of the southeast Alaska economy. It was done by Stewart Allen (U.S. Fish and Wildlife Service, Anchorage), Guy Robertson, and Julie Schaefers, the latter two with the Forest Service's Alaska Region. Conducted during the heart of heated debate over the post-pulpmill future of the Tongass National Forest, the study did not make projections but rather provided descriptions at as detailed a level as data would permit: kinds and sources of income and the large and complex effect of the national forest on the subsistence, timber, fishing, and tourist industries, only one of which is growing. There is wide economic diversity among communities in the region, but less within them because towns are small.[358]

In 1998 Haynes, McGinnis, and Horne explained and endorsed a method used in the interior Columbia basin work for identifying economies that might be affected by changes in land management. They noted that projections of regional- and county-level economic change in the past, such as in the spotted owl (FEMAT) analyses, often had been obscured by other economic forces at work. They distinguished between economies and communities. They also concluded that county-level data, whatever their limitations, are the best available for characterizing economic systems.[359]

As Gedney and Smith had found in the 1960s, and Schallau and Maki in the 1980s, the idea of an economic base is clear enough in a mill town lacking any other reason to exist, but devilish to define otherwise. Lisa Crone, Haynes, and Reyna noted in 1999, during the interior Columbia basin project, that major public concerns arose over the definition of economic base, perhaps related to the finding that only 4 percent of the region's employment was calculated to be based on wood products, ranching, and mining.[360] The analysts described the two concepts of economic base used in the project. The assignment approach to defining economic base involves choosing the industries in the area that will be considered basic activity. Often those chosen are manufacturing and agriculture. The location quotient method to define economic base compares all economic activities in the area with large-region or national averages (discussed earlier in this section). An activity is basic if its share of the local economy is larger than its share in the Nation as a whole. The team pointed out limitations common to all economic-base ideas and models.

Whatever model is used, results can depend on the definition of the local community, which could be a neighborhood or a multistate region, or something in between. Economic analyses for the interior Columbia basin project focused mainly on counties. In 1998 Congress asked for a look at smaller geographic units, so Reyna and his staff analyzed 543 towns in the 98-county region, gauging their geographic isolation from larger cities. They then applied the location-quotient (specialization-ratio) definition of economic base to the 423 towns for which industrial employment data could be obtained. Social attributes and "community resilience indexes" were determined for 196 communities and 10 case studies were done of some much-changed communities.[361]

Thirty years after the Douglas-fir supply study made distinctions between central and peripheral areas and associated the economic base with excess employment ratios, those concepts were still considered relevant. The scale of analysis had steadily shifted downward, however, from whole states to forest subregions to multicounty areas to counties and finally to individual towns. And resilience had become a new analytical tool.

Industry and Market Structure, and Price Formation

Originally analogous to the agricultural marketing theme of market development and promotion, PNW's marketing work quickly evolved into studies of market structure, such as Tom Adams's assessments (1958-60) of Christmas tree and farm forest product markets; Fedkiw's analysis (1964) of forest industry capacity, production, and log supplies; McMahon's assessment (1964) of land ownership; Walter Mead's (University of California, Santa Barbara) and Hamilton's work (1968) on competition in the Northwest forest industry; and Haynes' studies (1980s) of competition in national forest timber sales. Organizationally, the work on foreign trade was divided from the marketing research, which had become oriented to macroeconomic questions.

The number and size of wood products operations have pitched up and down with abrupt waves in demand and longer economic swells driven by depressions, wars, recoveries, and the value of the dollar. In the background have been surges of innovation, tsunamis of raw material policy, and a long groundswell of change in the character of timber.

Wood products differ greatly in their scale and capital-intensity of manufacture, which create natural monopsonies when coupled with relatively low value per unit weight and bulk of the raw material. End products compete intensely, however, because of their commodity character and global mobility. End-product demand is generally price-inelastic in the short run; raw material demand is even more inelastic. Each of this paragraph's statements is a hypothesis, drawn from general economic principles. Each invites testing against reality, extrapolation from data-rich researchable situations, and forecasting into the future.

Such studies are not new in America, but the oceanic allusion intentionally implies constant change in the wood-based economy and in perceptions of its future. An early venture was a 1911-14 Bureau of Corporations report on the lumber industry, which was aimed at the "lumber trust" and concentration of timberland ownership.[362]

Tom Adams brought marketing research to PNW with his 1958 study of the structure of Christmas tree production and transactions in the Northwest.[363] He broadened the work to all minor forest products over the next two years.[364]

During 1964 two PNW papers covered industry structure in the Douglas-fir region. Fedkiw described the lumber, plywood, and pulp industries. He found that while lumber prices had fallen since World War II, stumpage prices had tripled. He concluded that log harvests would increase during the 1960s but not by enough to satisfy current manufacturing capacity. He foresaw a shift of capacity toward pulpmills and small-log sawmills and away from old-growth milling capacity. He found that the gap between capacity and log supply was greatest in Oregon, despite a high rate of cutting there. About 4 percent of the inventory was being harvested annually in southwest Oregon.[365]

In the same year, Mead looked at the structure of the region's lumber industry. He found an active increase in concentration after 1940, the start of his study, and especially after 1955, which affected both milling capacity and timberland ownership. He noted that dominance of geography gave firms a competitive advantage in buying federal timber. He also found, however, that the degree of concentration in private resource ownership, lumber production, and wholesale lumber distribution in the region was low relative to concentration elsewhere in the U.S. economy.[366]

Sales arrangements for federal timber were an issue in the 1960s and 1970s. By 1972 national forests supplied over half of the timber processed in 11 Oregon counties and over 90 percent in 2 counties. National forest stumpage prices were seen as much lower than those in the private sector. New or revived ways of selling timber were proposed, as were ways to increase competition. Much of the discussion of the situation—what would work and how well—was based on anecdotal or incomplete information or faulty assumptions.

One price-differential issue, rather specific to the Northwest, was the disparity between the value of timber as appraised by the agencies and actual (typically much higher) prices received at auction. One question was how a large difference could occur considering that the appraisals were carefully made from market data. Another question was whether the premium was consistent with economic theory, with lower prices associated with sales involving few bidders, barriers to entry, and large-firm market power. In 1968, after screening out one-bidder and token-bid sales, Mead and Hamilton examined bid-appraisal ratios and conducted extensive interviews. They concluded that the number of bidders and the size of the winning firm were important, with bidder density raising the bid-appraisal ratio and firm size restraining the ratio. The type of sale—sealed versus oral bids—made little difference. High demand for lumber pulled ratios upward.[367]

Beuter, in 1971, dealt with the above-mentioned persistent, large differences between appraised and bid prices for Northwest public timber, which continued to trouble law-makers and the public. Why were sellers apparently willing to leave so much money on the table? Beuter provided conceptual and pragmatic reasons for such differences and laid out illustrations in which valuations might differ even when buyers and sellers were well and equally informed.[368]

In 1970 Hamilton examined whether national forest stumpage prices might be influenced by the overall regional volume of timber sold on national forests. This was an important matter because federal stumpage prices had been rising for 20 years and were expected to continue upward. From past data, Hamilton distinguished long- and short-term fluctuat-ions. He concluded that prices were affected mostly by demand rather than supply, with supply responses from other regions dampening supply-side price effects in the Douglas-fir region.[369]

In 1974 Tom Adams examined price behavior of logs, by grade, in western Washington and northwestern Oregon, where log exporting had become important. He suggested several structural-change reasons for an unexpected 1973 surge in log prices, both domestic and export.[370]

In 1976 studies for THIS, Haynes and Lloyd Irland (Yale University) separately assessed economic concentration as it had developed in wood products. Irland looked at recent wood products concentration and found a mixed bag. Haynes made projections of the relative value of shipments accounted for by the four and eight largest firms in the lumber and plywood segments, respectively. Further industry concentration seemed likely. To deal with Small Business Administration set-aside sales of federal timber, which reserved timber for relatively small firms, Haynes modified a framework suggested by Irland for anticipating concentration.[371]

The 1976 National Forest Management Act required that timber sales be screened for collusive activity. How would one know collusion if seen? In 1979 Haynes examined two measures of competition and collusion: the dollar overbid and the bid-appraisal ratio. Using sales data for several years he tested statistically whether elements of these measures changed over time. If they did, those elements rather than competition would at least partially account for the appearance of competition changes.[372] The next year, Haynes did a competition study that interested a committee of the House of Representatives. The report covered three Forest Service regions (Northern, Pacific Southwest, and Pacific Northwest). Using overbid (bid price minus road costs and appraised stumpage) as a measure of competition, Haynes found that the impacts of sealed bidding and the small-operator set-aside program differed greatly, but that overall there was little indication of collusive activity.[373]

Haynes also analyzed the opposite of collusive bidding: arm-length bidding using sealed bids. Sealed bidding was invoked by NFMA, though rescinded later. The issues were whether bidders from outside the community would win and destabilize communities dependent on the timber source, and whether inside firms would have to bid away their assets. Haynes found that sealed bidding did not result in more outside bidders in the Pacific Northwest Region, and sealed bidding did not cause stumpage prices to rise.[374]

One argument against sealed bidding was that it discouraged high bidding in instances where local mills were in dire need of timber but might lose it to a sealed bid from outsiders.[375] In 1983 Haynes led an empirical survey of sealed bidding's results in four timber-dependent communities to determine whether outside bidding was a significant factor. The case studies indicated that in the short run outside bidders did not impair community stability: insiders won the sales. There were more outside bidders and prices rose, but prices did not force local mills out of the chase, partly because they were able to rely on uncut volume remaining from previous purchases.[376]

The 1977 price transmission work was expanded in 1983 by Dave Merrifield (Western Washington University) and Haynes to a regression model of lumber-plywood output and prices, demand determinants, and labor and stumpage supply with certain of their determinants. This embellished production function with elasticities of factor substitution used data from 1950 through 1976. Elasticity estimates throughout the model were largely supported by economic events in the following several years.[377]

Moving away from the woods, Sohngen and Haynes examined the 1993 spike in westside stumpage and lumber prices by looking for one or more causes. Using 1910 to 1993 data, they decomposed market behavior into trend, cycle, seasonal, and random elements. They found that price run-ups are a normal part of the lumber market. They concluded that the region's old-growth conflict could well account for the price volatility, having already done so three times in four years (1988 to 1992).[378]

Mesomarket research—Microlevel production economics models markets at the firm level, and macrolevel work reaches across the national economy. They leave a geographic and conceptual void involving intraregional, translocal supply, demand, and interactions of economic forces; hence the term "mesomarket."

In 1969 Austin defined 15 functional economic areas in the Douglas-fir region, each a relatively self-contained commuting and shopping unit. He reported the timber dependence of employment in each of these areas, which differed widely, exacerbated by a wood products recession in 1966. Wood manufacturing capacity and production were tallied for each area, and their log sources were arrayed by owner group. Thus it was possible to see that, for instance, only 2 percent of logs from the Mount Baker National Forest (northern Washington) went as far as Tacoma. This information was important to an understanding of industry concentration, competition, and timber dependence.[379]

The 1982 national timber situation report led Haynes, Connaughton, and Darius Adams into two papers on developing regional demand estimates for stumpage and projecting the estimates, in this case to 2030.[380]

In 1983 Connaughton and Haynes pursued the theoretical and analytical problem of estimating regional demand for national forest timber. Their abstract says:

> The first approach is to assume that the Regional demand curve for national forest stumpage is horizontal. The second is to assume that the national forest demand curve...has the same slope as for all ownerships. The third is to assume that the elasticity of demand [is the same for] all ownerships in a region.

The theoretical properties of the assumptions were discussed and an empirical example was shown. There were major differences among the three approaches.[381]

In 1986 Alex Obiya (Michigan State University), Chappelle, and Schallau noted that the central analytical core of forestry economics had been based largely on microeconomics; that is, economic matters facing individuals, firms, and other unitary decisionmakers. These matters did not typically have a geographic dimension. Regional analysis was emerging, and these analysts launched a compilation of spatial and regional analyses dealing with forestry, topics included here in mesoeconomics.[382]

Brooks did something about the need for a regional focus. In 1987 he developed SPATS (Southern pine age-class simulator), which was aimed at aggregates of stands (area by age class) and used a yield-table projection method. He included a probabilistic approach to anticipating future regeneration. It had a regional orientation that obscured its probable potential for use in other regions having relatively even-aged stands.[383]

Just as RPA needed and received from PNW a mechanism for integrating regional supplies with national demand, so the NFMA, with its mandate for forest-level planning, required integrating local supplies with regional demands. Somehow, each national forest must be able to determine the volumes of timber that will be sought at various price levels, under various circumstances in the economy at large, and net of supplies flowing into regional and local markets from nearby suppliers. Connaughton, Dave Jackson (University of Montana), and Gerard Majerus (Bureau of Land Management, Lewiston, Montana) developed a supply-demand model for this task and applied it to Montana in 1988. Using a single demand specification, they examined four alternative supply specifications.[384] In an extension of that work, they found that in three of four case-study Montana national forests, stumpage prices were correlated with regional supply and demand. They found useful relations between local quantity demanded and regional and subregional stumpage prices.[385] A means of gauging the precision and relative reliability of such estimates was offered by the same scientists in 1989.[386]

In 1989 Fight was involved in two commentaries on the evolving timber resource in the West. In one he, Fahey, and Briggs pointed out that the demise of Douglas-fir old growth was leaving the Northwest with little comparative advantage relative to other regions; indeed, there would be higher logging costs and longer transport to end-product buyers. Recovery studies were showing that an advantage in clear wood with narrow rings could be gained, however, via appropriate young-growth management. Whether this would be economically attractive depended on many factors, as discussed in earlier pruning publications. In the second paper, Fight argued for attention in regional timber supply studies to the character of wood as well as its volume. For interpreting timber assessments, he called for resolution of the myriad product grades into fewer, with assessment data and projections dealing in tree species and tree or log size classes.[387]

Modeling translocal forest economics usually involves modeling trans-stand forest behavior—projections of timber inventories that predict forest development and depletion. One result of the IIASA (International Institute for Applied Systems Analysis) program, discussed in “Including Europe and hardwoods in trade studies” section, below, was consideration of the elements of regional and country forestry that could be standardized and meshed with market models. Brooks, Haynes, Jeff Vincent (Harvard University), and Peter Cardellichio (University of Washington) pursued this subject in 1987 to 1990.[388]

Interregional and national market dynamics—The conceptual and empirical research at this broader level is almost synonymous with TAMM, the timber assessment market model, mentioned earlier. TAMM is a means to several ends. One cluster of them is RPA-related; therefore, much of the TAMM-based work is reported in that section (“Multiregional Analyses and the Long Reach of RPA,” above).

The clearcutting issue came to a head in 1975 with a federal court decision halting it in the Monongahela National Forest and all other Southern seaboard-state national forests. Timber sales came to a stop in that region, and because a similar suit stopped clear-cutting in Alaska, it was supposed that national forest harvesting, at least of the kind the Forest Service had known, would be halted nationally. Darius Adams, Darr, and Haynes addressed the matter of stumpage, lumber, and plywood prices over the next two decades. Projected impacts (gains for sellers) were 35 to 45 percent for stumpage and 15 to 20 percent for the products.[389] These estimates were based on an assumed reduction of national forest harvesting by half in the West, a fraction seen at the time as incredibly high by agency people and the forest industry. Little did they know what lay 15 years ahead!

The model also was used to estimate the economic welfare effects on consumers and producers, from the stump to product purchases, caused by national forest efforts to stabilize prices. Those efforts were part of the Ford administration's program to address inflation. In 1977 Darius Adams, Haynes, and Darr calculated changes in consumer and producer surplus, or their proxies in the cases of price-inelastic demand and supply, for situations in which stumpage or end product prices were held constant in the face of changing real supply and demand. Even in 1975 dollars, the numbers were in billions.[390]

In a THIS study published in 1977, Darius Adams, Haynes, and Darr worked through an example of a national forest harvest-flow change to show the relative significance of effects on consumers, timber processors, stumpage producers, government agencies, and trade. They noted regional differences and changes in asset values as well as cash flows. They argued that cost-benefit analyses should include, particularly, effects on consumers and estimation at the regional level.[391] Publication of this study caught the attention of Senator Herman Talmadge (Georgia), powerful chair of the Committee on Agriculture, Nutrition, and Forestry. The study revealed that increased national forest harvests in the West would reduce demand and prices for southern pine. Talmadge indicated to the Western Timber Association that he was in no rush to ease the strict national forest even-flow rules then (and now) in place via the NFMA.[392]

In 1977 Haynes examined the elasticity of price transmission between lumber and stumpage markets; that is, the proportional change in stumpage prices associated with a unit proportional change in product prices. He reported the implicit elasticities, and formulas used, in earlier studies. He found that transmission elasticities apparently were different between the South and West, which meant that a uniform change in national lumber prices would generate different absolute changes in regional stumpage prices. Haynes suggested a change in the lumber-stumpage price link method then in use in Forest Service projections.[393] Change occurred.

The merits of forest management depend, of course, on potential stumpage prices. The 1980 RPA assessment contained all-species average-price projections, by region. A challenge was to disaggregate the volume-weighted averages into projections for individual species. Haynes, Connaughton, and Darius Adams did this in two steps. First, past data were used to relate the price of each region's major species to the average. The next step was to relate prices of other species to those of the major species. Projections by species were then made by decade from 1980 to 2030.[394]

Another early application of TAMM was in 1982, after nondeclining even flow had been ordained for the national forests. Some slack was being considered for the system to allow modest harvest increases in early years provided the subsequent decrease would not push cutting below the calculated long-term, sustainable level. Darius Adams and Haynes considered four patterns of departure, three for the Douglas-fir region and one for the Rocky Mountains. They forecast effects on other timber sellers and forest product producers, within and beyond the departure regions, through 2000. They found small effects on consumers, as much as 20-percent reductions in the welfare (producer surplus) of producers (because of price reduction), and less surprising impacts elsewhere.[395] The slack was provided.

Price stabilization was still an issue when, in 1982, Darius Adams, Haynes, and others estimated the effects of private, rather than national forest, management intensities. They projected market consequences of constant private intensity and, alternatively, a world in which owners would undertake management investments returning 4 percent in real returns, after considering the long-term effects of those investments on prices and their feedback to future returns. The analysts concluded that prices could be leveled by the private sector after 2000 (20 years hence), which would eliminate softwood lumber imports after 2030 and expand the dominant role of southern regions in wood product markets.[396]

Kris Jackson analyzed effects of the Staggers Rail Act of 1980, which deregulated rail freight rates. For over a hundred years, rail rates had been the bane of Western lumber producers, affecting mill location decisions and interregional shifts, and encouraging "cargo mills" built close to tidewater to move wood products to the east coast by ship. Jackson examined whether the relative and absolute comparative advantage of U.S. supply regions changed materially after the act passed. Adams and Haynes had found no change in real rates from 1974 to 1981. Jackson found post-1980 changes for lumber and plywood on some major routes. Between the West and the Northeast, lumber and paper inflation-adjusted shipping costs continued an upward trend, but for plywood real rates turned downward.[397]

In 1988 Fred Cubbage (University of Georgia) and Haynes produced a considerable essay on market responses and government programs reacting to timber scarcity. Their conclusion is quoted in part:

> Studies of the responsiveness of stumpage markets generally indicate that price elasticities of supply and demand are quite unresponsive....[This] suggests that if significant declines in resources supplies (inventories) do occur, large real price increases are likely. These results are not particularly astounding, nor are they apt to change the attitudes of persons who either strongly oppose or favor public intervention in timber markets.
>
> ...if rising real prices and price volatility are not considered pernicious, there is no problem. If they are, there is.[398]

Also in 1988, Haynes, Fahey, and Fight produced price projections for Douglas-fir lumber.[399] No previous long-term projections had been done, yet they were important to silvicultural decisions. An all-species projection had been done to 2030 for the 1988 *The South's Fourth Forest* (see note 289). An assumed relation to that projection was used for an all-grade Douglas-fir projection. Next, the myriad fir grades were aggregated into seven clusters, each of which was then related to the all-grade projection via a group of cluster equations by using volume-weighted data from the previous 16 years. Prices were projected to rise 25 to 50 percent, depending on grade, by 2020 and then stabilize.

In 1989 Darius Adams and Haynes used national demand assumptions from the South's fourth forest report (see note 289) and emerging harvest data from individual national forest plans to estimate future total national forest harvests, both as planned and under an alternate scenario wherein one-fourth of the planned old-growth harvest would be halted by new forest reserves. This would be about 20 percent of the planned national forest cut in 2030, but only 3 percent of the total projected U.S. harvest. Nonetheless, it would generate significant regional effects, increased lumber imports, and less overall U.S. consumption of wood products.[400]

Claire Montgomery (then at University of Washington, now at Oregon State University), in 1989, devised a model from 1963-85 data for estimating future supply of and demand for housing at the national level. She made projections to 2040. She found demographics to be most important in explaining long-run demand, with rental prices and current sale prices useful in the short run.[401]

In 1989 Darius Adams and Haynes used TAMM to generate supply functions for stumpage in the U.S. West from 13 to 40 years of annual historical data. A multipart model was developed to predict stumpage prices (cut and bid) and sold volumes (cut and uncut) from national forest regions, with emphasis on the Douglas-fir region. Included was recognition of effects of nonnational forest timber supplies.[402]

Lumber price projections used in the 1992 pine pruning analysis by Fight and others, (and elsewhere), were published, as well as forecasts for west-side species and grades. Haynes and Fight used a method Haynes had used a decade earlier for stumpage, starting with all-species, all-grade regional-average RPA projections (this time from the 1989 timber assessment) and disaggregating them to individual species. This was done by decade to 2040. Premiums for ponderosa pine over other species on the east side were expected to continue, as was the 80-percent relation between hem-fir and Douglas-fir averages. The projections were complicated by a changing export market, which had been strong for lumber relative to logs but weakening overall. Prices were expected to rise gradually overall until about 2005 and then level out.[403]

Between 1967 and 1996, at least 21 market models pertinent to wood products were developed. In 1998 Darius Adams and Haynes classified them by the number of market levels treated, spatial contexts, and assumptions about future knowledge available to market participants. They then remarked on several decades of timber-trend studies in the United States, addressing whether such studies had changed forest policy. The answer appeared to be that policymaking had changed with the ability to consider price futures and deal with complex data interactions and myriad data sets.[404]

Global Forestry Issues and International Trade

At its simplest, international trade is domestic trade with an exchange rate, tariffs, and transport problems. But historically trade has never been simple, largely because of political and economic institutions on every side.

Wood products have been among America's oldest import and export goods. It holds true for the west coast and is well documented. In the 1700s, well before explorations by George Vancouver and Lewis and Clark or the Columbia River fur trade, logs went to Asia from Hawaii and California.

Strategic concerns and U.S. timber policy analyses—The Korean War of the 1950s and the world oil crisis of the early 1970s generated concerns about rapid and ample access to basic materials. "Materials policy" teams were established by the White House.[405] Analysts noticed that real prices of many key materials, including minerals and energy, supposedly stock resources with fixed supplies, had declined over time, while those for timber, a renewable resource, had risen. The seeming anomaly can be seen in retrospect arising from discoveries of new reserves and new extraction and processing technology. Better grades of timber were actually fixed in supply over periods of decades.[406] Wood products were not among a list of 75 critical materials identified for stockpiling by the federal government, although feathers and opium were.

Economic warfare was implicit in a "we will bury you" Soviet Union outburst of the time suggesting, say, a flooded world market for wood products. I joined a group of analysts that assessed the possibilities. Soviet destabilization and partial capture of world timber markets was considered feasible but could neither be done quickly nor was it apt to have high priority within the USSR, for several reasons.

The United States was never a dumper or a dumpee in wood products. Nonetheless economic independence has resonated with Americans at times, accompanied by tariffs and import quotas. Such "America first"-ism prevailed in the 1930s and immediately after World War II, for example.

In 1976, as part of the THIS enterprise, I examined the role of U.S. timber as a strategic resource. I identified four broad objectives: military security, including stockpiling and economic warfare; self-sufficiency; future economic welfare relative to the present; and U.S. long-term well-being relative to other nations. Each objective yielded several criteria against which alternative Forest Service timber harvest policies were judged.[407]

Isolationism was gradually overcome as better times arrived and the goodness of trade became apparent. Wanting imports, many Americans realized that we should export that which we could provide most efficiently and avoid beggaring other nations (via trade restraints) if they were potential customers for U.S. exports.

Log export issues and analyses—There was significant growth in log exports to Japan in the early 1960s, which was stimulated by a Northwest windstorm-driven supply shock and a Japanese economic surge. This led to a series of PNW studies on the status and future of the log trade, the likely consequences of various trade impediments, and the Northwest's economic welfare with and without log exports.

Japanese interest in Northwest logs was a surprise, a puzzle, and an opportunity. Surprising, because exports to Japan had traditionally been lumber, in modest volumes. Puzzling, because it was unclear how large the market would become, how long it would endure, and how it would affect the existing Northwest industry. Opportunity, in that it seemed to offer the first chance for commercial thinnings since the pulp industry had scorned roundwood for mill residues, and because some exporters were quietly but clearly making money.

Potential revenue impacts and redirection of timber flows were so large that log exporting became the focus of numerous congressional hearings, where arguments were intense but simplistic. Marketing work at PNW was quickly reoriented toward exports. Tom Adams, Beuter, and Hamilton were active in these studies; Darr became well-known for his extensive work on the subject. Information was collected and disseminated on the extent of the trade, the kinds of logs being sold, and their prices.

An immediate economic and political issue was the obvious fact that logs exported would not be processed in domestic mills. Federal and state laws were proposed to keep logs at home. The Station did several analyses showing that export produced more employment initially but efficiencies in log handling soon made export less demanding of labor than domestic milling. In 1965 Tom Adams and Hamilton published cost, price, and employment numbers for a typical log spectrum, which, because of the windstorm and domestic priorities, was largely hemlock at the time, mostly under 23 inches in diameter. Exporting paid more. Domestic processing used more labor, in the approximate ratio of 12 to 3 (labor in hours per thousand board feet, log scale, lumber manufacture versus loading for export).[408]

Darr revisited these figures in 1975.[409] Hemlock was still the major export log species. The labor ratio was now about 12 to 1, mainly because specialized log ships had come into use. Because of different market cycles between Japan and North America, exporting had been advantageous in only 2 of the previous 9 years.

Few forestry issues have been pressed more vigorously than the log-export matter, but with relatively narrow perspectives. Hamilton, Darr, and Haynes were alone in pointing out the complex interactions among intercountry log and lumber flows, showing directions of change in domestic product markets that would be caused by export restrictions, and making quantitative estimates of these effects. In 1971 Hamilton pointed out the limited relevance of standard trade and location theory to the domestic and overseas log markets. He enumerated the complexities and recounted the history of those markets in the 1960s, when exports had increased sixfold.[410]

Federal policy on log exports was proclaimed in 1968, with an embargo on all but a historical export level of logs from federal west coast forests. Oregon and Alaska imposed log export restrictions pertinent to state-owned lands. Washington considered and defeated the restriction.[411] Congress forbade all log and cant exports from federal lands in the West in 1973, and forever after. Two species, Port-Orford-cedar (*Chamaecyparis lawsoniana* [A. Murr.] Parl.) and Alaska-cedar (*C. nootkatensis* [D. Don] Spach), were exempted as surplus to domestic needs. The congressional action reflected high domestic timber and wood product prices, the result of uncommonly high construction activity in both the United States and Japan.[412]

Demand projections required an understanding of the market's structure in Japan, so studies were made of wood use there, especially in housing. Because Japanese imports were dominated by large trading companies, in 1969 Beuter pointed out a U.S. law (the Webb-Pomerene Act) permitting protection of multicompany consortia from antitrust problems.[413]

In 1976 Haynes looked into the possible effects of a log export ban on U.S. domestic stumpage and lumber prices under various assumptions about the degree to which offshore log customers shift to imports of lumber to replace logs. Depending on that response, U.S. domestic supplies would range between significant increase and significant decrease. He estimated lumber prices ranging from a 16-percent decline to a similar percentage of increase, with stumpage prices changing in the same directions by almost twice as much.[414]

In the same year, Darr looked not at the domestic market effects of a trade constraint but rather at the offshore market effects of domestic forest policy. Specifically, in a THIS study, he developed rationales, data, and techniques for tracing the impacts of national forest timber-flow changes on international wood products trade. He pointed out that the intermediate mechanism was wood product prices, here and abroad, with derivative effects on substitute and complement industries. He noted the complicating effects of trade barriers and floating exchange rates.[415]

In 1978-79 Darr surveyed wood products trade from four perspectives. He assembled a status report on the Japanese market for logs. He pointed out that Japanese demand might decline because they were expected to use less wood per house and to need fewer houses as replacements for quickly built post-War substandard homes. In the short run, though, the falling U.S. dollar, relative to the yen, was holding log exports up; they reached a record 3 billion board feet in 1978.[416] For wood fiber and pulp, he saw increased world demand and supply in the near term. Ten to twenty years hence, a shift to hardwood fiber was probable because of a softwood fiber supply decline. He was unsure of future prices but gave a conceptual framework for assessing price effects of supply and demand shifts.[417]

In general, trade had raised timber and wood chip prices in the Northwest over the previous decade. Although high prices were good for intensive forest management, it wasn't possible to quantify the link. Darr expected trade to slow in coming years for reasons of Japanese demand, but the Pacific Rim would become a bigger share of the Northwest's clientele as the South and Canada pressured midwestern and eastern U.S. markets.[418] Looking globally, he pointed to language barriers and differing business practices and product specifications as reasons why Americans concentrated on serving their own immense markets. Too, both product imports and log and chip exports impinged on domestic employment. He judged that world fiber-product markets had better growth prospects than did solid-wood outlets.[419]

Lindell, in 1978, provided a summary of log export restrictions affecting timber in nine western jurisdictions—federal, state, and provincial. Although varying in particulars, the general theme was prohibition of log exports. Manufacturing requirements generally involved cants and squares upwards of 8 inches in their smallest dimension.[420]

In 1979 Lindell summarized lumber market situations in the major producer and consumer countries: United States, Canada, Japan, Europe, Scandinavia, Europe, and the Soviet Union. The USSR, using more than all of North America, was the largest consumer of lumber. More lumber moved between Canada and the United States than between any other pair of supply and demand regions and accounted for one-third of world lumber trade. World lumber consumption was expected to increase by half between 1975 and 2000, a substantial increase but much less proportionately than that for fiber-based products, expected to grow to 2½ times the 1975 level.[421]

Controversy over log exporting had elevated the issue to senior administration levels by the early 1970s. In the next RPA assessment, the subject was designated for special study. Darr, in a major issue paper, addressed the question of the extent to which trade in raw logs should be controlled. At the time, U.S. log exports were about 3 billion board feet, equal to one-sixth of west coast harvests. Darr traced the history of the trade, the issue, and the main contenders. He addressed pros and cons of six options: increasing volume and species exceptions under present law, eliminating the substitution constraint (described below in this section), banning all substitution, returning to pre-1973 restrictions, eliminating all restrictions, and banning all west coast log exports.[422]

Lindell laid out the substitution issue in 1980. Export of federal logs had been forbidden, but logs from private lands still could go abroad. There emerged a zero-sum game within firms and the region as a whole: private-log exports grew as public logs were restrained. Substitution rules were imposed that forbade purchasers of federal timber from exporting both public and private logs; they had to choose between the two activities. Large companies with operations in several parts of the Northwest could export from one district and buy (and use or sell) federal logs in another, and there was a grandfather clause. Lindell's work helped establish how much timber could be grandfathered.[423]

In 1980 Darr, Haynes, and Darius Adams advanced four alternative hypotheses about the effects of halting softwood log exports altogether. They then traced these effects through the U.S. timber economy. Previous trade studies had dealt with U.S.-Canada-Japan interactions but not the network of impacts among U.S. regions. The authors also discussed the history of wood products trade after 1950 and world demand and supply areas. The three scenarios were a direct tradeoff between logs restrained and lumber export expanded: (1) no tradeoff—Japan would not substitute North American lumber for logs; (2) Japan would substitute Canadian but not U.S. lumber for the logs foregone; and (3) a mixed scenario in which Japan would fully offset with North American lumber, with half each from Canada and the United States but with no expansion of Northwest milling capacity.[424]

Darr noted in 1980 that Portland, Oregon's, chamber of commerce had, in 1936, objected to the export of Port-Orford-cedar, which demonstrated a long history of opposition by some to timber trade. Reflecting on some trade-limiting proposals, he suggested that proponents consider six questions: How much of the log volume that would have been exported would instead be processed? If more log volumes were processed, would the products be exported or sold domestically? If lumber exports increased, would milling occur in new or existing plants? Would reduced cash flows after an export ban be made up by other market options? By how much would Canadian lumber exports to the United States and Japan be affected by a ban? Would our restrictions provoke foreign constraints?[425]

Darr and Lindell composed a series of four 1980 articles on prospects for U.S. trade in timber products.[426] They cited general agreement by analysts that growth prospects were good, especially for fiber products, because of global expansion of income, population, and industrial activity. They asked, What does this mean for us in the United States? and suggested answers based on their work for the 1979 RPA assessment. They pointed to future prices as welfare determinants; prices were expected to increase in real terms. They expected a gradual decline in solid wood exports after 1990 owing to depletion of old-growth sawtimber in the Northwest, with slowly rising pulp, paper, and paperboard shipments. Strong U.S. markets would discourage exports. They listed 10 economic factors whose outcomes would determine U.S. trade prospects.

Michihiko Ueda (an economic consultant in Japan) was recruited by Darr to help analyze Japanese housing demand. They estimated population growth, headship rates, the number of households, and vacancy rates, from which they projected housing starts and wood consumed per housing unit from 1980 to 2000.[427] They saw Japanese housing activity leveling or even declining during the period.

The interplay of export and domestic markets, driven by sometimes different factors, had interested Darr and Haynes in 1976.[428] In 1981 Darr set up six hypotheses about price formation and tested it with 15 years of quarterly data. The premises involved various relations between domestic and export prices and volumes for lumber and plywood. The overall issue was whether strong demand overseas propels prices upward in the United States, and whether U.S. producers bounce in and out of export markets depending on how well they can sell at home, a point of complaint among foreign buyers. Darr found that U.S. market conditions did indeed affect exporting; demand shifts affected export markets for rough lumber, and supply shifts affected dressed lumber and plywood.[429]

In 1982 Darr went beyond earlier analyses of Pacific Rim wood trade by evaluating new land-use developments in Alaska, implications of water-borne imports from Canada, and the timber resource's rapid development in British Columbia and major policy evolution there.[430]

For the 1982 RPA timber situation report, Darr and Lindell wrote a chapter on international trade.[431] They covered U.S. trends in imports and exports, likely trends in world timber demand, and world forest land and timber resources, with emphasis on Canada, tropical hardwoods, and the Soviet Union. They also discussed tariffs and other barriers, transport costs, changing consumer preferences, and operations at the extensive margin, which were expected to continue. From this information they projected U.S. imports and exports of major wood product groups to 2030.

Despite the problems with log exporting, export markets for other wood products were of high interest in the 1970s and 80s. In 1983 Darr explained for a general audience how export promotion programs act, economically, to expand demand and the countervailing effects on prices driven by expanded supplies. He used the concept of excess supply and excess demand that he had elaborated in the six-hypotheses paper.[432]

With public interest in timber trade issues came analysts interested in modeling this dynamic sector, particularly as it affected U.S. domestic markets. A Canadian element was included in TAMM, described earlier. Darr found in 1983 that, in the United States, only a half-dozen analytical studies had examined wood trade, and then only with Canada and Japan. He noted that no major U.S. wood product trade flows could be considered bilateral; there were multiple trade trajectories. He was involved in building the TAMM supply-demand market component, and a separate simulation approach to other arcs. He became convinced that history-based models would not be very useful in evaluating the effects of alternative trade policies. He was concerned about the RPA need for trade projections a half-century ahead.[433]

In 1984 Darr did a background paper for the Secretary of Agriculture on wood products trade. He covered existing trade patterns; the mechanics of estimating market responses to elimination of tariff and nontariff barriers (using excess supply and demand and assumed or discovered price elasticities); barriers then existing, by country; probable responses of trade to removing barriers; marketing issues; and data needs. He was complimented by Tom Mills, then in the Washington office of the Forest Service and later PNW director, on his description of possible ways to analyze market interactions.[434]

Cubic measure, as in cubic feet and cubic meters, is for several reasons preferred to board feet in some transactions, especially abroad. Habit and understanding, as well as fear of being outmaneuvered in unfamiliar units, have kept most American traders attuned to board measure. Darr, in 1984, pointed out that measurement conversion matters can affect trade policies. Instances cited were volume comparisons of finished versus round wood trends in imports by Japan and comparisons of stumpage values in Canada with those of the United States. He pointed out that while a conversion can be precise for a piece or even a shipload of logs of known dimensions, a typical situation involves year-long or regionwide numbers for variegated pieces.[435]

Among the 1985 Haynes-Adams market simulations were four relating directly to trade.[436] Relative to the base scenario, they (with selected consequences) were (1) removal of federal log export restrictions (log exports expand 19 percent by 2000); (2) a 10-percent duty imposed on lumber from Canada (U.S. lumber prices rise 48 percent by 2000); (3) a 20-percent duty on Canadian lumber (U.S. lumber prices rise 54 percent by 2000); and (4) lumber and plywood exports double by 2030 and log exports are displaced by 2010 (U.S. lumber prices rise 42 percent by 2000).

Haynes and Darius Adams employed those and other simulations in addressing several other trade questions. They showed that a U.S. comparative advantage in wood products, via lower prices, could be increased by adopting all seemingly economic forest practices on private lands; however, that would take over two decades and perhaps half a century. They noted that import substitution (putting increased harvests into the domestic market to displace Canadian material), would do more for consumer welfare than exporting the increased supply. They also estimated that a 6-percent change in the value of the U.S. dollar relative to Canada's would change imports from Canada by 3 percent. They concluded that large percentage changes in solid-wood exports, whether lumber or logs, would have small percentage changes on the U.S. wood products economy, because U.S. domestic production and consumption is so large.[437]

In the 1980s, 80 percent of all solid wood shipped among Pacific Rim countries was in log form. With old-growth logs fading from the export supply mix, offshore log buyers were turning to two distinct classes of roundwood, here termed construction-grade (lower) and structural-grade (middle) portions of the log array produced in Pacific Rim countries. Some coauthors and I made separate trade projections for these classes, which extended over several years and two types of trade models. The results helped to explain the various log flows and price strata and to forecast their trends over one to two decades.

Using a simultaneous-equation model, Richard Vlosky and I, in 1986, developed separate supply and demand equations for each softwood-log exporting and importing Pacific Rim country involved in construction-grade log trade—nine nations altogether. These relations were then projected forward 5 and 10 years based on forecasts of such factors as exchange rates, economic growth, housing starts, timber production, and domestic consumption. Adjusted for shipping costs, these curves were aggregated to determine Pacific Rim-wide average prices and then decomposed to arrive at log flows from individual regions.[438]

The outlook for midgrade (structural or performance quality) log prices and flows around the Pacific Rim, as seen from Alaska, was pursued by McGinnis and me in 1989. Using the same methodology as for construction grades in 1986, we concluded that, by 2000, prices in Alaska would rise about 50 percent. This seems to have occurred, though not for all of the expected reasons, which included a robust Japanese economy.[439]

With record high prices for all softwood log grades, a broadening range of prices between low and high grades, and increasingly different supply and demand opportunities for premium versus lower grades, the need had expanded for grade-differentiated market forecasts. In projecting log trade to 2000 for each Pacific Rim country, Andrea Anderson, McGinnis, and I distinguished four trans-Pacific grade groups and projected prices and flows for the middle two. Prices of the upper middle grade were estimated to remain roughly stable while the lower grades would remain flat through the 1990s and then decline because of competition.[440]

That model was replaced in subsequent trade work by a more elegant simultaneous equation system. Multiple log grades were replaced by concurrent analyses of markets, at home and abroad, for Northwest lumber and logs. The first application was a 1989 assessment of two alternative trade policies being considered by Congress. One was to release for export all federal logs. The other policy was to embargo state-owned as well as federal logs. McGinnis and I looked at domestic and offshore effects of the proposals—prices, flows, and employment—separately for midgrade and construction-grade logs. The study covered three periods: one of confusion and uncertainty, one of speculation and pipeline filling, and the long term. Because of their abundance, price effects for lower grade logs were expected to be relatively small.[441] The state-log embargo was adopted.

By the late 1980s, timber exports had been a regular feature of trade from western North America for 150 years. Involved now were several hundred specialized ships, billions of dollars of annual transactions, and a distinctive and highly competitive industry structure. Although the rate of increase of total Pacific Basin softwood log movements seemed to have declined, the trend remained upward and average log prices were increasing much faster than inflation. In 1991 Anderson, McGinnis, and I reported on the emerging scale and structure of the trade; species preferences, prices, and the export premium; demand and supply determinants; and seasonality and reaction times.[442]

After mid-1990, economies of the Pacific Rim in general, and the U.S. timber industry in particular, moved downward. By early 1991, building activity in the United States reached its lowest level in a decade, and construction in Japan had reversed an upward trend. The four-sector model was used to gauge the effects, individually and collectively, of the new state-log embargo, spotted owl conservation, federal forest replanning for other reasons, and the recession. A 1991 analysis involved the near and long terms, logs and lumber, the Northwest and the Pacific Rim, production and exports, prices and volumes. Together, those events were predicted to reduce harvests by one-fourth and log exports by a third. Log and export lumber prices were forecast to double, with lumber prices in domestic markets rising by about one-eighth. It was estimated that conservation for the spotted owl would account for over two-thirds of the rise in log and lumber prices relative to 1990.[443]

The export premium got specific treatment in a 1993 assessment. For as long as logs had been exported from the Northwest, they were worth more at the dockside than delivered to the tidewater mill down the street. Five reasons given for the difference were the inconvenience of trade, the extra "haul and hassle" in log preparation and sorting, quality, continuity in export arrangements, and export embargoes. It was noted that logs of lower quality did not seem to carry a premium, that price premiums differed greatly year-to-year, and that trade policy changes typically affected the export premium more, proportionately, than they affected export volumes.[444] This study figured in preparations for negotiating with Canada the issue of their lumber exports to the United States.

For Northwest accountants involved in timber, I reviewed in 1993 the export situation and its reverberations in the face of export restraints and the owl situation. I estimated the effects of a 10-percent tax on exports, under discussion in Congress at the time. I showed that even if all log and lumber exports were halted, the volume saved would barely offset the harvest reductions indicated in the Northwest Forest Plan. Export response from New Zealand was predicted to be considerable, and from Russia, potentially large but not soon.[445]

In 1994, for faculty economists at Oregon State University, I compared various trade models. I rationalized the love affair of analysts with own and cross-price elasticities and how inconstant they can be. I cited "tricky math" approaches that use short-term models to simulate long-term responses, but these approaches overlook the fact that nothing lasts forever, and little lasts for very long.[446]

Some studies were done from the vantage point of other trading nations looking at North America and elsewhere. Brooks, Haynes, Lane, and I used that perspective in analyses for Taiwan, Korea, Japan, and eastern Russia in the early 1990s.[447]

With the help of our Canadian friends: import issues and studies—Between 1969 and 1973, annual U.S. log exports grew almost 40 percent. So had imports of lumber, mostly from Canada. Pertinent to the Canadian lumber import issue was the Jones Act, passed in 1920 to protect the U.S. maritime industry, including shipbuilding. It required that intercoastal shipments be made in vessels built, owned, and operated by Americans. It had had the perverse effect of driving intercoastal shipments to rail and giving waterborne lumber shipments to the U.S. east coast from British Columbia an edge over those from Puget Sound. Or so it was supposed in arguments before the U.S. Congress in 1975. Austin and Darr looked into the arguments and noted that, given that Canadian lumber mostly traveled by rail and appeared to be produced more cheaply, the act might not be making much difference.[448]

In 1975, amid the policy flux at state and federal levels, concern about protecting jobs and old growth from export, and debate about protecting jobs from imports, Darr arrayed policy options that might be undertaken and explained their consequences, including some effects that had not had public discussion. He concluded that almost any option to change the pattern of U.S. forest products trade would be constrained by other national objectives.[449]

In 1980 Darius Adams and Haynes examined the U.S. effects of administered impediments to lumber imports from Canada, were they to be imposed. They concluded that Canada was the most price-elastic source of U.S. lumber supply: as prices changed, shipments from Canada had been the most responsive in percentage terms (and perhaps in absolute terms relative to TAMM's other source regions). Using TAMM they looked at two possibilities: a 15-percent import tariff, and an import quota equal to recent levels. They concluded that lumber consumption would decline under either barrier, and stumpage prices would rise across the country. Private harvests would increase. In terms of price-times-quantity, U.S. producer gains would exceed consumer losses in the lumber market, but this would be offset somewhat in other wood product sectors.[450]

The Jones Act was revisited in 1986 by Kris Jackson and Charles McKetta (University of Idaho). They pursued three objectives: determine the differences between freight rates for equivalent vessels under U.S. and foreign flags, pertinent to Alaska; estimate the effect of Jones Act rate differences on the directions of trade; and estimate act-caused monetary losses to Alaskans and their customers. They concluded that removing the act would have a small effect in Alaska, but more impact in the Puget Sound area.[451] The Jones Act was still being pressed as an issue at the end of the 20th century.

Economists from PNW have backstopped their Forest Service Washington office counterparts at times during trade expansion, tariff, and quota negotiations. These can be delicate events for federal scientists as they deal with an administration position on one hand and maintaining the researcher's role of detachment and full disclosure on the other. I participated, in a background context, in 1995 softwood lumber trade talks between Canada and the United States, which included a formal briefing for both sides.[452] This was but one instance of PNW's counsel on the Canadian-lumber trade matter, an issue that outlived the 20th century, as Canada's share of the U.S. lumber market moved steadily from about 17 percent in the early 1970s to 35 percent by 2000.

Including Europe and hardwoods in trade studies—Europe became a factor in PNW's trade research in 1979 when the IIASA, a multination policy research group centered in Austria, proposed a group of studies of the world's timber and wood products economy, together called the Forest Sector Project. The United States, a member of IIASA, made available Haynes' TAMM model. But it had been built to deal with U.S. regions for RPA and other broad resource reviews. There also was considerable interest in the states in trade questions that might be addressed with, and would be hard to address without, a model having more than a Pacific Rim perspective.

It was decided that individual country teams would build national models, to be linked by a necessarily flexible global model. By 1983 three potential prototypes were available for the nation-level models, one of them TAMM. Haynes and Brooks were on the U.S. team. They worked out goals for the U.S. segment and described their experience with forest sector models.[453] Brooks became involved with building tariffs into the solution mechanism and, especially, modeling resource dynamics for the country models.

Work on the linking model led IIASA to abandon the consensual approach and adopt a mandated framework for the country models. The final product, a policy-assessment model called the global trade model (GTM) has been described as partly a trade model, with relative costs determining competitive advantage and relative prices determining trade flows; but the array of national and linking models is more a simulator of the forest sector than a trade analyzer. According to Brooks, "Trade analysis is neither the focus nor the central contribution of these models."[454]

The Forest Sector Project work ended in 1985; however, PNW's global trade modeling continued, with Brooks's development of the world assessment market model (WAMM), a TAMM-like mechanism intended for use in the then upcoming 1989 RPA timber assessment.[455] The magnitude of the job and limited resources hindered WAMM development; however, Brooks and Kincaid developed REACTT, an improvement on the reactive programming method that had been used for interregional equilibrium modeling of commodity supply and demand, to maximize the sum of producer and consumer surpluses.[456]

In 1992 and 1993, Haynes and others had reported on models considered at a satellite meeting of the 10th World Forestry Congress and at a University of Washington symposium.[457] Haynes suggested that, whatever its complexity, a modeling effort requires advocacy by decisionmakers.

With the winding down of the IIASA venture, the center of gravity for global timber studies shifted from Austria to Geneva. There the European timber trends studies (ETTS), a series of timber outlook analyses, was conducted. It was supported by two United Nations agencies, the Economic Commission for Europe and the Food and Agriculture Organization. Modeling was a strong feature of ETTS.

Each ETTS cycle drew on technical input from member countries, and Brooks was invited into the loop. He was involved in two underlying working papers. One, with Anders Baudin (Umea University, Umea, Sweden) and Peter Schwarzbauer (Universitat für Vodenkulture, Vienna), laid out the modeling work dealing with the relation between consumption and production of forest products and various driving factors. For each of nine European countries, import and domestically sourced consumption and production for domestic use and export were estimated from prices, gross domestic product, and relative currency values where appropriate. Given the solved-for coefficients (elasticities in this model), projections were made for each of a score of European countries to 2020 for three gross national product (end-use-index) trajectories. For most product groups, the projections tended along tracks moving smoothly upward at rates not very different from experience since 1965.[458]

The Station's ties to ETTS were useful in at least two ways. They provided an outlet for PNW's considerable multiregion modeling skills, thereby enhancing Europeans' modeling portfolio. And they also gave PNW trade analysts an excellent window on prospects for wood exports from Europe to Pacific Asia, a growing trade channel that was surprising to both the Asians and Europe's competitors.

After ETTS V, Brooks drew conclusions about promising lines of future quantitative market research, aimed at projections of demand on European forests. He suggested more work on the supply side, including recognition of inventory changes, and extended substitution considerations, including improved price data. Expansion of the timber trends studies to the transition countries of eastern Europe was seen as desirable but still quite difficult.[459]

In 1996 Alig and Darius Adams followed up on Haynes' 1992-93 review of large-area models with a discussion of those in use in the United States: TAMM, FASOM, and others.[460]

Meanwhile, Brooks joined a working group of the United Nations Food and Agriculture Organization concerned with data for timber supply studies. The working group also dealt in kinds of data. Data on nontimber forest commodities, timber-based manufactures, indicators of forest sustainability and management, and capital inputs were suggested by Brooks. Despite the increasing complexity of forest issues and information needs, he warned against letting the desire to be complete override established standards for accuracy.[461]

Most U.S. timber-trade policy issues and commercial questions have involved softwoods moving between countries facing the Pacific Ocean; however, post-World War II America imported significant volumes of hardwoods, especially "mahogany," a catch-all name for various Asian species whose wood had similar appearance. Veneers and plywood from various tropical countries and supplies of preferred species were in decline from the start. Further, as Brooks pointed out in 1993, domestic demand in tropical countries was growing steadily, with the likely prospect that they would become net importers within a couple of decades, partly because the kinds of wood needed in the course of development could be different from domestic stocks.[462]

For centuries, Japan was a primary importer of tropical woods, which mostly were used domestically. In the 20th century before World War II, Japan's role grew as an importer of logs and flitches (lengthwise cuts of a tree trunk) for reexport as furniture and other manufactured goods. After the War, that trend continued, not for lack of domestic demand but rather because of the desperate shortage of foreign exchange. As the economic tide turned for Japan, with higher labor costs at home, hardwood product manufacture gradually moved offshore, toward the raw material source countries, especially for plywood and knocked-down furniture, both easily shipped to Japan, Europe, and America.

Brooks pointed out that Canada and the United States have been relatively small participants in tropical timber markets, although in 1990 their imports of tropical logs, sawn wood, veneer, and plywood totalled nearly US$ 600 million. Pulp and paper added another US$ 400 million.[463]

Meanwhile, Brooks found, more than 80 percent of the estimated harvest from tropical forests was used for fuel, an amount that exceeded total industrial timber production in developed countries.

In 1994 Brooks applied to tropical hardwood plywood a relatively simple import demand model that Anders Baudin and he had used previously for European forest products. The plywood application was to the United States, and it worked well.[464]

Environmental effects of trade—Restrictions on log exports often were supported on behalf of the environment. Not only would old growth be spared but so would visual and aquatic impacts of clearcutting, habitat changes, and the like. Even after allowing for the partial export substitution of lumber for logs (whose estimation generated several PNW studies), there was apt to be more environmental gain than loss. Overseas, though, the sequence was expected to be different, with former users of U.S. softwood logs shifting to other roundwood sources as well as lumber from other countries. What might be the extent of substitution abroad? Were we simply exporting environmental impacts? If so, what were the time lags and the degrees of substitution? Were buyers and sellers responding to U.S.-induced price signals, to customs and traditions, or both?

In 1995 Brooks reasoned that declining softwood log exports from the Northwest, caused by reduced harvests and embargoes on log exports, might induce increased harvests in the Russian Far East and possibly cause environmental harm there in a zero-sum tradeoff for reduced impacts here. He suggested that Russian impacts might in fact be quite large, given the relatively large acreage of logging required there to recover a given timber volume as well as slow rates of regrowth. He recited reasons not to rush to judgment, however, about export of environmental damage, including my finding (see note 441) that as Northwest harvests declined, not all of the decreased U.S. exports would be replaced overseas by substitute sources.[465]

David Tomberlin (University of Wisconsin), Buongiorno, and Brooks revisited the subject in 1998 and concluded that global environmental effects of log export restrictions could well be small given the Northwest's small preembargo exports relative to world log consumption and the availability of end-use substitutes. This view contrasted with opinions of some other analysts, but Brooks and his companions pointed out that even though economic theory could deal with the subject, data and experience were scant. And the same was true for the reverse effects: impacts of environmental policies on trade.[466]

In 1999 Brooks participated in U.S. preparations for a round of accelerated tariff liberalization, in which forest products were one of nine industries covered. The U.S. intent was to reduce its forest product import tariffs by almost half, from an average of 3.1 to 1.8 percent. Brooks led an assessment of global economic and environmental effects that might follow from the reductions. Effects were expected to be small in all respects, with an increase in world trade in forest products of 2 percent. There would be no effect on overall U.S. timber harvest, a 0.5-percent increase elsewhere (although as much as 11 percent in certain countries), and an increase in world trade in forest products by 2 percent. Assuming that environmental impacts would be linked to harvests, with some shifting to plantation forestry via conversion of natural forests, barren lands, or farmland, ecologic effects would be felt accordingly. Harvesting also would decline in some countries.[467]

Substitution overseas for traditional products—Meanwhile in 1994, Roger Sedjo, Clark Wiseman (both with Resources for the Future, Washington, DC), Brooks, and Ken Lyon (Utah State University) sent an emissary to Japan to discuss with manufacturers and importers their willingness to change their national wood sources in response to price. For plywood—a key product—shifting sources would mean installing veneer peeling and plywood fabrication mills in Japan for logs from temperate climates, a significant matter. Bringing in softwood plywood already manufactured would mean accepting North American standards. Vincent, Brooks, and Alamgir Gandapur (Harvard University) had discovered, in 1990 and 1991, that saw logs from North America, Russia, and the South Pacific had seemingly been price-competitive substitutes for each other in Japan.[468] Separately, I had found that U.S. spruce-pine-fir and Russian softwood logs had been moving easily into Japanese mills for both veneer and lumber. The Vincent group confirmed this observation with calculated cross-elasticities (percentages of change in Japanese imports from a non-U.S. source relative to a 1–percent change in U.S. log prices). As theory and market movements had suggested, price differentials made a difference.[469]

There was more to substitution for tropical hardwoods, however. Analysts of the time apparently viewed with wonder the ease with which wood product makers and vendors could move among materials and sources, far faster than did consumers. Brooks enumerated four substitution venues: material for material, capital for material, quality for material, and product for product. To save tropical hardwoods, substitution of all these kinds might be relevant. For instance, in the U.S. market, the share of tropical lumber decreased from 15 to 10 percent in 10 years after 1980. In Japan, medium-density fiberboard and oriented strand board were cited as potential substitutes for plywood, as they had been in the United States. Brooks found numerous instances of increasing real prices for tropical hardwoods and their products. That these rates exceeded those for competitor products was apparent but not yet proven.[470]

Brooks proved it for U.S. imports of hardwood plywood. Econometrically he found a strong relation between import volumes and independent variables reflecting the unit value of those imports, the price of domestic hardwood plywood and related products, and levels of activity in end uses (construction, all manufacturing production, and furniture production).[471]

In 1997-98, the Asian economic crisis drew Brooks into a forest outlook study for the Asia-Pacific region, including projections to 2010. The immediate concern was to understand and forecast macroeconomic circumstances, a challenge that eluded the International Monetary Fund, the World Bank, and even Harvard economists, who were heavily concerned with monetary policy. The Asia-Pacific Forestry Commission of Food and Agriculture Organization of the United Nations took a broader, longer term, more sanguine look. Indeed, they expressed concern about pending prosperity-based expansion of farmland into forests, growth in forest manufactures, and implications for sustainable forest management.[472]

Currency exchange rates—Ever since the dollar was floated in 1973, there had been controversy about exchange rates: Were they too volatile? Should they be re-tied to gold? Was the U.S. role as central banker to the world a good thing? Should U.S. policy make exchange rate stability a primary or at least a high priority, or should it let the dollar wander? What level of the dollar was too high or too low? Indeed, how should the dollar's value be measured internationally?

Throughout the early log export debates, the United States was shipping gold from Fort Knox to other countries to offset our negative balance of payments. We were importing more goods, services, and capital than we were exporting. To save the gold, the United States went off the gold standard in 1971 and then floated the dollar, letting its value go where it would relative to other currencies (with periodic attempts to nudge the system). For reasons that require a textbook, concerns about the value of the dollar would replace worries about the balance of payments. Enhancing the balance of payments became irrelevant as an argument for selling logs overseas or curtailing lumber imports. Protecting the value of the dollar was the logical replacement argument, but many in the Nation wanted a low-valued dollar to encourage exports of their products. Darr explained all this in more detail in 1977.[473]

In 1985 McCarl (Oregon State University) and Haynes discussed three-way currency exchange rates between Japan, Canada, and the United States.[474] At the time there were U.S. claims that Canadian stumpage prices were lower than those in the United States and that this allowed Canada to penetrate the U.S. lumber market. During the period of penetration, however, the value of the Canadian dollar fell, which in itself made Canadian lumber cheaper. Similarly, Canadian rail rates that seemed unduly low may have been only partly responsible for lumber movements southward. Because the yen grew stronger against the U.S. dollar while the Canadian dollar declined, Canada gained a particular trade advantage with Japan during the study period, 1975 to 1983.

It is easy to trivialize currency questions as seen from the U.S. timber sector. Whether dollar export prices reflect, say, a low yen price and a high exchange rate, or a high yen price and low exchange rate, should be a matter of indifference. But it is not. For one thing, with their relatively great weight and bulk per unit of value, wood products move ponderously from stump to trade partner. When prices are contracted in advance, currency changes in 3 to 6 months of the life of a forest product can seriously help or hurt the contract's holders.

In 1995 I reiterated this and other currency matters affecting wood products vendors and buyers dealing with Japan and Canada and included a description of five distinct periods of exchange rate behavior since 1974.[475]

Forest sustainability abroad: means, ends, and economics—In a new departure for U.S. forest policy, concern has emerged for the sustainability of overseas forests and wood supplies. This is a critical matter for much of the world, if only because half of global wood consumption is for firewood.

The forest sustainability issue suggests a reprise of the conservation conversations of a century ago, or the even-flow, sustained-yield technical issues addressed at PNW in the 1960s. In the 1990s, it was more the former but moving toward the latter. Yet it was a decade in which, like "community stability," "forest sustainability" suffered for lack of tight definition and thereby was diluted and perhaps squandered as a public and technical concern.

Brooks pointed out this problem:

> Finally [following a review of global timber supply and demand studies], it is important to recognize that any operational definition of sustainability will be a result of public choice based on an expression of values. Although there is necessarily a biophysical component to the choices, and some choices are neither sensible nor likely to endure, biophysical information is not sufficient to determine, for example, whether forests are "sustainably managed."[476]

In 1992 Brooks and Gordon Grant proposed principles to guide "new" forestry, presumably of the sustainable sort, that (lightly paraphrased) called for staying flexible while honoring whole ecosystems, at various and adjustable geographic and time scales, involving a full range of forest users, and dealing with cumulative effects, resilience, site productivity, and population viability.[477]

Later that year, Brooks reinforced his principles, this time for forest modeling: spatial scales larger than stands, time scales longer than one rotation, distance bounds dictated by biology and geography (not county or state lines), and multioutput management objectives. He criticized extant models that literally offered to cover the world but which maximized present value of a single, commodity product. He avoided any definition of sustainable forestry but submitted that models of sustainable forest ecosystems are policy models by definition.[478]

Forestry journals stirred to deal with the definition issue.[479] Meanwhile, a consortium of international economists (Brooks, Heikki Pajuoja [Finnish Forest Research Institute, Helsinki], Tim Peck, Birger Solberg [both at Ureeofian Forest Institute, Joensuu, Finland], and Phil Wardle [retired from United Nations Food and Agriculture Organization, Rome]) assessed projections of global wood consumption, production, and trade to distinguish among developed and developing country groups. They concluded that prime movers of supply and demand would continue to be population, economic growth, technologic growth, institutions, policies, and prices. A key part of their projections to 2050 was per capita consumption of, separately, fuelwood and industrial roundwood, both functions of per capita income and price. Alternative scenarios produced similar projections for fuelwood but broad differences for industrial wood. Production was modeled separately and was somewhat better "behaved." They examined analytically the sources of uncertainty in such projections. Overall, they foresaw relatively static consumption of fuelwood and a slower rate of growth in industrial wood, despite a doubled population.[480]

Their implications for sustainable forests were necessarily general. Absent a universally accepted definition of *sustainability*, the analysts chose to use it broadly in its socio-economic and environmental sense rather than as even flow of trees. Given the multitude of uncertainties about the future, they recommended adaptive management—the frequent resetting of management strategies. They liked genetic and biologic diversity, consideration of costs and options, flexible forestry, and somehow adapting to population growth, probably by foregoing some features of sustainment in some places and doing something about firewood supply. Agroforestry (plantations and tree farms), especially in regions of fast growth, might be a means of taking pressure off natural forests and sustaining rural society. Aggravated deforestation should be stopped and that might well occur, with extensive agriculture concentrating on good sites and trees returning to the marginal lands. They saw the dichotomy between dominant-use and multiple-use management, with different forest functions separated spatially or combined on the same area, as a growing issue not easily resolved.

In 1993 I addressed Pacific Rim forest sustainability in terms of venerability, viability, vastness, variety, vagrance (resource mobility), value (enemy or friend of sustainability), veneration, and vista. Vista was my view that forested lands are so incredibly vast, so variegated, and so vigorous that I was optimistic, both for 1993 and the long term.[481]

Some economists suggested that American imperialism should be brought to bear on nations and organizations whose forestry practices were not in accord with U.S. preferences: If burning forests in Brazil were putting smoke in our eyes, we should add a mote to theirs. So, in the 1980s and 1990s, the issue of environmental equity and ethics went international. For this matter, Peter List (Oregon State University) and Brooks raised the likelihood that the land-ethical standards as held by people around the world might differ and if so, they wondered, whose standards should prevail? They also raised questions about intergenerational equity; differing social, economic, and ecological effects of broad-stroke actions in different places; and unintended consequences of "isolating wood as a material, or the forest industry as a business, apart from other forms of economic activity or consumption...."[482]

Most Wanted, Least Acknowledged: PNW's Economic Data

Collection of forest economic data for internal studies and dissemination of compilations to the world at large have been a part of PNW's program since the 1920s. Methods have ranged from forest inventories to searches of foreign-language publications.

The "quarterly report"—The most demanded publication issued by PNW has been our "quarterly report," formally titled "Production, Prices, Employment, and Trade in Northwest Forest Industries." Started in 1963 as an adjunct to the Station's marketing research, it became so useful to so many research clients that PNW was unsuccessful in ending it (reasons for ending it have been its cost and its not being seen as pure research). Valued both for its current data and its consistent long series, the report involves hundreds of data elements each quarter. The data content has expanded steadily. In 22 pages, the first issues had 11 tables on log production, stumpage prices, harvest volumes, and allowable cut with some summarizing text. By 1997, there were 130 pages with 106 detailed tables.

The compilers and summarizers have been as follows:

Tom Adams, 1963-64

Tom Hamilton, 1964-68

John Austin, 1968-70

David Darr, 1970-72

Ed Holt, 1972-74

Florence Ruderman, 1974-85

Debra Warren, 1985-

Special compilations—Occasionally the Station's economists assembled and published special data sets that had wide usefulness. These have included stand treatment and harvesting costs, historical log and lumber prices, and shipping costs.

The larger timber assessments carried compendia of forest resource data that were unique assemblages and therefore widely sought and used. In addition, data specific to the regional composites, economic strata, and forest types appropriate to the TAMM work were assembled. Those that were published are mentioned here. What can never be fully described is the effort that went into both kinds of compilations, involving scores of people and months of time.

In 1968, 1970, and 1974, Tom Adams published data on log prices for the west side.[483]

Monthly national forest stumpage prices for 1975 through 1989 and volumes sold were collected by Haynes in 1991 for the east and west sides of Oregon and Washington. The report included an assessment of whether the data would be much different if it were "deseasonalized." The answer was negative. In 1998 Haynes repeated the data venture for quarterly data and included volumes cut, for 1984 to 1996. These data also were arrayed by species.[484] The data were assembled to stratify the regional average data that PNW had published in the quarterly report since 1963.

North American data on production, consumption, and prices of softwood products were published in 1979 by Darius Adams, Haynes, Tom Mills (then at the Riverside, California, Fire Laboratory), David Shearer, and Steven Childress (both at Oregon State). The figures were for regions corresponding to those used in the assessment analyses for 1950 through 1976.[485]

That information was updated in 1988 by Darius Adams, Jackson, and Haynes. The data period this time was 1950-85.[486]

In 1986 Haynes published data on the inventory and value of old-growth timber in the Douglas-fir region. This was done by age class and owner. It suggested that, around 1980, about 30 percent of west-side timberland had mature timber, defined as beyond culmination of m.a.i. Its value was half again as high as that of second growth.[487]

Florence Ruderman and Haynes published volume and stumpage prices, by species, for Northwest national forests, in 1986. The data period was 1973 to 1984.[488] Haynes and Debra Warren extended that report in 1989. The new data set was for 1974 to 87.[489]

In 1989 Waddell and others published comprehensive tables of forest statistics for the United States for 1987.[490]

Hardwood log price data for the Northwest, for 1980 through 1991, by month and region within each state, was published by Sohngen and Haynes in 1994. Data received from mills directly and via commercial reporting services were compared analytically with prices from Oregon and Washington state forestry agencies and found to be reasonably consistent.[491]

Not all the data collections for RPA timber assessments were published. An example is the work of John Mills for the 1989 and 1993 assessments. The effort and people involved are only partly traceable now.

On a broader scale, in 1995 Brooks assembled global data on temperate forests and timber trade (in publications mentioned later, he did the same for tropical forests). The occasion was the International Northern Forests Organization Project, centered at the University of Washington Northwest Policy Center. Underlying the project was concern that, at the time, most activity in environmental policy vis-a-vis forest development and trade concentrated on tropical regions, while temperate regions were largely ignored. Yet nontropical forest regions covered 36 percent more land area and generated nine times the amount of trade in wood products.

Brooks noted that forests cover one-third of Earth's land area and that the United States is the world's leading importer of forest products and is second to Canada as an exporter. Over the previous 40 years, though, U.S. exports of forest products grew more rapidly than imports and were nearly equal to imports value-wise in 1992. Perhaps surprisingly, tropical countries as a whole imported more wood products from the United States than they sent us. Exports of floral greens from the west coast of North America were worth $130 million in 1989, a large number until one considers that cork exports from Portugal were valued at $550 million. Brooks observed that the U.S. forest products economy, although small relative to the Nation's total activity, is significant globally. The United States leads the world in production and consumption of forest products.[492]

The high U.S. production and consumption rates are one reason why Chmelik, Brooks, and Haynes assembled U.S. trade data for forest products for 1978 through 1987. They identified relatively narrow product groupings, individual source and destination countries, and clusters of U.S. customs districts. Forest products accounted for about 3 percent of U.S. merchandise trade. The United States accounted for about 20 percent of world imports and more than 10 percent of world exports of forest products. We were an important market or supplier for almost every country involved in forest products trade.[493]

Among the unsung heroes of the Station have been those in forest survey (renamed Forest Inventory and Analysis [FIA] and then Pacific Resource Inventory, Monitoring, and Evaluation [PRIME], now currently FIA) who have made innumerable special data compilations for the economists. FIA's data are a substantial, largely untapped store of information of which FIA analysts are fully cognizant but, with limited staff, they cannot fully utilize. Nonetheless, Bolsinger, Gedney, Oswald, Wall, and their predecessors have added greatly to the understanding of the Pacific coast's forest economy.

Monitoring multiple forest resources—As professional and public interest moved from trees to whole ecosystems, so did the focus of forest survey. With much of the Alaska mystique founded on its supposedly immense wildlife resources on its certainly immense scenic lands, PNW analysts have been drawn into evaluations of these resources. The Alaska inventory unit was the first in the Nation to inventory nontimber resources. This pioneering work in classifying and aggregating resource opportunities produced techniques that were used outside Alaska. It was an example of just-in-time research; actually, just ahead of time. The analysts were disappointed by the absence of a clientele for their information, which pertained to lands outside the national forests.

Addressing multiresource inventories, Bob Buckman (then the PNW Director) and Fight said flatly in 1974 that there are resource decisions, notably those bringing gain to a few and spreading cost among many, that would not be affected by better inventory data. Data are important to more balanced conflicts, however, where seeing tradeoffs is useful. They observed that descriptions of tradeoffs involve three different subjects, each involving a different field of expertise: the social values of alternative products, the mix and timing of those products, and the resources available to produce them.[494]

By the 1990s, the need for habitat information was acute. This went beyond areas specific to owls and salmon-supporting streamsides. Resource planning was becoming more localized, but it also was being done at scales beyond even the size of a national forest, which were themselves being merged. Decisions about, planning for, and economic analyses of activities such as wildlife habitat management, prescribed burning, and scarce-species recovery were occurring at the trans-state level. Questions concerned not only current status; they included directions and rates of change in vegetation and land use. Meanwhile, budgets barely budged. An example was work in the South on forage and wildlife outputs in concert with timber, for the Southern timber supply study, done in the late 1980s. There was a question as to whether whole new multioutput models should be built versus using existing models such as TAMM and ATLAS and adding to them collateral models for, for instance, forage or ecological effects of climate change. Linda Joyce (Rocky Mountain Research Station, Fort Collins) and Haynes pursued the latter, linked-model approach in two case studies, with results that presumably satisfied the analysts.[495]

The 1988-90 inventory of western Washington's forest resources, conducted by PNW's inventory staff,[496] collected over 150 plot variables, from which a wildlife resource data set was derived.[497] Alig, Darius Adams, and Marco Boscolo (University of Washington) defined a habitat suitability index based on plant communities and stand conditions. For a range of wildlife species (10 birds and 14 mammals), they developed specific indexes driven by three life requisites: breeding, forage, and resting (or cover). They assembled an array of models to exploit this data by using John Mills's ATLAS as a core.[498]

In 1992 the Forest Service nationally began looking at an annual (rather than roughly decennial) inventory cycle.[499] In 1998 Congress decided the issue by mandating that one-fifth of inventory plots were to be visited annually in each state, so that data sets no more than 5 years old would be available. Assuming the number of plots per state did not change, this amounted to doubling the inventory work relative to a 10-year cycle.

This was arguably the biggest change to inventory since double sampling, by using air photos, began 55 years before. On the west coast, the procedure had been to move through ground plots, whose number was determined by prescribed precision standards, state by state until the region was completed. The pace was determined by funding, which declined in real terms, so that instead of a 10-year cycle, it gradually moved closer to 20. A state might require several years and then not be revisited for 15 years. The precision was good but ephemeral. In a fast-changing forest world, users of this sole source of uniform, statewide data were frustrated; hence, the legislation.

The mandate has been interpreted to require an annual update in each state, implying visits to plots across every state yearly, but different ones each year, rather than starting in one corner and marching across. Whether erratic numbers will appear is still unknown. Indeed, whether the faster pace will be funded is not yet clear.

Afterword

No one now living has been party to the entire 70-year track of PNW's economics research, the technical possibilities and policy issues that drove it, and the tumult of depression, war, and social change that churned in the background.

This chronicle does not portray a seamless flow of interconnected studies building toward a series of research triumphs. Rather, as in the history of science generally, a mixture of curiosity, advances in economic theory and technique, and imperatives driven by policy issues have shaped a program that may appear diverse, even erratic, but never aimless. During eight decades of economics research, virtually every technical notion covered in any forest economics textbook has been employed, if not developed at the Station. Almost every policy issue with economic content—and most have some—has been analyzed by the Portland-based group.

A popular historian would tell a series of selected research stories, each built on a well-known problem addressed or a clever solution found. I elected to mention every study that reached publication. That has left gaps in some stories in which politics moved issues into or out of view, or when people left and took their research venues with them. The surprising thing is that PNW carried the research ball, from start to finish, on so many topics.

Some have wondered about the relevance of economics in the Age of Ecology. These pages have shown that, even as commodity issues persist, economists have been drawn increasingly into land-use questions reaching far afield from timber and dollars. Ecosystem management raises economic questions much like those of the days of "forests" and "stands," that become imperative at policy-decision time:

- Who gains and loses, by how much, where, and when?
- Given the absence of a free lunch, what are the tradeoffs among generated ecosystems and their manipulated states?
- What are the social and dollar costs of the next increment of, say, ecosystem health? What about economics of scale and diminishing returns?
- Are there alternative ways to the same end?

- Should all acres of the same ecotype be treated alike? If not, how can criteria, ranking, and worth be brought to bear?
- Given finite budgets, how should multiple restorations and management schemes be spaced over time?

Economists know well how to display, measure, and reconcile disparate outcomes and their intricate repercussions. Whether in riparian habitat or global warming issues, the naturalist will be joined by the resource economist.

The Station generally has maintained a strong group of research economists relative to other organizations. This reflects the competence of the people involved, the orientation of the research to contemporary issues, and consequent support from a broad clientele. At times the support has been grudging. Despite trafficking in heavy-duty theory and math, economic analyses often produce clear pocketbook and land-use conclusions, not always enjoyed by all readers.

The PNW Station is alone among Forest Service research units in having kept most of its economists in a centralized critical mass. Some administrators, appreciative of economists' roles, have proposed breaking up the set to put an economist at each field location. Although some researchers enjoy technical isolation, in practice, professional improvement and career advancement have clearly tended to slow when away from the dynamism of an economics group. Too, economics research easily can become submerged beneath the "real" work of the field unit.

One knows researchers who drift from study to study, drawn by their curiosity or fashions in science. At PNW, and in Forest Service research generally, it is apparent that economics research has been more focused, with topics usually involving interplay among Washington office staff specialists, regional research administrators, and scientists' perceptions of relevant issues. Certainly at PNW, economics studies never lacked for audiences. In reviewing several hundred studies, I found few whose implications for the state of the art, forest policy, or practice on the ground were not obvious, though some were ahead of their time.

Economists at PNW have been invited to several thousands of meetings, hearings, and consultations. Technical and topical questions, on perhaps a thousand subjects, have been put before them, many inviting methodical research but without time to do so. Hundreds of researchable questions have remained unaddressed; that is the nature of science. One can only speculate as to whether right choices were made or whether more mandate and less choice would have been better.

Acknowledgments

Richard Haynes drew me into this endeavor and was, as always, patient as I worked my way through it. Judy Mikowski and Karen Esterholdt kept me on the track and, after their long associations with PNW economists, shared welcome perspectives. They did much to heal my occasional crippling of history and the English language.

Station Directors who abided and advanced economics research during often constrictive times were Bob Cowlin, Phil Briegleb, Bob Buckman, Bob Tarrant, Bob Ethington, Charlie Philpot, and Tom Mills. Cowlin spent his entire career at PNW, from measuring plots for forest survey to directing the Station. Afterward he wrote a superb 550-page history of the place, its people, and their work, through 1972. I salute him.

Metric Equivalents

When you know:	Multiply by:	To find:
Inches	2.54	Centimeters
Feet	.304	Meters
Miles	1.61	Kilometers
Square miles	2.60	Square kilometers
Acres	0.40	Hectares
Tons	0.91	Tonnes

Notes

1. Evolution of research groups inevitably leads to name changes. The Pacific Northwest Forest Experiment Station became “Forest and Range” in 1938, then compressed the name, though not its roles, to its present title in 1985. Here it is called PNW or the Station.

2. **U.S. Senate. 1920.** Timber depletion, lumber prices, lumber exports, and concentrations of timber ownership. Report on Senate Resolution 311, 66th Congress, 2nd Session. [Capper Report].

3. The forest area was estimated in:

   Kellogg, R.S. 1907. The timber supply of the United States. Circ. 97. Washington, DC: U.S. Department of Agriculture, Forest Service. 16 p.

   Area clearcut before 1920 is estimated in later forest survey reports:

   Andrews, H.J.; Cowlin, R.W. 1940. Forest resources of the Douglas-fir region. Misc. Publ. 389. Washington, DC: U.S. Department of Agriculture, Forest Service. 169 p. + maps.

   Cowlin, R.W.; Briegleb, P.A.; Moravets, F.L. 1942. Forest resources of the ponderosa pine region of Washington and Oregon. Misc. Publ. 490. Washington, DC: U.S. Department of Agriculture, Forest Service. 99 p. + maps.

   Pre-1920 clearcutting may have been underestimated on the east side of the Cascade Range. In particular, lodgepole pine and white fir were unwanted and probably left standing in tractor-logged areas. Effectively, the desired species were clearcut. On the west side, cable logging knocked down almost everything.

4. **Van Tassel, A.J. 1940.** Mechanization in the lumber industry. Natl. Res. Proj. Rep. M-5. Philadelphia: Federal Works Agency, Works Projects Administration. 201 p.

5. **Schwantes, C.A. 1993.** Railroad signatures across the Pacific Northwest. Seattle: University of Washington Press. 360 p.

   Schwantes draws data from:

   Adams, K.A. 1961. Logging railroads of the West. New York: Bonanza (Superior). 160 p.

   A small, rusted locomotive moldering in the city park of some Northwest valley town may seem a quaint anachronism. But the steam locomotive, with its companion steam yarders, was the ubiquitous backbone of harvesting for 45 years, into the 1930s. In 1920 over 600 locomotives and 2,500 yarders were in use in Oregon and Washington woods. In all the Northwest except southwest Oregon, logging rails ran up every river valley and into most side tributaries. Above the glacier-carved valleys around Puget Sound, the lines zigzagged about 1,500 feet vertically. In some places they went higher with steep inclines on which cables hauled the rail cars, but this was slow and expensive.

   Logging locomotives were powerful. A carload of logs weighed about 20 tons, and several to a dozen cars were pulled at once. (Down in the valley on the mainline, there might be thirty 50-ton cars in a train moving toward the mill, sometimes with two engines.)

On some rail lines were portable skidders with built-in steel towers. Such machines weighed up to 150 tons. The locomotive had to pull these gargantuas uphill.

Cable yarders did and still do bring logs from the stump by reaching out from the rail or road spur 600 to several thousand feet, depending on the size and complexity of the skidding system. A long span could add a thousand feet vertically to the cutover area. Often left behind in railroad logging were sharp ravines, “long corners” (areas where placing rails meant much rock blasting), timber beyond the swell of the ridge, stands of unwanted species, and tracts owned by somebody who wouldn’t sell to the big rail outfit. Truck logging got those in later decades.

By the end of the 1920s, 75 percent of east-side yarding was done with tractors equipped with cable drums and logging arches, in lieu of horses and cable systems. They were suited to “selective logging,” in which big pines were dragged out from among groups of smaller trees.

6. Van Tassel 1940 (see note 4).

7. **Ficken, R.E. 1987.** The forested land, a history of lumbering in western Washington. Durham, NC: Forest History Society; Seattle: University of Washington Press. 324 p.

8. Shepard’s work is mentioned by Cowlin in his history of PNW:

   Cowlin, R.W. 1973. Federal forest research in the Pacific Northwest. Typescript. 549 p. On file with: Pacific Northwest Research Station, Communications Group, P.O. Box 3890, Portland, OR 97208-3890.

9. January 1928.

10. **Brandstrom, A.J.F. 1957.** Development of industrial forestry in the Pacific Northwest. Col. William B. Greeley Lectures in Industrial Forestry, Number 1. Seattle: University of Washington, College of Forestry. 33 p.

11. The quotation, from an unspecified source, is in Brandstrom 1957 (see note 10).

12. On the other hand, by 1933 about 2.2 million acres of Northwest forest land were bare of trees where trees might well grow, mostly because of past fires.

13. **U.S. Senate, 73rd Congress. 1933.** A national plan for American forestry, letter from the Secretary of Agriculture, the report of the Forest Service of the Agricultural Department on the forest problem of the United States. Washington, DC: Government Printing Office: 176. Vol. 1.

14. Civilian Conservation Corps and Works Project Administration.

15. **Brandstrom, A.J.F. 1933.** Analysis of logging costs and operating methods in the Douglas fir region. Seattle: Charles Lathrop Pack Forestry Foundation; West Coast Lumbermen’s Association. 117 p.

16. Except for the following, publications mentioned in this paragraph are cited later:

   Rapraeger, E.F. 1934. How motor trucks are used in Douglas fir logging. Journal of Forestry. 32(1): 24-28.

Kirkland, B.P. 1934. Regulating the cut by the continuous inventory-flexible rotation system. Journal of Forestry. 32: 818-825.

Matthews, D.M. 1935. Management of American forests. New York: McGraw-Hill. 495 p.

17. See note 3.

18. **Erickson, K.A. 1994.** Lumber ghosts, a travel guide to the historic lumber towns of the Pacific Northwest. Boulder, CO: Pruett Publishing Co. 132 p.

19. From the 1870s forward, “conservation” was the antidote to exploitation and resource mining. That forests were disappearing from the face of the Nation was apparent; their replacement was not. With depletion came desolation. Whole counties became burned-over stumpland. Presidents Theodore and Franklin Roosevelt, 35 years apart, took umbrage at the carnage and declared empathy for its refugees.

    Of separate but substantial concern was timber supply. Forests were vast but not endless. Tree planting was nice but trivial; for decades fires burned more than planting replaced. By the 1940s, however, tree planting and fire control were main axes of forestry. Conservation had been that plus reservation of forest lands, regulation of harvesting, and watershed reclamation.

    The 1930s and 1940s also brought an emphasis on “sustained yield,” applied solely to timber, as in the Sustained-Yield Forest Management Act of 1944, which let the Forest Service do cooperative harvest planning with the private sector. The intent was to ensure that after private timber was cut, federal forests would be available to sustain the flow. In the 1880s, Bernard Fernow, chief of the U.S. Division of Forestry, proclaimed that sustained yield meant retaining forest capital while harvesting only its interest. H.H. Chapman, a prominent forestry scholar said, in 1931, that sustained yield required that there be no reduction in the flow (during the Depression). Forest Service Chief McArdle saw sustained yield as a long-term upper level on harvests, with “allowable cut” pertaining to the short term. Assistant Chief Ed Cliff said in the 1950s that sustained yield meant increasing harvest to reach the maximum “allowable cut,” or the point at which extraction was equaled by replacement. He said that his greatest achievement had been to approach that allowable-cut ceiling.

    Cliff’s second definition was really quite different, though he may not have meant it to be. Extraction equaling replacement can occur when the underlying growing stock is nil, as happened in the Northern United States in the 1940s. The maximum sustainable yield there was very low indeed.

    In the 1960s, conservation and sustained yield yielded to the environmental movement, which brought not only public aversion to clearcutting but also a movement away from commodity aims toward land, air, and water stewardship. Holding trees for later use was less important, in the popular view, than holding trees intact. A central theme was reversing resource degradation.

    Latter-day enthusiasm for sustainability has led to a vigorous exercise in finger pointing even as books and conferences unfold to deal with workable definitions of sustainability. To Richard Manning (2000 Inside passage, a journey beyond borders. Washington, DC: Island Press. 210 p.),

> A lot of effort and ink have been spent in defining exactly what is meant by sustainability, much of it sophistry. We don't need to get into that here, simply because we have so many clear examples of what is not sustainable. Sustainability has been defined by its absence.

The conservation ethic may have gone full circle, back to two themes. One is natural science (ecology and ecosystem management); the other is a return to commodity conservation, but rather than preservation or rationing, it is a "cut a tree, plant a tree" dynamic concept. That simple notion, embodied in "sustainable forestry," is complex economically. Although retailers sell lumber certified as coming from sustainable forests, just how those forests will evolve and whether they will endure remains to be seen. Meanwhile, one observer (MacCleery 1994. Resiliency and recovery, a brief history of conditions and trends in U.S. Forests. American Forests. 38: 135) has said, "It is a measure of the success of past conservation policies that the U.S. now has the option to consider [forest-use] choices."

20 . Examples were:

Worthington, N.P. 1949. Lumber grade recovery and milling costs. The Timberman. Sept.: 58-66.

Matson, E.E. 1950. Lumber grades from young growth Douglas-fir. Res. Note PNW-70. Portland, OR: U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station.

Worthington, N.P.; Shaw, E.W. 1952. Cost of thinning young Douglas-fir. The Timberman. Aug.: 136-138.

21. **Cone, J. [N.d].** Interview with John Crowell. Forest Planning. 2(1): 10-13.

Quoted in:

O'Toole, R. 1988. Reforming the Forest Service. Washington, DC: Island Press: 145.

22. **Le Master, D.C.; Popovich, L., eds. 1977.** Crisis in forest land management. Washington, DC: Society of American Foresters. 110 p.

23. An ecosystem, it is said, is all of the organisms in a given place in interaction with their nonliving environment; similarly, a community of organisms and their physical environment interacting as an ecological unit. Alternatively, it is the natural plant community that would exist in an area if it were undisturbed by man or natural agents.

Ecoparlance has attracted a host of embellishments and permutations. Forestry literature of the 1990s was replete with combinations of columns A, B, and C:

Late-seral	Ecosystem	Integrity
Late-successional	Ecoregion	Sustainability
Aquatic	Landscape	Diversity
Riparian	Biome	Health
Wetland	Bioregion	Resilience
Grassland	Ecotope	Viability
Montane	Ecotype	Renewability
Terrestrial	Community	Disturbance

A Disneyesque fairy dell is an ecosystem. So is a single leaf or an entire watershed. Economists are comfortable with the accordion scale of ecosystems; in this respect ecosystems parallel economies. There is another analogy in the multitude of organisms, climates, and inorganic parts of an ecosystem. Multiplicity and diversity confront, intrigue, and puzzle economists just as they do ecologists. A third parallel is in dynamics. Change is endemic to both environments. A fourth is interactions: interdependency over space and time.

A fifth familiarity is intervention. Management of economies is contentious and follows fashions. It responds to shocks and tends toward preserving the status quo. Its outcome is often uncertain and surprising. Ecosystem management is contentious, largely undefined, and thus ephemeral, following fashions. It responds to disturbance, tending toward preservation and restoration. Results are largely uncertain and often surprising.

Definitions in the first paragraph above are taken from:

Jensen, M.E.; Bourgeron, P.S., tech. eds. 1994. Volume II: Ecosystem management: principles and applications. Gen. Tech. Rep. PNW-GTR-318. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 376 p. (Everett, R.L.; assessment team leader; Eastside forest ecosystem health assessment).

Quigley, T.M.; Arbelbide, S.J., tech. eds. 1997. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; U.S. Department of the Interior, Bureau of Land Management. 335 p. Vol.1. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).

24. **Fedkiw, J. 1998.** Managing multiple uses on national forests, 1905 to 1995: a 90-year learning experience and it isn't finished yet. Washington, DC: U.S. Department of Agriculture, Forest Service. 212 p.

25. "Ecosystem management" is a slippery concept. As used by the Forest Service, it implies multiple resource dimensions as much as multiple use, protection as much as yield, but dynamics more than statics, and arguably large areas more than small.

In mandating ecosystem management to his staff and field units, Cliff meant it as a successor phrase and behavior to "multiple use," which had come in practice to signal timber primacy. Earlier, Cliff had said that an ecosystem approach would provide a high-quality environment for recreational opportunities, fish and wildlife, water, forage, and timber in harmony with *the needs of lesser organisms* (quoted in Fedkiw 1998: 131; see note 24). But Cliff did not define ecosystem management.

Whatever the state of ecosystems at the time, uses were expanding. Recreational activity of all kinds was growing on national forests; so was timbering. Dams were still being built. Fishing was big; so was hunting. Salmon derbies were still common in Puget Sound and along the Northwest coast. Across the West there were too many deer, too many coyotes, and bounties on wolves and cougars. Municipal watersheds were flourishing, with their nonwater uses varying according to cities' wishes. In the Northwest, the largest resource allocation problem may have been that roads and clearcuts were obliterating favorite trails. Certainly authority to create wilderness areas sat well with the public.

Resource conflicts and tradeoffs were more often *intra*resource than *inter*resource: sheep vs. cattle, deer vs. elk, bass vs. other fish in lakes, resorts vs. none, hemlock vs. fir, hardwood vs. softwood, ponderosa vs. lodgepole, pulp vs. saw logs, and so on. These matters were far more intricate and intense than they sound now, with much at stake.

In the land-managing agencies, cross-resource analyses and planning faced two rigidities that had tremendously depressing effects. One was functional budgets; the other was functional organization. The first reached right into Congress, as it probably still does, although line items have been broadened and combined. The other was almost as tough, with Washington office and regional subject-matter staffs grimly determined to protect the turfs of their field people. That was their job, but it cooled cooperation at those levels.

Helping to break down the walls within resource management were emerging clusters of economists in research and planning staffs, who raised and answered questions about production economics. They worked in the shadows of received forestry doctrines like "owls at any cost," "a tree tomorrow is worth as much as a tree today," and "2 million acres of habitat (or timber) is twice as good as 1 million."

26 . **American Forestry Association. 1905.** Proceedings of the American forest congress (held at Washington, DC, January 2 to 6, 1905). Washington, DC: American Forestry Association; H.M. Suter Publishing Company. 474 p.

The Presidential address is on p. 3-12.

27. **Clapp, E.H. 1926.** A national program of forest research: report of a special committee on forest research of the Washington Section of the Society of American Foresters. Washington, DC: The American Tree Association for the Society of American Foresters. 232 p.

28. **The Secretary of Agriculture. 1933.** Letter from the Secretary of Agriculture transmitting in response to S. Res. 175 (72nd Congress) the report of the Forest Service of the Agricultural Department on the forest problem of the United States. A national plan for American forestry. S. Doc 12, 73rd Congress, 1st session. [The Copeland Report.] Washington, DC: Government Printing Office. 1677 p. Vols. 1 and 2.

29. Clapp 1926: 2 (see note 27).

30. **Hall, R.C. 1931.** Progress report of the forest taxation inquiry, taxation of timber properties in Oregon and Washington (Fred Rogers Fairchild, Director). No. 14. New Haven, CT: U.S. Department of Agriculture, Forest Service. 35 p.

31. **Kurtz, W.B.; Noweg, T.A.; Moulton, R.J.; Alig, R.J. 1994.** An analysis of the retention, condition, and land use implications of tree planting established under the Soil Bank Program, the Forestry Incentives Program, and the Agricultural Conservation Program. Stn. Rep. SR 464. Columbia, MO: University of Missouri, Missouri Agricultural Experimental Station. [Irregular pagination].

32. For nonintervention:

Worrell, A.C. 1956. Optimum intensity of forest land use on a regional basis. Forest Science. 2: 199-240.

For viewing with alarm:

Duerr, W.A. 1948. The small, low-income landholding: a problem in forest conservation. Iowa State College Journal of Science. 22: 349-361.

33. **McMahon, R.O. 1964.** Private nonindustrial ownership of forest land. Bull. 68. New Haven, CT: Yale University School of Forestry. 122 p.

    Flora, D.F. 1966. Time discounting by certain forest landowners. Bull. 69. New Haven, CT: Yale University School of Forestry. 55 p.

34. **Kirkland, B.P.; Brandstrom, A.J.F. 1936.** Selective timber management in the Douglas fir region. Washington, DC: Forest Service Division of Forest Economics. 122 p.

35. **Munger, T.T. 1950.** A look at selective cutting in Douglas-fir. Journal of Forestry. 48(2): 97-99.

36. **Munger, T.T.; Brandstrom, A.J.F.; Kolbe, E.L. 1936.** Maturity selection system applied to ponderosa pine. West Coast Lumberman. 63(11): 33.

    Munger, T.T. 1941. They discuss the maturity selection system. Journal of Forestry. 39: 297-303.

    Maturity selection involved taking some of the best trees from mixed-age old-growth stands, making it financially feasible to drop snags and remove ill-shaped, retarded, and misplaced trees at the same time.

37. **Weigand, J.F.; Haynes, R.W. 1991.** Economic considerations for green tree retention. Forest Perspectives. 1(3): 11-12.

38. Weigand and Haynes 1991 (see note 37).

39. An early challenge to research was identifying best economic opportunities for forestry investment, in situations where many activities and many acres competed for limited funds. It was common planning practice to assume that the projects for the next year would cost about as much, on average, as those of the past year, and that acres treated in the future would not differ much from the recent average. Field foresters knew, however, that steep sites and tough, remote country would push costs up, and to keep the average down, they would search for the least costly places and treatments. Pressures to do things cheaply were, and are, intense.

    That seems prudent, but economists argued that lowest cost might be linked to lowest returns. Tree planting might, for example, be easiest on poor sites where brush is least dense but where trees would grow slowly. There are myriad examples of low-cost forestry yielding poor returns. The trick was to operate where the ratio of returns to costs was greatest. This was not an easy calculation if timeframes between expenses and returns were long and variable among opportunities. From such matters was production economics born.

    Ranking of forestry options led to marginal analysis: moving down the rate-of-return list of projects one at a time, until the next one considered was at or just above the cost of capital. This process of looking at next, individual options is marginal analysis; it disdains looking at averages or at projects already accepted. Having acquired timber and built an expensive road, a harvester using marginal analysis would take out no tree having a value less than its logging cost, no matter how much investment had been made or the worth of the other trees.

40. Brandstrom 1933 (see note 15).

41. For instance:

Chapman, H.H. 1950. Forest management. Bristol, CT: The Hildreth Press. 258 p.

Duerr, W.A.; Fedkiw, J.; Guttenberg, S. 1956. Financial maturity: a guide to profitable timber growing. Tech. Bull. 1146. [Washington, DC]: U.S. Department of Agriculture. 74 p.

Gaffney, M.M. 1960. Concepts of financial maturity of timber and other assets. A.E. Inf. Ser. 62. Raleigh: North Carolina State College, Department of Agricultural Economics. 105 p.

42. **Fedkiw, J.; Yoho, J.G. 1960.** Economic models for thinning and reproducing even-aged stands. Journal of Forestry. 58(1): 26-34.

43. **Flora, D.F. 1966.** Economic guides for ponderosa pine dwarfmistletoe control in young stands of the Pacific Northwest. Res. Pap. PNW-29. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 16 p.

Flora, D.F. 1966. Economic guides for a method of precommercial thinning of ponderosa pine in the Northwest. Res. Pap. PNW-31. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 10 p.

44. **Worthington, N.P.; Fedkiw, J. 1964.** Economic considerations in management of Douglas-fir growing stock—a case study. Res. Pap. PNW-12. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 17 p.

45. **Adams, T.C. 1965.** High-lead logging costs as related to log size and other variables. Res. Pap. PNW-23. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 38 p.

Adams, T.C. 1965. Economic comparison of relogging and clean logging in mature hemlock. Res. Pap. PNW-24. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 20 p.

46. **Payne, B.R. 1964.** Trends in reforestation and its cost in the Pacific Northwest. Misc. Publ. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 11 p.

47. **Chappelle, D.E. 1969.** A computer program for evaluating forestry opportunities under three investment criteria. Res. Pap. PNW-78. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 64 p.

48. **Worthington, N.P.; Staebler, G.R. 1961.** Commercial thinning of Douglas-fir in the Pacific Northwest. Tech. Bull. 1230. Washington, DC: U.S. Department of Agriculture. 124 p.

49. **Adams, T.C. 1967.** Production rates in commercial thinning of young-growth Douglas-fir. Res. Pap. PNW-41. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 35 p.

Adams, T.C. 1968. Marketing survey of thinnings and other intermediate-cut sales. In-service report. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110. 28 p.

50. **Darr, D.R.; Fahey, T.D. 1973.** Value for small diameter stumpage affected by product prices, processing equipment, and volume measurement. Res. Pap. PNW-158. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 16 p.

51. **Curtis, R.O.; Reukema, D.L.; Silen, R.R. [and others]. 1973.** Intensive management of coastal Douglas fir. In: Loggers handbook. Portland, OR: Pacific Logging Congress. 6 p. Vol. 33.

A counterpart article by the same authors appeared in Forest Industries in 1974 (Oct.: 48-50).

52. **Randall, R.M.; Darr, D.R. 1974.** Douglas-fir thinning values sensitive to price-diameter relationships. Res. Note PNW-227. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 7 p.

53. **Randall, R.M. 1976.** Commercial thinning as an income opportunity for small woodland owners. In: Managing young forests in the Douglas-fir region: Proceedings of a symposium. Corvallis, OR: School of Forestry, Oregon State University: 115-127. Vol. 5.

54. **Randall, R.M.; Sutherland, C.F., Jr. 1974.** Marketing Oregon-produced poles and piling. Res. Pap. 24. Corvallis, OR: Forest Research Laboratory, School of Forestry, Oregon State University. 11 p.

55. **Sassaman, R.W. 1972.** Economic returns from planting forage in national forests. Journal of Forestry. 70(8): 487-488.

56. **Sassaman, R.W.; Fight, R.D. 1975.** A tool for estimating the financial returns on forage grasses seeded in thinned ponderosa pine. Journal of Range Management. 28(3): 185-189.

Sassaman, R.W.; Spink, L.R.; Twombly, A.D. 1975. Important range implications of new ponderosa pine stocking guides—help for multiresource forest officers. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

Sassaman, R.W.; Spink, L.R. 1976. Potential forage production of interior Northwest forested ranges. Abstracts, 29th annual meeting, Society of Range Management. [Place of publication unknown]: [Publisher unknown]: 37-38.

57. **Fight, R.D.; Randall, R.M. 1977.** Cost comparison of alternative management regimes on two national forests. In: Background reports to timber harvest scheduling issues study. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Western Resource Economics R&D Program. 10 p.

Fight, R.D.; Randall, R.M. 1976. The cost of increments of wood produced on two national forests. In: Timber harvest scheduling issues study. Washington, DC: U.S. Department of Agriculture, Forest Service: A72-A74.

58. **Randall, R.M. 1977.** Financial consequences of commercial thinning regimes in young-growth Douglas-fir. Res. Note PNW-293. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 8 p.

59. **Randall, R.M. 1978.** Precommercial thinning as it affects financial returns and volume yields from Douglas-fir stands. In: Proceedings of IUFRO Project Group P4.02, Economics of harvesting thinnings. Corvallis, OR: [Publisher unknown].

60. **Sassaman, R.W.; Barrett, J.W.; Twombly, A.D. 1977**. Financial precommercial thinning guides for Northwest ponderosa pine stands. Res. Pap. PNW-226. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 27 p.

61. **Miller, R.E.; Fight, R.D. 1979.** Fertilizing Douglas-fir forests. Gen. Tech. Rep. PNW-83. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 29 p.

A shorter version appeared as:

Miller, R.E.; Fight, R.D. 1979. Analyzing forest fertilization: study evaluates costs, benefits. Forest Industries. Sept.: 60-62.

62. **Randall, R.M. 1979.** Some financial implications of 5-year fertilizer trials in ponderosa pine. In: Gessel, S.P.; Kenady, R.M.; Atkinson, W.A., eds. Proceedings, forest fertilization conference. Contrib. 40. Seattle, WA: University of Washington, College of Forest Resources: 231-233.

63. **Firch, R.S., chair. 1975.** Task force report on research needs in factor inputs and conversion into final products and consumer demand and welfare (production and marketing economics). Berkeley, CA: Western Regional Planning Committee of the Western Association of Agricultural Experiment Station Directors. 11 p.

64. **Brannman, L.; Buongiorno, J.; Fight, R. 1981.** Quality adjusted price indices for Douglas-fir timber. Western Journal of Agricultural Economics. 6(2): 259-272.

65. **Fight, R.D.; Dutrow, G.F. 1981.** Financial comparison of forest fertilization in the Pacific Northwest and the Southwest. Journal of Forestry. 79(4): 214-215.

66. **Fight, R.D.; Chittester, J.M.; Clendenen, G.W. 1984.** DFSIM with economics: a financial analysis option for the DFSIM Douglas-fir simulator. Gen. Tech. Rep. PNW-175. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 22 p.

67. **Fight, R.D.; LeDoux, C.B.; Ortman, T.L. 1984.** Logging costs for management planning for young-growth coast Douglas-fir. Gen. Tech. Rep. PNW-176. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 10 p.

The costs, updated and in equation form, were published in:

LeDoux, C.B.; Fight, R.D.; Ortman, T.L. 1986. Stump-to-truck cable logging cost equations for young-growth Douglas-fir. Western Journal of Applied Forestry. 1(1): 19-22.

68. **Fight, R.D.; Snellgrove, T.A.; Curtis, R.O.; DeBell, D.S. 1986.** Bringing timber quality considerations into forest management decisions: a conceptual approach. In: Douglas-fir: stand management for the future. Seattle: University of Washington, College of Forest Resources: 20-25.

69. **Fight, R.D.; Briggs, D.G. 1986.** Importance of tree size and volume removed in silvicultural decisions. In: Douglas-fir: stand management for the future. Seattle: University of Washington, College of Forest Resources: 317-322.

70. **Lambert, M.B.; Howard, J.O. 1990.** Cost and productivity of new technology for harvesting and in-woods processing small-diameter trees. Res. Pap. PNW-RP-430. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 37 p.

71. **Fight, R.D.; Cahill, J.M.; Snellgrove, T.A.; Fahey, T.D. 1987.** Financial analysis of pruning coast Douglas-fir. Res. Pap. PNW-RP-390. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 17 p.

72. **Fight, R.D.; Cahill, J.M.; Snellgrove, T.A.; Fahey, T.D. 1987.** PRUNE-SIM users guide. Gen. Tech. Rep. PNW-GTR-209. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 21 p.

73. **Fight, R.D.; Cahill, J.M.; Fahey, T.D.; Snellgrove, T.A. 1988.** A new look at pruning coast Douglas-fir. Western Journal of Applied Forestry. 3(3): 46-48.

74. **Briggs, D.G.; Fight, R.D.; Buhler, R.C. 1988.** The role of utilization considerations in planning silvicultural regimes. In: Proceedings of the 1987 Society of American Foresters national convention. Bethesda, MD: Society of American Foresters: 237-241.

    A users guide for TREEVAL was published:

    Ayer Sachet, J.K.; Briggs, D.G.; Fight, R.D. 1989. Tree value system: users guide. Gen. Tech. Rep. PNW-GTR-234. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 45 p.

75. **Fight, R.D. 1991.** Silvicultural regimes for optimal wood quality of Pacific Northwest Douglas-fir in the United States. In: II simposio economia forestal en Chile. Concepcion, Chile: Universidad del Bio Bio, Departamento de Ingeneria Industrial: 269-279.

    A counterpart U.S. presentation was:

    Fight, R.D.; Fahey, T.D.; Johnston, S. 1992. Timber quality and pruning: an analysis of management regimes for the Siuslaw National Forest. In: Proceedings of the national silviculture workshop. Gen. Tech. Rep. INT-GTR-291. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 93-95.

76. **Fight, R.D.; Cahill, J.M; Fahey, T.D. 1992.** DFPRUNE users guide. Gen. Tech. Rep. PNW-GTR-300. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 12 p.

77. TREEVAL2 and FIP were discussed in:

    Briggs, D.G.; Fight, R.D. 1992. Modeling the interaction of silvicultural practices, wood quality, and product value in Douglas-fir. In: Pacific Rim forestry—bridging the world. Proceedings of the Society of American Foresters national convention. Bethesda, MD: Society of American Foresters: 86-91.

    Briggs, D.G.; Fight, R.D. 1992. Assessing the effects of silvicultural practices on product quality and value of coast Douglas-fir trees. Forest Products Journal. 42(1): 40-46.

    PP PRUNE was covered in:

Bolon, N.A.; Fight, R.D.; Cahill, J.M. 1992. PP PRUNE users guide. Gen. Tech. Rep. PNW-289. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 p.

78. **Fight, R.D.; Bolon, N.A.; Cahill, J.M. 1992.** Financial analysis of pruning ponderosa pine. Res. Pap. PNW-RP-449. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 17 p.

79. **Fight, R.D.; Bolon, N.A.; Cahill, J.M. 1993.** Financial analysis of pruning Douglas-fir and ponderosa pine in the Pacific Northwest. Western Journal of Applied Forestry. 8(2): 58-61.

80. **Fight, R.D.; Johnston, S.; Briggs, D.G. [and others]. 1995.** How much timber quality can we afford in coast Douglas-fir stands? Western Journal of Applied Forestry. 10(1): 12-16.

81. **Eastin, I.L.; Lane, C.; Waggener, T. [and others]. 1996.** An assessment of the market for softwood clearwood lumber products. CINTRAFOR Work. Pap. 59. Seattle: University of Washington, College of Forest Resources. 91 p.

Related reports were:

Eastin, I.; Lane, C.L.; Fight, R.D.; Barbour, R.J. 1998. An assessment of the industrial markets for softwood clear lumber. Forest Products Journal. 48(11/12): 48-54.

Waggener, T.; Fight, R.D. 1999. Clearwood quality and softwood lumber prices: What's the real premium? Western Journal of Applied Forestry. 14(2): 73-79.

The latter article reminded readers that, although the clearwood premium had not diminished, rising prices are an incentive for users to substitute lower grades, lower priced species, or nonwood materials for higher priced appearance grades.

82. **Fight, R. 1996.** Making pruning profitable. Northwest Woodlands. Spring: 20-21.

83. These efforts are described in three papers published in:

Hanley, D.P.; Oliver, C.D.; Maguire, D.A. [and others], comp., eds. 1995. Forest pruning and wood quality of western North American conifers. Seattle: University of Washington, College of Forest Resources.

> Haynes, R.W.; Fight, R.D. Trends in price premiums for clear wood in the western United States: 106-114.
>
> Briggs, D.G.; Fight, R.D. Decision aids for choosing forest pruning systems: 153-163.
>
> Fight, R.D.; Bolon, N.A. Is forest pruning a good investment for the Pacific Northwest? 65-73.

84. **Eng, H.; Johnson, N.; Fight, R.D. 1990.** Financial analysis of early stand treatments in southwest Oregon. Res. Pap. PNW-RP-427. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 25 p.

85. **Johnson, R.L.; Alig, R.J.; Moore, E.; Moulton, R.J. 1997.** NIPF landowners' view of regulation. Journal of Forestry. 95(1): 23-28.

Johnson, R.L.; Alig, R.; Kline, J. [and others]. 1999. Management of non-industrial private forest lands: survey results from western Oregon and Washington owners. Res. Contrib. 28. Corvallis, OR: Oregon State University, College of Forestry, Forest Research Laboratory. 39 p.

86. **Flora, D.F. 1964.** Uncertainty in forest investment decisions. Journal of Forestry. 62(6): 376-380.

87. **Schweitzer, D.L.; Pierson, R.N. 1970.** The manage-lease-sell decision under uncertainty. Presented at: 43rd annual meeting of the Northwest Scientific Association, Salem, Oregon. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

88. **Schweitzer, D.L. 1970.** The impact of estimation errors on evaluations of timber production opportunities. Res. Pap. NC-43. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 18 p.

89. **Schweitzer, D.L. 1972.** Forest fertilization in the Pacific Northwest: a case study in timber production under uncertainty. In: Lundgren, A.L.; Thompson, E.F., comps. Uncertainty in forestry investment decisions regarding timber growing: 15th IUFRO world congress. FWS-1-72. Blacksburg, VA: Virginia Polytechnic Institute and State University: 23-29.

Schweitzer followed this work with a THIS report:

Schweitzer, D.L. 1977. Timber harvest scheduling and the role of uncertainty in defining Forest Service options. In: Background reports to timber harvest scheduling issues study. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Western Resource Policy Economics R&D Program. 37 p. Vol. 3.

90. **Fight, R.D.; Bell, E.F. 1977.** Coping with uncertainty—a conceptual approach for timber management planning. Gen. Tech. Rep. PNW-59. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 18 p.

The publication was preceded by two THIS reports:

Bell, E.; Fight, R. 1976. Risk and uncertainty in timber harvest scheduling. In: Timber harvest scheduling issues study. Washington, DC: U.S. Department of Agriculture, Forest Service. A80-A105.

Bell, E.; Fight, R. 1976. Risk and uncertainty in timber harvest scheduling. In: Background reports to timber harvest scheduling issues study. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Western Resource Economics R&D Program. 26 p. Vol. 1.

91. **Sassaman, R.W. 1981.** Threshold of concern: a technique for evaluating environmental impacts and amenity values. Journal of Forestry. 79(2): 84-85.

Musser, L.A.; Morse, E.; Sassaman, R.W. 1981. Environmental analysis: a ranger district's approach to NEPA. Journal of Forestry. 79(2): 84-85.

This article showed how a field unit was using Sassaman's threshold-of-concern approach.

92. **Klemperer, W.D.; Cathcart, J.F.; Haring, T.; Alig, R.J. 1994.** Risk and the discount rate in forestry. Canadian Journal of Forest Research. 24: 390-397.

93. **Johnson, H.M.; Hanzlik, E.J.; Gibbons, W.H. 1926.** Red alder of the Pacific Northwest: its utilization, with notes on growth and management. Bull. 1437. Washington, DC: U.S. Department of Agriculture.

94. **Johnson, H.M. 1932.** Utilization of bigleaf maple of the Pacific Northwest. Circ. 225. Washington, DC: U.S. Department of Agriculture. 36 p.

95. **Worthington, N.P.; Ruth, R.H.; Matson, E.E. 1962.** Red alder: its management and utilization. Misc. Publ. 881. Washington, DC: U.S. Department of Agriculture, Forest Service. 44 p.

96. **Yoho, J.G.; Chappelle, D.E.; Schweitzer, D.L. 1968.** The marketing of red alder pulpwood and saw logs. Res. Note PNW-96. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 7 p.

97. **Yoho, J.G.; Chappelle, D.E.; Schweitzer, D.L. 1969.** The economics of converting red alder to Douglas-fir. Res. Pap. PNW-88. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 31 p.

98. **Dimock, E.J., II; Bell, E.; Randall, R.M. 1976.** Converting brush and hardwoods to conifers on high sites in western Washington and Oregon—progress, policy, success and costs. Res. Pap. PNW-213. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 16 p.

Randall, R.M. 1978. Techniques and costs of converting hardwood stands to conifers. In: Briggs, D.G.; DeBell, D.S.; Atkinson, W.A., comps. Utilization and management of alder: Proceedings of a symposium. Gen. Tech. Rep. PNW-70. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: 353-364.

99. **Raettig, T.L.; Connaughton, K.P.; Ahrens, G.R. 1995.** Hardwood supply in the Pacific Northwest: a policy perspective. Res. Pap. PNW-478. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 80 p.

100. One advocate was John Fedkiw, a senior PNW economist.

101. **U.S. Department of Agriculture, Forest Service. 1969.** Douglas-fir supply study, alternative programs for increasing timber supplies from national forest lands. Washington, DC: Region 5 [Pacific Southwest Region]; Region 6 [Pacific Northwest Region]; Pacific Northwest Forest and Range Experiment Station. 53 p.

102. **Payne, B.R. 1972.** Accelerated roadbuilding on the North Umpqua—an economic analysis. Res. Pap. PNW-137. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 32 p.

103. **Schallau, C.H. 1970.** An economic analysis of accelerated road construction on the Bureau of Land Management’s Tillamook Resource Area. Res. Pap. PNW-98. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 29 p.

Schallau, C.H. 1971. Who says accelerated roadbuilding pays? Journal of Forestry. 69(5): 279-280.

104. **Newport, C.A. 1962.** Economics of forest pest control. Journal of Forestry. 60(5): 306-308.

105. Flora 1966 (see note 43).

106. **Randall, R. 1974.** Douglas-fir tussock moth program—benefit/cost analysis of a proposed increase in funding for FY 1976. 9 p. Unpublished report. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

107. **Randall, R.M. 1972.** An operations approach to Douglas-fir thinning. Res. Pap. PNW-148. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 23 p.

Randall, R.M.; Schweitzer, D.L. 1973. Adapting mathematical programming to Douglas-fir thinning—a case study in manager-researcher cooperation. In: O'Leary, J.E., comp., ed. Planning and decisionmaking as applied to forest harvesting: Proceedings of symposium. Corvallis, OR: Forest Research Laboratory, School of Forestry, Oregon State University: 149-154.

Schweitzer, D.L.; Randall, R.M. 1974. Manager-research cooperation—the key to getting research applied. Journal of Forestry. 72(7): 418-419.

108. Quoted from:

Lavender, D. 1956. Land of giants, the drive to the Pacific Northwest 1750-1950. Garden City, NY: Doubleday. 422 p.

109. **McArdle, R.E. 1930.** Effect of fire on Douglas-fir slash. Journal of Forestry. 28: 568-569.

Munger, T.T.; Matthews, D.M. 1941. Slash disposal and forest management after clear cutting in the Douglas-fir region. Circ. 586. Washington, DC: U.S. Department of Agriculture. 55 p.

110. **Adams, T.C. 1964.** Some characteristics of a sample of logging residue in eastern Oregon. Res. Note PNW-10. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 5 p.

111. **Adams, T.C. 1970.** Supply curve for logging residues. Data in unpublished letter of August 3, 1972, to Don Gedney. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

112. Four articles in *Forest Industries*, November 1971, 98(12): 22-27. General title "Forest Products Residues—Their Volume, Use and Value."

Howard, J.O. 1. Volume of residues from logging.

Gedney, D.R. 2. Residues from primary manufacturing.

Hamilton, T.E. 3. Prices of primary manufacturing residues.

Wall, B.R. 4. Residues from secondary manufacturing.

113. **Adams, T.C. 1972.** Logging residues: opportunities for greater utilization. Presentation to Portland Chapter, Society of American Foresters, January 17. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

114. **Austin, J.W. 1973.** Fiberwood use in Washington, Oregon, and California, 1970-80. Res. Pap. PNW-169. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 31 p.

A companion publication was:

Austin, J.W. 1973. Price trends in fiberwood used by mills in Northwest. Pulp & Paper. March: [pages unknown].

115. **Snellgrove, T.A.; Darr, D.R. 1976.** Lumber potential for cull logs in the Pacific Northwest. Forest Products Journal. 26(7): 51-54.

116. **Grantham, J.B.; Adams, T.C.; Estep, E.M. [and others]. 1974.** Energy and raw material potentials of wood residue in the Pacific Coast States—a summary of a preliminary feasibility investigation. Gen. Tech. Rep. PNW-18. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 37 p.

117. **Hamilton, T.E.; Howard, J.O.; Adams, T.C. 1975.** Per-acre pricing—its effect on logging residue. Resour. Pap. PNW-192. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 7 p.

118. **Adams, T.C.; Smith, R.C. 1976.** Review of the logging residue problem and its reduction through marketing practices. Gen. Tech. Rep. PNW-48. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 22 p.

Adams, T.C. 1976. Economic availability of logging residue in the Douglas-fir region. Resour. Bull. PNW-64. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 9 p.

119. **Adams, T.C. 1980.** Managing logging residue under the timber sale contract. Res. Note PNW-348. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 12 p.

120. **Haynes, R.W. 1999.** Chip prices as a proxy for nonsawtimber prices in the Pacific Northwest. Res. Note PNW-RN-537. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 25 p.

121. "Decadent" and "thrifty" were in remarkably common use, especially outside the agency, when referring to public forest management.

122. **Gross, L.S. 1950.** Timber management plans on the national forests. Washington, DC: U.S. Department of Agriculture. 59 p.

U.S. Department of Agriculture, Forest Service. 1983. Forest Service Manual 2413. Washington, DC.

123. In more detail: There were several formulas, of which the two most common in the Northwest were the Hanzlik formula for the west side of the Cascade Range and, in the pine region with uneven-aged stands, the Austrian formula. These were derived from European methods and are described in forest management texts of the mid-20th century and in other sources listed below.

Generally the (fairly similar) formulas involved this sequence: First, for each forest type, estimate the average annual growth of a representative acre year by year over its lifetime. A graph of this measure typically arches upward and then downward. Next, locate the top of the curve; this is the age of maximum average annual growth (mean annual increment or m.a.i., later termed the "sustained yield capacity"). To maximize harvests over time, this is the age at which each successive stand should be cut; it is the tentative rotation length. For the west side, rotations ranged from 80 to 150 years, depending on productivity of the site and the intensity of anticipated forestry. There might be several rotations in the same national forest, for different areas. This complicated later steps.

In the next step, the length of the rotation was used to determine the area to be cut each year during the present rotation. If the rotation were *n* years, 1/*n* of the property must be cut each year so that a "normal" forest would develop with a stairstep pattern of age classes, so that in all future rotations areas cut each year would be equal, and in each rotation the ground would be fully harvested.

By the 1960s, parts of every national forest had already been cut, so the annual-area calculation included some old-growth and some young-growth area. How much volume would be cut might be another matter, considered in the next step. Not only did harvest volume include 1/*n* of the existing old growth, but it also embraced a fraction of whatever new growth might reach commercial size during the first rotation. This was the "increment" part of the first-rotation cut. Depending on local circumstances and decisions, it might include commercial thinnings, salvage of dead or stagnant trees, as well as that part of the m.a.i. expected to occur during the first-rotation years in the new stands expected to come along. The increment had various shapes over time, depending on salvage opportunities, access to stands under the rotation age, the area of such stands, etc. Folding that into the total cut and smoothing the total over time was the next step. Usually an oldest-first cutting rule was invoked to allow existing young stands to reach harvestable size (during the first rotation), acreage was adjusted to keep the flow of "decadent" old growth constant until it ran out at the end of the first rotation, and increment was fitted in to jury-rig an overall even flow of acreage and volume. Hence, the area-volume check.

Economists generally saw the whole thing as uneconomical: capital was being tied up and even allowed to decay in the resident old growth, and rotations had physical but not economic meaning.

Formalized processes were laid out over the years; see for instance:

Hanzlik, E.J. 1922. Determination of the annual cut on a sustained yield basis for virgin American forests. Journal of Forestry. October: [Pages unknown].

Gross 1950 (see note 122).

West Coast Forestry Procedures Committee. 1950. Recommended forest practices and techniques. Portland, OR: Western Forestry and Conservation Association. 94 p.

Chapman 1950: chapter 20 (see note 41).

There were many proposals to alter the formulas. Those with timber on their minds wanted shorter rotations, which would create larger portions of old growth for harvest. Others wanted departures from even flow. Still others wanted longer rotations to ensure a permanent (if shifting) reservoir of old-growth habitats.

124. Gross 1950 (see note 122).

125. PNW's involvement included:

Flora, D.F. 1966. A method of forecasting returns from ponderosa pine dwarfmistletoe control. Res. Pap. PNW-32. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 17 p.

Schweitzer, D.L.; Sassaman, R.W.; Schallau, C.N. 1972. Allowable cut effect, some physical and economic implications. Journal of Forestry. 70(7): 415-418. [In the April 1973 issue, they also replied to a comment by Dennis Teeguarden.]

Sassaman, R.W.; Barrett, J.W.; Smith, J.G. 1972. Economics of thinning stagnated ponderosa pine sapling stands in the pine-grass areas of central Washington. Res. Pap. PNW-144. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 17 p.

Schweitzer, D.L.; Sassaman, R.W. 1973. Harvest volume regulation affects investment value. Forest Industries. 100(3): 35.

Fight, R.D.; Schweitzer, D.L. 1974. Sensitivity of allowable cuts to intensive management. Gen. Tech. Rep. PNW-26. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 10 p.

Bell, E.; Fight, R.; Randall, R. 1975. ACE the two-edged sword. Journal of Forestry. 73(10): 642-643.

Bell, E.F. 1976. Yes, increased yields can reduce harvests! Res. Note PNW-282. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 5 p.

Bell, E.F. 1977. Declining harvest from linking the allowable cut to the budget on national forests. Journal of Forestry. 75(11): 701-702.

126. **Schallau, C.H.; Wirth, M.E. 1980.** Reinvestment rate and the analysis of forestry enterprises. Journal of Forestry. 78(12): 740-742.

127. **National Forest Management Act of 1976,** PL 94-588, 90 Stat. 2955.

128. Randall 1972 (see note 107).

129. **Chappelle, D.E. 1966.** A computer program for calculating allowable cut using the area-volume check method. Res. Note PNW-44. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 4 p.

Sassaman, R.W.; Chappelle, D.E.; Fritchman, K. 1969. User's manual for ARVOL computer program. Fortran IV for IBM 7040 computer. Office report. 30 p. On file with: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forest Policies and Markets Team, 3200 SW Jefferson Way, Corvallis, OR 97331.

130. **Sassaman, R.W.; Chappelle, D.E. 1967.** A computer program for calculating allowable cut using area regulation and a comparison with the ARVOL method. Res. Note PNW-63. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

This was supported by:

Chappelle, D.E.; Sassaman, R.W. [N.d.] User's manual for AREA computer program. Version 2. Fortran IV for IBM 7040 computer. 39 p. On file with: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forest Policies and Markets Team, 3200 SW Jefferson Way, Corvallis, OR 97331.

131. **Chappelle, D.E.; Sassaman, R.W. 1968.** A computer program for scheduling allowable cut using either area or volume regulation during sequential planning periods. Res. Note PNW-93. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 8 p.

A supporting publication was:

Sassaman, R.W., Chappelle, D.E.; Fritchman, K. 1969. User's manual for the SORAC computer program. Misc. Pap. [Place of publication unknown]: [Publisher unknown]. 80 p. On file with: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forest Policies and Markets Team, 3200 SW Jefferson Way, Corvallis, OR 97331.

132. **Sassaman, R.W.; Holt, E.; Bergsvik, K. 1972.** User's manual for a computer program for simulating intensively managed allowable cut (SIMAC). Gen. Tech. Rep. PNW-1. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 50 p.

133. **Bell, E.F. 1976.** Goal programing for land use planning. Gen. Tech. Rep. PNW-53. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 12 p.

134. **Bell, E.F. 1975.** Problems with goal programing on a national forest planning unit. In: Systems analysis and forest resource management proceedings. Athens, GA: University of Georgia: 119-126.

135. **Navon, D.I. 1971.** Timber RAM...a long-range planning method for commercial timber lands under multiple-use management. Res. Pap. PSW-70. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station.

136. **Bell, E.F. 1976.** The unusual ACE in RAM. In: Timber harvest scheduling issues study. Washington, DC: U.S. Department of Agriculture, Forest Service: A61-A67.

137. **Bell, E.F. 1977.** Mathematical programing in forestry. Journal of Forestry. 75(11): 701-702.

138. **Chappelle, D.E.; Mang, M.; Miley, R.C. 1976.** Evaluation of timber RAM as a forest management planning model. Journal of Forestry. 74(5): 288-293.

139. **Bell, E.F. 1976.** A comparison of harvest scheduling models. In: Timber harvest scheduling issues study. Washington, DC: U.S. Department of Agriculture, Forest Service: A67-A71.

140. **Johnson, K.N.; Jones, D.B. 1979.** A user's guide to multiple use-sustained yield resource scheduling calculation (MUSYC). Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section.

141. **Bell, E.; Johnson, N.; Burkhardt, A. 1977.** Rotation flexibility and allowable cut. Journal of Forestry. 75(11): 699-700.

142. **Kelly, J.W.; Kent, B.M.; Johnson, K.N.; Jones, D.B. 1986.** FORPLAN version 1: user's guide. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section.

Johnson, K.N.; Crim, S.A. 1986. FORPLAN version 2—an overview. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Land Management Planning Systems Section.

143. USDA Forest Service (see note 101).

A summary was presented to SAF:

Schallau, C.H.; Gedney, D.R. 1969. Some economic implications of a timber supply projection for the Douglas-fir region of Washington and Oregon. In: Proceedings of the 1969 national Society of American Foresters convention. [Place of publication unknown]: [Society of American Foresters]: [Pages unknown].

144. **U.S. Department of Agriculture, Forest Service. 1963.** Timber trends in western Oregon and western Washington. Res. Pap. PNW-5. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 5 p.

145. Long-time readers may remember this as $P_{1\text{-}1/2}$RC.

146. Fedkiw 1998 (see note 24).

147. Fedkiw 1998: 136 (see note 24).

148. **U.S Department of Agriculture, Forest Service. 1973.** Forest regulation study. Unpublished report. On file with: U.S. Department of Agriculture, Forest Service, Division of Forest Management, 201 14th Street SW, Washington, DC 20250.

Popovich, L. 1976. Harvest schedules, the vagaries of sustaining the yield. Journal of Forestry. 74(9): 635.

149. Forest Service Manual Chapter 2410 as recited in:
Federal Register 38(174): 24778, Sept. 10, 1973.

Popovich 1976 (see note 148).

O'Toole, R. 1988. Reforming the Forest Service. Washington, DC: Island Press: 142.

150. **The President's Advisory Committee on Timber and the Environment. 1973.** Report. Washington, DC: Government Printing Office. 4 p.

151. **Le Master, D.C. 1984.** Decade of change, the remaking of Forest Service statutory authority during the 1970s. Westport, CT: Forest History Society and Greenwood Press.

The legislation was the Forest and Rangeland Renewable Resources Planning Act of 1974, which called for periodic resource assessments in which PNW has been involved ever since. See the RPA discussion in a later section.

152. The 29 concurrent studies are listed below. They were compiled in three volumes, each study report comprising an unnumbered chapter with its own pagination. Together they were issued as an unnumbered office report:

U.S. Department of Agriculture, Forest Service. 1976. Background reports to timber harvest scheduling issues study. Portland, OR: Pacific Northwest Forest and Range Experiment Station, Western Resource Economics R&D Program. On file at: USDA Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, P.O. Box 3890, Portland, OR 97208-3890.

The work was led by R.E. Worthington, staff director, Timber Management, Washington, DC; C.G. Jorgensen, director, Timber Management, Pacific Northwest Region; and me.

A summary publication was prepared by those three:

U.S. Department of Agriculture, Forest Service. 1976. Timber harvest scheduling issues study. Washington, DC. 292 p. [plus appendices].

The underlying studies were:

Adams, D.M. The response of softwood stumpage and end product prices to changes in national forest timber harvest schedules. 157 p.

Adams, D.M.; Haynes, R.W.; Darr, D.R. Price effects of changes in national forest timber flows [a nontechnical comparison of models for estimating the effects of changes in timber flows on forest products prices]. 63 p.

Bell, E.; Fight, R. Risk and uncertainty in timber harvest scheduling. 26 p.

Bentley, W.R.; Davis, L.S. Assessment of long-term forecasting in timber economics. 53 p.

Calish, S. The effect of nontimber values on optimum timber rotations. 146 p.

Darr, D.R. Effects of national forest timber flows on international trade patterns. 53 p.

Fight, R.D.; Randall, R.M. Cost comparison of alternative management regimes on two national forests. 10 p.

Flora, D.F. Long-term strategic objectives of the nation as a factor in public timber policy. 31 p.

Haynes, R.W. The influence of national forest harvest flows on the competitive structure of the forest products industry. 19 p.

Howe, C.W. Economic and social perspective relevant to forest policy. 110 p.

Hrubes, R.J. National forest system working circles: an issue of size and ownership composition. 31 p.

Irland, L.C. Impact of alternative national forest timber harvest levels on the economic structure of the forest products industry. 76 p.

Johnson, K.N. Consequences of economic harvest scheduling procedures. 59 p.

Johnson, K.N. National forest timber flows when the calculation procedure allows a variable cutting age in regenerated timber. 28 p.

Josephson, H.R. Economic considerations in national forest timber harvesting. 50 p.

Lewis, G.D. Effects of Forest Service timber policies on consumption on nonwood construction materials. 19 p.

Marty, R. Options for incorporating intensive management in allowable cut calculations. 23 p.

Porterfield, R.L. Utilization—status and trends. 44 p.

Rafsnider, G.T. A model for integrating risk considerations in timber management through a harvest loss indemnity program. 14 p.

Randall, R.M. Effects of harvesting alternatives on forest ecosystems. 36 p.

Sassaman, R.W. Effects of harvest scheduling on nontimber benefits. 22 p.

Schuster, E.G.; Solomon, H.; Tornabene, C.J.; Turowski, A.D. Local economic impact: a decision variable in forest resources management. 157 p.

Schweitzer, D.L. Timber harvest scheduling and the role of uncertainty in defining Forest Service options. 37 p.

Shumate, J. Effect of harvest scheduling alternatives on financing, employment, and legislative authority required for the Forest Service. 31 p.

Stevens, J.B. The Oregon wood products labor force: job rationing and worker adaptations in a declining industry. 128 p.

Teeguarden, D.; Dennis, N. Effect of harvest scheduling alternatives on the stock of social capital: the case of housing. 23 p.

YoungDay, D.J. Who benefits from cheap wood? 52 p.

Zinn, G.W. Analyzing regional economic and related social impacts of alternative public timber supply policies. 58 p.

153. **Randall, R.M. 1977.** Timber harvesting issues. In: Proceedings of the national Indian timber symposium. [Place of publication unknown]: [Publisher unknown]: 310-323.

154. Genesis of the National Forest Management Act of 1976 is covered in the following:

LeMaster 1984 (see note 151).

Clary, D.A. 1986. Timber and the Forest Service. Lawrence, KS: University Press of Kansas. 252 p.

155. **Fight, R.D.; Schweitzer, D.L. 1974.** What if we calculate the allowable cut in cubic feet? Journal of Forestry. 72(2): 87-89.

156. **Gedney, D.R.; Oswald, D.D.; Fight, R.D. 1975.** Two projections of timber supply in the Pacific Coast states. Resour. Bull. PNW-60. U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 40 p.

157. **Johnson, K.N. [N.d.]** Timber activity scheduling on the national forests: the second revolution. 9 p. Unpublished document. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

158. **Fox, A. 1989.** Timber supply in the Pacific Northwest, aggregate implications of forest plans. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 39 p.

159. **McGuire, J.R. 1979.** Concerning the President's direction to implement a temporary departure from the non-declining, even-flow policy. Testimony before the Subcommittee on Environment, Soil Conservation, and Forestry, Committee on Agriculture, Nutrition, and Forestry, United States Senate, June 22, 1979.

160. **Adams, D.M. 1976** (see note 152).

161. Adams, D.M.; Haynes, R.W.; Darr, D.R. 1976 (see note 152).

Adams, D.M.; Haynes, R.W.; Darr, D.R. 1977. Alternative techniques for analysis of price effects of changes in national forest timber flows: a background report. Gen. Tech. Rep. PNW-60. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 18 p.

162. **Haynes, R.W. 1975.** An dynamic, spatial equilibrium model of the softwood timber economy with demand equations specified. Raleigh, NC: North Carolina State University. 102 p. Ph.D. disseration.

163. **Adams, D.M.; Haynes, R.W. 1980.** The 1980 timber assessment market model: structure, projections, and policy simulations. Forest Science. 26(3): Monograph 22. 64 p.

A collateral, though later description was:

Adams, D.M.; Haynes, R.W. 1986. A spatial equilibrium model of U.S. forest products markets for long-range projection and policy analysis. In: Kallio, M.; Andersson, A.E.; Seppala, R.; Morgan, A., comps., eds. Systems analysis in forestry and forest industries. TIMS Studies in the Management Sciences 21. Amsterdam, Netherlands: Elsevier Science Publishers: 73-87.

164. Although it now has many appendages, TAMM began as a linear programming mechanism for modeling the minimum total cost of logging, manufacture, and transport from 21 producing regions to 23 consuming regions within North America for a dozen aggregate wood-based product groups, given mill capacity and timber-harvest constraints. Between successive periods the constraints were revised, with the outputs of one period affecting the options in the next period, thereby giving the model its dynamic (recursive) character. Novel to the method (and an important advance in modeling) was inclusion of demand functions (rather than single prices) for the product groups, and there was ownership and tree diameter-class detail. (Timber supply was price-inelastic and used the Forest Service TRAS [Timber Resource Assessment System] updating model). In addition to receiving timber supply input from the computation of the previous period and timber growth and availability estimates, the analysis of each period included exogenous adjustment of regional demand, based on population, GNP, and housing starts.

Larson, R.W.; Goforth, M.H. 1974. TRAS: a timber volume projection model. Tech. Bull. 1508. Washington, DC: U.S. Department of Agriculture, Forest Service. 15 p.

The approach was fortuitous in meeting the policy needs of the time, taking advantage of expanding computer resources, and having access to advances in linear programming methods. The origins of TAMM are described in:

Haynes, R.W.; Holley, L.D., Jr.; King, R.A. 1978. A recursive spatial equilibrium model of the softwood timber sector. Tech. Rep. 57. Raleigh, NC: School of Forest Resources, North Carolina State University. 71 p.

Adams, D.M.; Haynes, R.W. 1987. Development of the timber assessment market model system for long-range planning by the U.S. Forest Service. In: 18th IUFRO World Congress Division 4, Planning, Economics, Growth and Yield Management Policy. Vienna, Austria: International Union of Forestry Research Organizations: 158-169.

165. **Adams, D.M.; Haynes, R.W. 1996.** The 1993 timber assessment market model: structure, projections and policy simulations. Gen. Tech. Rep. PNW-GTR-368. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 58 p.

166. **Haynes, R.W.; Adams, D.M. 1981.** Problems of integrating growth models into economic models. In: LeMaster, D.C.; Baumgartner, D.M.; Chapman, R.C., eds. Forestry predictive models, problems in application. Pullman, WA: Washington State University, Cooperative Extension: 95-100.

167. **Tedder, P.L.; Schmidt, J.S.; Gourley [Kincaid], J. 1980.** TREES: timber resource economic estimation system. Volume I: A user's manual for forest management and harvest scheduling. Bull. 31a. Corvallis, OR: Oregon State University, Forest Research Laboratory. 81 p.

Tedder, P.L.; La Mont, R.N.; Kincaid, J.C. 1987. The timber resource inventory model (TRIM): a projection model for timber supply and policy analysis. Gen. Tech. Rep. PNW-GTR-202. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 82 p.

168. **Mills, J.R. 1987.** An evaluation of an inventory-projection system: TRIM model predictions vs. FIA field measurements in North Carolina. In: Ek, A.R.; Shifley, S.R.; Burk, T.E., eds. Forest growth modelling and prediction, volume 2: Proceedings of IUFRO forest growth modelling and prediction conference. [Place of publication unknown]: [Publisher unknown]: 770-777.

Mills, J.R. 1989. TRIM timber projections: an evaluation based on forest inventory measurements. Res. Pap. PNW-RP-408. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 27 p.

169. **Mills, J.R. 1989.** An introduction to PC-TRIM. Res. Note PNW-RN-491. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 11 p.

170 **McWilliams, W.H.; Mills, J.R. 1990.** Integrating harvest into regional growth and yield projections. In: Burkhart, H.E.; Bonnor, G.M.; Lowe, J.J., eds. Research in forest inventory, monitoring, growth and yield: Proceedings from IUFRO world congress. Publ. FWS-3-90. Blacksburg, VA: Virginia Polytechnic Institute and State University, School of Forestry and Wildlife Resources: 174-179.

Mills, J.R. 1990. Developing ATLAS growth parameters from forest inventory plots. In: LaBau, V.J.; Cunia, T., tech. eds. State-of-the-art methodology of forest inventory: a symposium proceedings. Gen. Tech. Rep. PNW-GTR-263. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Mills, J.R.; Kincaid, J.C. 1992. The aggregate timberland assessment system—ATLAS: a comprehensive timber projection model. Gen. Tech. Rep. PNW-GTR-281. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 160 p.

171. **Alig, R.J.; Adams, D.M.; Haynes, R.W. 1983.** Long-range projection of forest area change: new approaches are needed. Journal of Forestry. 81(11): 723-727.

172. **Adams, D.M.; Alig, R.J.; Callaway, J.M. [and others]. 1996.** The forest and agricultural sector optimization model (FASOM): model structure and policy applications. Res. Pap. PNW-RP-495. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 60 p.

In a personal communication, Alig has described the shares of effort roughly as follows: Adams handled the timber market, Alig dealt with land use and forest resources, Callaway treated the carbon sector, B.A. McCarl covered agriculture, and S.M. Winnett reflected EPA interests and policy analysis.

Related publications are:

Adams, D.M.; Alig, R.J.; McCarl, B.A. [and others]. 1998. The effects of factor supply assumptions on intertemporal timber supply behavior: the cases of investable funds and land. Canadian Journal of Forestry Research. 28: 239-247.

Alig, R.J.; Adams, D.M.; Haynes, R.W. 1995. Regional changes in land uses and cover types: modeling links between forestry and agriculture. Gen. Tech. Rep. SE-92. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station.

Alig, R.J.; Adams, D.M.; Haynes, R.W. 1996. Regional changes in land uses and cover types: modeling links between forestry and agriculture. In: Proceedings of the 24th annual southern forest economics workshop. Athens, GA: University of Georgia: 90-100.

Adams, D.M.; Alig, R.J.; Callaway, J.M. 1994. Forest and agricultural sector optimization model description. Boulder, CO: RCG Hagler Bailly; final report. [Irregular pagination].

173. Le Master and Popovich 1977: 99 (see note 22).

174. **Rickard, W.M.; Hughes, J.M.; Newport, C.A. 1967.** Economic evaluation and choice in old-growth Douglas-fir landscape management. Res. Pap. PNW-49. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 33 p.

175. **Hughes, J.M. 1965.** Wilderness land allocation in a multiple use forest management framework in the Pacific Northwest. Res. Note PNW-26. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 4 p.

Hughes, J.M. 1964. Bureaucracy, communication, and wilderness. In: Proceedings of 5th biennial conference on Northwest wilderness. [Place of publication unknown]: [Publisher unknown]: 76-81.

176. Fedkiw 1998: 102 (see note 24).

177. **Fight, R.D. 1980.** Multiple use reexamined: town meeting forestry—issues for the 1980s. In: Proceedings of the 1979 convention of the Society of American Foresters. [Place of publication unknown]: [Publisher unknown]: 42-43.

178. Bell 1976 (see note 133).

179. **Fight, R.D. 1980.** Planners guide for estimating cost per user-day of proposed recreational facilities. Gen. Tech. Rep. PNW-110. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 9 p.

180. **Fight, R.D.; Randall, R.M. 1980.** Visual quality and the cost of growing timber. Journal of Forestry. 78(9): 546-548.

181. Randall, R.M. 1976 (see note 152).

182. Sassaman, R.W. 1976 (see note 152).

Randall, R.M.; Sassaman, R.W. 1979. Identifying and evaluating environmental impacts associated with timber harvest scheduling policies. Gen. Tech. Rep. PNW-81. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 20 p.

183. For instance:

Sassaman, R.W.; Randall, R.M. 1977. A method of evaluating timber impacts on nontimber forest resources. In: Transactions of the 42nd North American wildlife and natural resource conference. Washington, DC: Wildlife Management Institute: 185-189.

184. **Bell, E.F.; Randall, R.M. 1982.** Opportunities to increase national forest softwood harvest. Journal of Forestry. 80(3): 152-156, 160.

185. **Calish, S.; Fight, R.D.; Teeguarden, D.E. 1978.** How do nontimber values affect Douglas-fir rotations? Journal of Forestry. 76(4): 217-221.

Calish, S. 1977. The effect of nontimber values on optimum timber rotations. In: Background reports to timber harvest scheduling issues study. Portland, OR: U.S Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Western Resource Economics R&D Program. [Pages unknown].

Fight, R.D. 1976. Opportunity costs of economic rotation lengths. In: Timber harvest scheduling issues study. Washington, DC: U.S. Department of Agriculture, Forest Service: A74-A79.

186. **Connaughton, K.P.; Fight, R.D. 1984.** Applying trade-off analysis to national forest planning. Journal of Forestry. 82(11): 680-683.

187. **Fight, R.D. 1983.** What good are efficient timber prescriptions? In: Economics of silvicultural investments: Proceedings, national silviculture workshop. Washington, DC: U.S. Department of Agriculture, Forest Service, Division of Timber Management: 129-133.

188. **Alexander, S.; Greber, B. 1991.** Environmental ramifications of materials used in construction and manufacturing in the United States. Gen. Tech. Rep. PNW-GTR-277. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 21 p.

189. **Weigand, J.F.; Burditt, A.L. 1992.** Economic implications for management of structural retention on harvest units at the Blue River Ranger District, Willamette National Forest, Oregon. Res. Note PNW-510. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 17 p.

A collateral publication was mentioned early in this history:

Weigand, J.F.; Haynes, R.W. 1991. Economic considerations for green tree retention. Forest Perspectives. 1(3): 11-12.

190. **Haynes, R.W. 1993.** Timber-supply issues associated with long rotation forestry. In: Weigand, J.F.; Haynes, R.W.; Mikowski, J.L., comps. High quality forestry workshop: the idea of long rotations: Proceedings of the meeting. Series SP15. Seattle: University of Washington, College of Forest Resources, Center for International Trade in Forest Products: 119-125.

191. **Weigand, J.F.; Haynes, R.W. 1993.** Summation: the agenda for research and management for high quality forestry. In: Weigand, J.F., Haynes, R.W.; Mikowski, J.L., comps. High quality forestry workshop: the idea of long rotations: Proceedings of the meeting. Series SP15. Seattle: University of Washington, College of Forest Resources, Center for International Trade in Forest Products: 203-210.

192. **Ince, P.J.; McKeever, D.B.; Haynes, R.W. 1995.** The role of markets and technology in conservation of timber resources. In: Proceedings of the 1995 international environmental conference. Atlanta, GA: TAPPI Press: 315-325.

193. **Horne, A.L.; Haynes, R.W. 1997.** Spatial and temporal scales of economic analysis for ecosystem management. In: Cordell, H.K., ed; Caldwell, L.; Mou, S., comps. Integrating social science and ecosystem management: a national challenge: Proceedings of the conference on integrating social sciences and ecosystem management. Gen. Tech. Rep. SRS-17. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 112-117.

194. **Haynes, R.W.; Weigand, J.F. 1997.** The context for forest economics in the 21st century. In: Kohm, K.A.; Franklin, J.F., eds. Creating a forestry for the 21st century, the science of ecosystem management. Washington, DC: Island Press: 285-301.

195. **Weigand, J.F.; Haynes, R.W.; Tiedemann, A.R. [and others]. 1993.** Economic assessment of ungulate herbivory in commercial forests of eastern Oregon and Washington, USA. Forest Ecology and Management. 61(Oct.): 137-155.

196. **Fight, R.D.; Chmelik, J.T. 1998.** Analysts guide to FEEMA for financial analysis of ecosystem management activities. Gen. Tech. Rep. FPL-GTR-111. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 5 p.

This development was anticipated by Fight:

Fight, R.D. 1997. Financial analysis of ecosystem management activities in stands dominated by small-diameter trees. In: Barbour, R.J.; Skog, K.E., eds. Role of wood production in ecosystem management: Proceedings of the sustainable forestry working group at the IUFRO all division 5 conference. Gen. Tech. Rep. FPL-GTR-100. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory: 90-94.

197. **Chmelik, J.T.; Fight, R.D.; Barbour, J.R. 1999.** Softwood lumber prices for evaluation of small-diameter timber stands in the Intermountain West. Res. Note FPL-RN-0270. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 4 p.

198. **Willits, S.; Barbour, R.J.; Tesch, S. [and others]. 1996.** The Colville study: wood utilization for ecosystem management, preliminary results of study of product potential from small-diameter stands. Res. Pap. FPL-RP-559. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 11 p.

199. Willits and others 1996: 8 (see note 198).

200. The first work was reported in:

Hartsough, B.R.; Gicqueau, A.; Fight, R.D. 1998. Productivity and cost relationships for harvesting ponderosa pine plantations. Forest Products Journal. 48(9): 87-93.

The second was:

Fight, R.D.; Gicqueau, A.; Hartsough, B.R. 1999. Harvesting costs for management planning for ponderosa pine plantations. Gen. Tech. Rep. PNW-GTR-467. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 8 p.

201. **Wagner, F.G.; Keegan, C.E.; Fight, R.D.; Willits, S. 1998.** Potential for small-diameter sawtimber utilization by the current sawmill industry in western North America. Forest Products Journal. 48(9): 30-34.

202. **Steen, H.K. 1976.** The U.S. Forest Service, a history. Seattle: University of Washington Press. 356 p.

203. **U.S. Department of Agriculture, Forest Service. 1978.** Draft environmental statement, roadless area review and evaluation. Washington, DC. 112 p.

Fedkiw 1998 (see note 24).

204. **Haynes, R.W.; Adams, D.M. 1979.** Impacts of RARE II withdrawals on softwood prices, consumption, and production. Journal of Forestry. 78(4): 230-233.

Haynes, R.W.; Adams, D.M. 1979. Impacts of RARE II on softwood prices, consumption and production in Northwest and national markets. In: Proceedings, 57th annual Washington state forestry conference. [Place of publication unknown]: [Publisher unknown]: 67-73.

205. **Fight, R.D.; Johnson, K.N.; Connaughton, K.P.; Sassaman, R.W. 1978.** Roadless area-intensive management tradeoffs on western national forests. Portland, [Revised]. OR: U.S. Department of Agriculture, Forest Service, Western Resource Policy Economics Research. 57 p.

Other products were:

Randall, R.M.; Fight, R.D.; Connaughton, K.P. [and others]. 1979. Roadless area-intensive management trade-offs on Pacific Northwest national forests. Res. Pap. PNW-258. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 69 p.

Bell, E.F.; Johnson, K.N.; Connaughton, K.P.; Sassaman, R.W. 1979. Roadless area-intensive management tradeoffs on the Bridger-Teton and Lolo National Forests. Gen. Tech. Rep. INT-72. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Hrubes, R.J.; Connaughton, K.P.; Sassaman, R.W. 1979. Roadless area-intensive management tradeoffs on the Sierra National Forest, California. Res. Pap. PSW-149. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station.

206. **Fight, R.D.; Johnson, K.N.; Connaughton, K.P.; Sassaman, R.W. 1979.** Can intensive management make up the harvest lost when roadless areas are left undeveloped? Journal of Forestry. 77(3): 148-151.

207. **Thomas, J.W.; Forsman, E.D.; Lint, J.B. [and others]. 1990.** A conservation strategy for the northern spotted owl: report of the Interagency Committee to Address the Conservation of the Northern Spotted Owl. Portland, OR: U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management, Fish and Wildlife Service, National Park Service. 427 p.

208. **Anderson, H.M.; Olson, J.T. 1991.** Federal forests and the economic base of the Pacific Northwest. Washington, DC: The Wilderness Society. 119 p.

209. **U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management. 1990.** Economic effects of implementing a conservation strategy for the northern spotted owl. Washington, DC. 38 p.

210. **U.S. Department of Agriculture, Forest Service. 1991.** Economic effects of implementing the proposed designation of critical habitat for the northern spotted owl on national forests: a response to the USDI Fish and Wildlife Service request for comments in the May 6, 1991, Federal Register (Vol. 56, No. 87.) [Place of publication unknown]. 47 p.

The economic effects team included Richard Haynes.

211. **Forest Ecosystem Management Assessment Team. 1993.** Forest ecosystem management: an ecological, economic, and social assessment. Portland, OR: U.S. Department of Agriculture; U.S. Department of the Interior [and others]. [Irregular pagination].

Haynes participated in authorship of the economic assessment, Chapter VI.

Lane, Haynes, and I prepared an analysis of habitat protection on export trade:

Flora, D.; Lane, C.; Haynes, R. 1993. Wood products trade, forest replanning, and forest habitat conservation in the U.S. Northwest. Unpublished report. On file with: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Northwest Forest Plan Issues Coordinator, P.O. Box 3890, Portland, OR 97208-3890.

A key feature was integration of the nonadditive joint effects of trade controls, non-owl forest replanning, and owl protection. It was never clear, however, that the report saw duty in the battle.

212. **Seattle Post-Intelligencer. 1993.** [Title unknown]. July 2; [sect. unknown]: 1 ff.

213. Fedkiw 1998 (see note 24) citing:

Hoberg, G. 1993. From logroll to logjam: structure, strategy, and influence in the old-growth forest conflict: Paper presented to the annual meeting of the American Political Science Association. Vancouver, BC: Department of Political Science, University of British Columbia. 33 p.

214. Haynes' segment is in:

Tuchmann, E.T.; Connaughton, K.P.; Freedman, L.E.; Moriwaki, C.B. 1996. The Northwest Forest Plan: a report to the President and Congress. Portland, OR: U.S. Department of Agriculture, Office of Forestry and Economic Assistance: 152-155.

215. **Raettig, T.L.; Christensen, H.H. 1999.** Timber harvesting, processing, and employment in the Northwest economic adjustment initiative region: changes and economic assistance. Gen. Tech. Rep. PNW-GTR-465. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 16 p.

216. **Weigand, J.F. 1994.** Economic issues in ecosystem restoration. In: Everett, R.L., comp. Eastside forest ecosystem health assessment—Volume IV: restoration of stressed sites and processes. Gen. Tech. Rep. PNW-GTR-330. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 6-12.

217. **Bormann, B.T.; Brookes, M.H.; Ford, D.E. [and others]. 1994.** Volume V: a framework for sustainable-ecosystem management. Eastside forest ecosystem health assessment. Gen. Tech. Rep. PNW-GTR-331. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 61 p. (Everett, R.L., assessment team leader: Eastside forest ecosystem health assessment).

218. **Hessburg, P.F.; Haynes, R.W.; Everett, R.L. 1994.** Alternative ecosystem management scenarios and a process to evaluate alternative rates of investment in ecosystem management. In: Everett, R.; Hessburg, P.; Jensen, M.; Bormann, B. Eastside forest ecosystem health assessment—Volume I: executive summary. Gen. Tech. Rep. PNW-GTR-317. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 30-37.

219. **Haynes, R.W.; Bolon, N.A.; Hormaechea, D.T. 1992.** The economic impact on the forest sector of critical habitat delineation for salmon in the Columbia and Snake River basin. Gen. Tech. Rep. PNW-GTR-307. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 33 p.

220. **Bolon, N.A.; Hansen-Murray, C.S.; Haynes, R.W. 1995.** Estimated economic impacts on the timber, range, and recreation programs on NFS and BLM public lands from adopting the proposed interim PACFISH strategy. Gen. Tech. Rep. PNW-GTR-344. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 80 p.

221. **Haynes, R.W.; Graham, R.T.; Quigley, T.M., tech. eds. 1996.** A framework for ecosystem management in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-374. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 66 p.

The framework is summarized in:

Haynes, R.W.; Graham, R.T.; Quigley, T.M. 1998. A framework for ecosystem management in the interior Columbia basin. Journal of Forestry. 96(1): 4-9.

A partial summary is in:

H**aynes, R.W.; Quigley, T.M. 1995.** Socioeconomic issues related to interior ecosystems. In: Ecosystem management in western interior forests: Symposium proceedings. Pullman, WA: Department of Natural Resource Sciences, Washington State University: 57-64.

This paper pointed to emerging economic issues: distribution of costs and benefits, equity over time, valuation of ecosystem products, economics of ecosystem restoration, and appropriate spatial scales for economic analyses.

222. The report cites President Clinton, in July 1993, directing the Forest Service to "develop a scientifically sound and ecosystem-based strategy for management of Eastside forests," based on the east-side forest health assessment, mentioned earlier. See Haynes and others 1996 (note 221).

223. Haynes and others 1996: 10 (see note 221).

224. **Quigley, T.M.; Haynes, R.W.; Graham, R.T. 1996.** Integrated scientific assessment for ecosystem management in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-382. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 303 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).

It was followed by:

U.S. Department of Agriculture, Forest Service. 1996. Status of the interior Columbia basin, summary of scientific findings. Gen. Tech. Rep. PNW-GTR-385. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 144 p.

Quigley, T.M.; Cole, H.B. 1997. Highlighted scientific findings of the interior Columbia Basin Ecosystem Management Project. Gen. Tech. Rep. PNW-GTR-404. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 34 p.

Quigley, T.M.; Haynes, R.W.; Hann, W.J. [and others]. 1998. Using an ecoregion assessment for integrated policy analysis. Journal of Forestry. 96(1): 33-38.

225. **Haynes, R.W.; Horne, A.L. 1997.** Economic assessment of the basin. In: Quigley, T.M.; Arbelbide, S.J. 1997 (see note 23).

Haynes, R.W.; Reyna, N.E.; Allen, S.D. 1998. Social and economic systems. Journal of Forestry. 96(10): 28-32.

226. **Interior Columbia Basin Ecosystem Management Project. 1997.** Commonly asked questions and answers: set 1. Interior Columbia River Basin Ecosystem Management Project. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

227. **Quigley, T.M.; Graham, R.T.; Haynes, R.W. 1999.** Interior Columbia basin ecosystem management policy case study. In: Johnson, K.N.; Swanson, F.; Henning, M.; Greene, S., eds. Bioregional assessments. Washington, DC: Island Press: 270-287. Chapter 11.

228. **Huppert, D.D.; Fight, R.D.; Everest, F.H. 1985.** Economic considerations. Gen. Tech. Rep. PNW-181. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 27 p. Part 14. (Meehan, W.R., tech. ed.; Influence of forest and rangeland management on anadromous fish habitat in western North America).

229. **Hueth, D.L.; Strong, E.J.; Fight, R.D., tech. eds. 1988.** Sport fishing: a comparison of three indirect methods for estimating benefits. Res. Pap. PNW-RP-395. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 99 p.

230. **Huppert, D.D.; Fight, R.D. 1991.** Economic considerations in managing salmonid habitats. In: Meehan, W.R., ed. Influences of forest and rangeland management on salmonid fishes and their habitats. Spec. Publ. 19. Bethesda, MD: American Fisheries Society: 559-585. Chapter 16.

231. **Alexander, S.J. 1995.** Economic analysis of forest management-fisheries interactions. Coastal Oregon Productivity Enhancement, Annual Report. 8(4): 9-11.

232. **von Hagen, B.; Weigand, J.F.; McLain, R. [and others], comps. 1996.** Conservation and development of nontimber forest products in the Pacific Northwest: an annotated bibliography. Gen. Tech. Rep. PNW-GTR-375. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 246 p.

233. **Blatner, K.; Alexander, S. 1998.** Recent price trends for nontimber forest products in the Pacific Northwest. Forest Products Journal. 48(1): 28-34.

Pilz, D.; Brodie, J.D.; Alexander, S.; Molina, R. 1998. Relative value of chanterelles and timber as commercial forest products. Ambio Spec. Rep. 9: 14-16.

Pilz, D.; Smith, J.; Amaranthus, M.P. [and others]. 1999. Managing the commercial harvest of the American matsutake and timber in the southern Oregon Cascade Range. Journal of Forestry. 97(3): 4-11.

Alexander, S.J. 1999. Indicator 14: Annual removal of nontimber forest products (e.g. fur bearers, berries, mushrooms, game) compared to the level determined to be sustainable. In: Oregon's forests at the millennium, a report to the Oregon State Legislature and a symposium. Salem, OR: Oregon Board of Forestry; Corvallis, OR: Oregon State University, College of Forestry: 64-68.

Alexander, S.J. 1999. Indicator 30: Value and quantities of production of nonwood forest products. In: Oregon's forests at the millennium, a report to the Oregon State Legislature and a symposium. Salem, OR: Oregon Board of Forestry; Corvallis, OR: Oregon State University, College of Forestry: 129-136.

Alexander, S.J. 1999. Indicator 34: Supply and consumption/use of nonwood forest products. In: Oregon's forests at the millennium, a report to the Oregon State Legislature and a symposium. Salem, OR: Oregon Board of Forestry; Corvallis, OR: Oregon State University, College of Forestry: 146-149.

234. **Kline, J.D.; Alig, R.J.; Johnson, R.L. 2000.** Forest owner incentives to protect riparian habitat. Ecological Economics. 33: 29-43.

235. **Alig, R.J.; Vasievich, J.M.; Lee, K.J. 1992.** Economic opportunities to increase timber growth on timberland. In: Qureshi, A., ed. Forests in a changing climate: North American conference on forestry responses to climate change. Washington, DC: Climate Institute: 115-125.

236. **Winnett, S.M.; Haynes, R.W.; Hohenstein, W.G. 1993.** Economic impacts of individual climate change mitigation options in the U.S. forest sector. Climate Research. 3(August): 121-128.

237. **Haynes, R.W.; Alig, R.J.; Moore, E. 1994.** Alternative simulations of forestry scenarios involving carbon sequestration options: investigation of impacts on regional and national timber markets. Gen. Tech. Rep. PNW-GTR-335. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 66 p.

238. **Mills, J.R.; Haynes, R.W. 1995.** Influence of climate change on supply and demand for timber. In: Productivity of America's forests and climate change. Gen. Tech. Rep. RM-271. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 46-55.

Joyce, L.A.; Mills, J.R.; Heath, L.S. [and others]. 1995. Forest sector impacts from changes in forest productivity under climate change. Journal of Biogeography. 22: 703-713.

239. **Alig, R.J.; Adams, D.M.; Haynes, R.W. 1996.** Regional changes in land uses and cover types: modeling links between forestry and agriculture. In: Global change and forestry, socioeconomic studies from the 1994 SOFEW meeting. Gen. Tech. Rep. SE-GTR-92. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 37-45.

Alig, R.J. 1997. Projecting land use shifts involving timberland: multi-sector approaches. In: Society of American Foresters national convention. Bethesda, MD: Society of American Foresters: 326-331.

240. **Alig, R.J.; Adams, D.M.; McCarl, B.A. 1998.** Impacts of incorporating land exchanges between forestry and agriculture in sector models. Journal of Agricultural and Applied Economics. 30(2, December): 389-401.

241. **Alig, R.J.; Adams, D.M.; McCarl, B.A. 1998.** Ecological and economic impacts of forest policies: interactions across forestry and agriculture. Ecological Economics. 27: 63-78.

242. **Alig, R.; Adams, D.; McCarl, B. [and others]. 1997.** Assessing effects of mitigation strategies for global climate change with an intertemporal model of the U.S. forest and agriculture sectors. Environmental and Resource Economics. 9: 259-274.

243. **Alig, R.J.; Adams, D.M.; McCarl, B.A. 1996.** Evaluation of effects of forestry and agricultural policies on forest carbon and markets. In: Fox, S.; Mickler, R.A., eds. The productivity and sustainability of southern forest ecosystems in a changing environment. New York: Springer-Verlag: 755-777.

244. **Adams, D.M.; Alig, R.J.; McCarl, B.A. [and others]. 1999.** Minimum cost strategies for sequestering carbon in forests. Land Economics. 75(3): 360-374.

245. **Harmon, M.E.; Harmon, J.M.; Ferrell, W.K.; Brooks, D. 1996.** Modeling carbon stores in Oregon and Washington forest products: 1900-1992. Climatic Change. 33: 521-550.

246. **Burton, D.M.; McCarl, B.A.; Adams, D.M. [and others]. 1996.** An exploratory study of the economic impacts of climate change on southern forests: preliminary results. In: Global change and forestry, socioeconomic studies from the 1994 SOFEW meeting. Gen. Tech. Rep. SE-GTR-92. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 5-18.

247. **Sohngen, B.L.; Haynes, R.W. 1997.** The potential for increasing carbon storage in United States unreserved timberlands by reducing forest fire frequency: an economic and ecological analysis. Climatic Change. 35: 179-197.

248. **Haynes, R.W.; Kaiser, H.F. 1990.** Forests: methods for valuing acidic deposition/air pollution effects. In: NAPAP state of science and technology. Rep. 27. Washington, DC: National Acid Precipitation Assessment: 109-115. Vol. 4, sect. B2.

Haynes, R.W.; Adams, D.M. 1990. Economic impacts of air pollution damage to U.S. forests. In: Proceedings division 4, 19th IUFRO world congress. Montreal: International Union of Forestry Research Organizations: 247-256.

Haynes, R.W.; Adams, D.M. 1992. Assessing economic impacts of air pollution damage to U.S. forests. In: de Steiguer, J.E., ed. The economic impact of air pollution on timber markets. Gen. Tech. Rep. SE-75. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 13-18.

249. **U.S. Department of Agriculture, Forest Service. 1963.** Timber trends in western Oregon and western Washington. Res. Pap. PNW-5. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

250. **Gedney, D.R. 1963.** Toward complete use of eastern Oregon's forest resources. Resour. Bull. PNW-3. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 71 p.

251. "Regulated" meant "normal," with equal areas in each age class.

252. **Newport, C.A. 1965.** Timber supply analysis. In: Proceedings of the 2nd annual forest industries marketing conference. Eugene, OR: University of Oregon: 137-144.

253. **Gedney, D.R.; Newport, C.A.; Hair, D. 1966.** Prospective economic developments based on the timber resources of the Pacific Northwest. In: Pacific Northwest economic base study for power markets: forest industries. Portland, OR: U.S. Department of the Interior; Bonneville Power Administration. 174 p. Vol. 2, part 6.

254. **Wall, B.R. 1969.** Projected developments of the timber economy of the Columbia-North Pacific Region. Res. Pap. PNW-84. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 87 p.

255. **Gedney, D.R.; Oswald, D.D.; Fight, R.D. 1975.** Two projections of timber supply in the Pacific Coast States. Resour. Bull. PNW-60. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station 40 p.

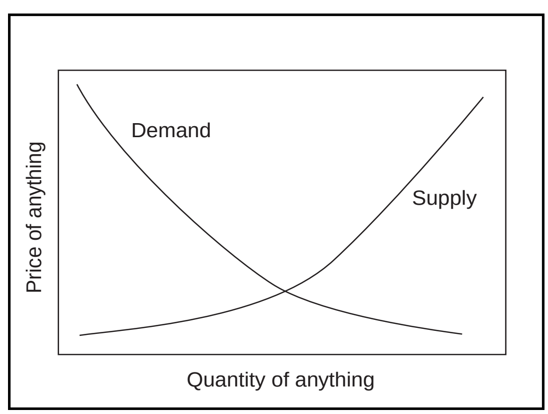
256. **Sassaman, R.W.; Schallau, C.H. 1970.** Allowable cut falldown: effects of log rules, rotations, and intensified management. Journal of Forestry. 68(10): 647-648.

Sassaman, R.W.; Schallau, C.H. 1970. Can log rules, intensified forestry affect the falldown in allowable cuts? Forest Industries. 97(9): 63.

Fight and Schweitzer 1974 (see note 155).

257. This note is for readers puzzled by the links and differences among supply and demand, production and consumption, sales and purchases, prices and quantities.

This graph is the primary portal to the economists' rookery. Within it resides the notion that producers are willing to produce and sell more of anything when prices are high. That price-production link is supply. Its companion curve is demand, which reflects low willingness to buy when prices are high, and so on. Where the curves cross is the supply-demand, production-consumption, sales-purchases transaction point. That price and that



quantity prevail...for a while. Any demand-supply chart pertains to a single period, and periods can range in length from moments, as in the stock market, to years. That the curves sag downward is generally but not always true. Demand and supply curves can pertain to past, present, or future periods. For longer periods, the curves are farther to the right and flatter, reflecting both larger amounts readily available for sale and more time to absorb purchases.

Now suppose one has a sense of the shapes of supply and demand curves pertinent to one period. Might they look different in later or earlier periods? Indeed; in particular, they shift. Rising imports from Canada shift the U.S. lumber supply curve rightward. If demand does not shift, the price-quantity intersection moves toward lower prices and larger purchases. But rising population or incomes may make demand shift rightward too. All that is the stuff of economic analysis.

For decades, early analysts of the national timber situation were flailed by economists for projecting future timber production and consumption without much reference to prices. Instead, trend lines of timber harvests or growth would be plotted with estimates of future need for timber. Usually, estimated future production was less than projected requirements. There was no systematic method for estimating whether consumption would adjust (downward) to match production or production would adjust (upward), or both; and if both, how far. Econometric methods that deal with the problem are used heavily at PNW and are mentioned in the main text.

258. **Mills, J.R.; Haynes, R.W. 1991.** Resource conditions around the Pacific Rim: the Pacific Coast States. In: Pacific Rim forestry—bridging the world: Proceedings of the 1991 Society of American Foresters national convention. Bethesda, MD: Society of American Foresters: 280-285.

259. **Haynes, R.W. 1993.** Economic prospects for the forest sector, Pacific Coast States. In: MediaMatch Communications, comps. Proceedings of a forest industry outlook conference: Alberta, growing for the future. Edmonton, AB: Alberta Economic Development and Tourism: 44-46.

260. **Haynes, R.W. 1993.** Public harvest reductions provides opportunity for small woodland owners. Northwest Woodlands. Winter: 16-17.

261. **Adams, D.M.; Haynes, R.W. 1990.** Public policies, private resources, and the future of the Douglas-fir region forest economy. Western Journal of Applied Forestry. 45(3): 64-69.

262. **Mills, J.R. 1990.** Western forests in transition: private timberlands. In: Forestry on the frontier: Proceedings of the 1989 Society of American Foresters national convention. Technical Group E1—economics, policy and law. Bethesda, MD: Society of American Foresters: 260-264.

263. **McWilliams, W.H.; Mills, J.R.; Burkman, W.G. 1993.** The state of the nation's forest land. National Woodlands. April: 8-13.

A counterpart presentation putting the private timberland situation into a national context was:

McWilliams, W.H.; Mills, J.R. 1992. Private sector timberland issues, status of forest resources in the United States. In: Private sector timberland issues, course materials. New Orleans: American Bar Association, Section of Natural Resources, Energy, and Environmental Law, Forest Resources Committee.

264. **Van Hooser, D.D.; Waddell, K.L.; Mills, J.R.; Tymcio, R.P. 1991.** The interior Douglas-fir resource: current status and projections to the year 2040. In: Baumgartner, D.M.; Lotan, J.E., comps., eds. Interior Douglas-fir, the species and its management: Symposium proceedings. Pullman, WA: Washington State University, Department of Natural Resource Sciences: 9-14.

265. **Weigand, J.F. 1998.** Composition, volume, and prices for major softwood lumber types in western Oregon and Washington, 1971-2020. Res. Pap. PNW-RP-509. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 61 p.

266. **Adams, D.M.; Alig, R.J.; Anderson, D.J. [and others].** 1992. Future prospects for western Washington's timber supply. Inst. For. Res. Contrib. 74. Seattle: University of Washington, College of Forest Resources. 210 p.

Auxiliary publications included:

Alig, R.J. 1992. Projecting area changes in forest management types in western Washington: ecological and economic factors. In: White, W., ed. Forestry and the environment-economic perspectives: Proceedings of the international conference on forestry and the environment. Rural Econ. Proj. Rep. Edmonton, AB: University of Alberta, Department of Rural Economy: 1-9.

Alig, R.; Adams, D. 1993. Long-term timber supply in western Washington: the role of nonindustrial private forest owners. Northwest Woodlands. 9(1): 14-15.

Anderson, D.J.; Alig, R.J.; Adams, D.M. 1994. Yield and inventory tables for western Washington, a technical supplement to future prospects for western Washington's timber supply. Spec. Pap. 12A. Seattle: University of Washington, College of Forest Resources, Center for International Trade in Forest Products. 149 p.

Alig, R.J.; Adams, D.M. 1995. Productivity of nonindustrial private forests in western Washington: alternative futures. Western Journal of Applied Forestry. 10(1): 29-35.

Adams, D.M.; Alig, R.J.; Stevens, J.A. 1994. An analysis of future softwood timber supply in western Washington. Western Journal of Applied Forestry. 9(3): 81-87.

267. **Bettinger, P.; Alig, R.J. 1996.** Timber availability on non-federal land in western Washington: implications based on physical characteristics of the timberland base. Forest Products Journal. 46(9): 30-38.

268. The compilation of forest exhaustion dates is from Clary 1986 (see note 154).

The more general discussion of ancient times depends on:

Steen 1976 (see note 202).

The 1896 estimate was in:

U.S. Department of Agrciulture, Division of Forestry. [1896]. Facts and figures regarding our forest resources briefly stated. Circ. 11. Washington, DC: Government Printing Office.

269. **Kellogg, R.S. 1906.** The timber supply of the United States in 1905. For. Serv. Circ. 52. Washington, DC: Government Printing Office. 16 p.

Kellogg 1907 (see note 3).

Kellogg, R.S. 1909. The timber supply of the United States. For. Serv. Circ. 166. Washington, DC: Government Printing Office. 24 p.

270. **Ficken, R.E. 1987.** The forested land, a history of lumbering in western Washington. Seattle: University of Washington Press. 324 p.

271. **Reynolds, R.V.; Pierson, A.H. 1923.** Lumber cut of the United States 1870-1920, declining production and high prices as related to forest exhaustion. Agric. Bull. 1119. Washington, DC: U.S. Department of Agriculture. 62 p.

272. **Gannett, H. 1899.** The forest reserves: Part 5. In: 19th annual report of the U.S. Geological Survey to the secretary of the Interior. Washington, DC: Government Printing Office: 15.

Cited in:

Steen, H.K. 1969. Forestry in Washington to 1925. Ann Arbor, MI: University Microfilms. 296 p. Ph. D. dissertation. [from Univ. Wash.].

273. Timber famine, or at least timber scarcity, was an important element of the conservation movement a century ago. Vast harvests across the Nation, propelled by railroad expansion, population growth, and logging technology, were followed by perceived climate changes and forecasts that civilization itself might be threatened by resource profligacy. Surely, timber famine had spread across New England, then regions westward and southward. White pine and chestnut (*Castanea* spp.), arguably the Nation's most important trees ever, disappeared. But the Nation never ran out of trees for cutting, partly because trees couldn't be kept from growing and partly because of expanded commercial acceptance of formerly unwanted species and their size and remoteness. That was certainly apparent in the Northwest.

Absent famine, was Northwest timber ever scarce? Indeed, we ran out of the timber that had made the Northwest world famous: big, close-grained softwoods without blemishes. Along the way, their supply shrank, and "big" came to mean diameters of 4 feet rather than 8. By the 1990s, 2 feet was "big."

Economists look to price as the best indicator of scarcity. "The price of lumber, not the quantity remaining on the Pacific coast, is the factor which will determine whether your son will build a house," said economists R.V. Reynolds and Albert H. Pierson in 1923 (cited below in this note). If timber shrinks in abundance but consumption falls faster, prices may decline and economic scarcity does not occur. This has happened for many resource commodities since 1870. For timber, though, and even for ordinary logs, prices have moved erratically upward in real terms for at least 130 years. Good wood and old trees are ever scarcer.

Economic scarcity, like most economic concepts, is not without "yes, buts." For instance, U.S. lumber prices obviously are influenced by growing imports from Canada and wood exports (lately diminished) to Japan. Sharp changes in these factors and U.S. home-building may affect wood prices far more in any decade than forest exhaustion or renewal. So also can technology. For instance, as the quantity of large logs needed for plywood declined, new manufacturing methods and new panel products held plywood prices in check. Its prime raw material became scant but the product did not.

The classic study on this subject is:

Barnett, H.; Morse, C. 1963. Scarcity and growth. Baltimore: Johns Hopkins. 288 p.

Their data were carried to 1973 by:

Manthy, R. 1978. Natural resources—a century of statistics. Baltimore: Johns Hopkins. 240 p.

An interesting followup is:

Smith, V.K. 1979. Scarcity and growth reconsidered. Baltimore: Johns Hopkins. 298 p.

An update of real prices to 1998 is in:

Brown, P.A.; Wolk, D. 2000. Natural resource scarcity and technological change. In: Economic and Financial Review: 1st quarter. [Place of publication unknown]: Federal Reserve Bank of Dallas.

Wood's ever-rising prices have been chronicled by:

Reynolds, R.V.; Pierson, A.H. 1923. Lumber cut of the United States 1870-1920, declining production and high prices as related to forest exhaustion. Bull. 1119. Washington, DC: U.S. Department of Agriculture. 62 p.

Irland, L. 1974. Is timber scarce? The economics of a renewable resource. Bull. 83. New Haven, CT: Yale University, School of Forestry and Environmental Studies. 97 p.

Skog, K.; Risbrudt, C. 1982. Trends in economic scarcity of U.S. timber commodities. Resour. Bull. FPL–11. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 25 p.

Manthy 1978 (cited in this note, above).

Reaching back to 1800 for lumber prices are:

Howard, J.L. 2001. U.S. timber production, trade, consumption, and price statistics 1965-1999. Gen. Tech. Rep. FPL-GTR-98. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 90 p.

Haynes, R.W. 1998. Stumpage prices, volume sold, and volumes harvested from the national forests of the Pacific Northwest region, 1984 to 1996. Gen. Tech. Rep. PNW-GTR-423. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 91 p.

274. **U.S. Department of Agriculture, Forest Service. 1946-48.** A reappraisal of the forest situation. Washington, DC.

Six reports are included:
- Report 1. Gaging the timber resource. 62 p.
- Report 2. Potential requirements for timber products. 70 p.
- Report 3. The management status of forest lands. 39 p.
- Report 4. Wood waste. 45 p.
- Report 5. Protection against forest insects and diseases. 39 p.
- Report 6. Forest cooperatives. 18 p.

275. **U.S. Department of Agriculture, Forest Service. 1958.** Timber resources for America's future. For. Resour. Rep. 14. Washington, DC. 715 p.

276. **U.S. Department of Agriculture, Forest Service. 1965.** Timber trends in the United States. For. Resour. Rep. 17. Washington, DC. 235 p.

277. **U.S. Department of Agriculture, Forest Service. 1974.** The outlook for timber in the United States. For. Resour. Rep. 20. Washington, DC. 374 p.

278. **Fight, R.D.; Gedney, D.R. 1973.** The land base for management of young-growth forests in the Douglas-fir region. Res. Pap. PNW-159. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 24 p.

279. **Seaton, F.A.; Clawson, M.; Hodges, R., Jr. [and others]. 1973.** Report of the President's advisory panel on timber and the environment [the PAPTE report]. Washington, DC: Government Printing Office. 541 p.

280. Seaton and others 1973: 113 (see note 279).

281. It was my view at the time that RPA was not special-interest legislation. Rather, it embodied the hopes of almost everybody concerned:

Economists and budget people—A move beyond "requirements" and gaps to supply and demand, incremental analyses, and financial-return examination of alternatives.

Congress—Making the budget transparent, seeing where the money went, and what was gained for additional funds spent.

Timber industry—A chance to show, by using regional inventories and new harvest scheduling schemes, that federal harvests could be increased.

Recreation planners—A chance to display consequences of the looming 4-day workweek and the changing mix of recreation types and places.

Resource planners generally—Bringing other resources into the same analytical framework and prominence as timber and showing how multiple use can work. Displaying the no-free-lunch situation of water quality, aesthetics, etc.

And to change planning processes:

Integrative planning—The agency said it could mesh top-down with bottom-up planning. This would be a place to demonstrate it.

Sequential planning—Here would be displayed the way that national and regional plans would flow from an assessment.

Options and criteria—By displaying alternative output mixes and various levels of those mixes relative to costs, options could be arrayed against a list of specific criteria.

282. Prof. John Zivnuska, University of California, is quoted by Steen (1976, see note 202) as having made such a proposal after TRR appeared.

283. **U.S. Department of Agriculture, Forest Service. 1977.** The nation's renewable resources—an assessment, 1975. For. Resour. Rep. 21. Washington, DC. 243 p.

284. **U.S. Department of Agriculture, Forest Service. 1982.** An analysis of the timber situation in the United States 1952-2030. For. Resour. Rep. 23. Washington, DC. 499 p.

Collateral publications involving PNW were:

Haynes, R.W.; Adams, D.M. 1981. Matching projections of supply and demand for forest products in the U.S. Forest Products Journal. 31(10): 77-81.

McKillop, W.; Adams, D.M.; Haynes, R.W. 1981. National impacts of softwood product price increases. Journal of Forestry. 79(12): 807-809.

A longer version of this paper is:

McKillop, W.; Adams, D.; Haynes, R.; Geissler, P. 1980. Social, economic and environmental effects of rising timber prices. Berkeley, CA: University of California. 59 p. Available from NTIS, 5825 Port Royal Rd., Springfield, VA 22161. (PB-83-105-387).

Stabilized prices would, relative to assessment projections, increase wood product output (because increased supply would be needed to hold prices in the face of rising demand); industry employment would rise; consumers would spend less for wood products; and the balance of payments would gain because of reduced demand for (Canadian) imported wood.

Haynes, R.W.; Adams, D.M. 1983. Research on TAMM and other elements of the U.S. timber assessment system. In: Seppala, R.; Row, C.; Morgan, A., eds. Forest sector models: Proceedings, 1st North American conference. Berkhamsted, England: A B Academic Publishers: 9-25.

Haynes, R.W.; Adams, D.M. 1983. Changing perceptions of the U.S. forest sector: implications for the RPA timber assessment. American Journal of Agricultural Economics. 65(5): 1002-1009.

Adams, D.M.; Haynes, R.W. 1985. Changing perspectives on the outlook for timber in the United States. Journal of Forestry. 83(1): 32-35.

The last two papers describe how simultaneous changes in only a few of the many assumptions implicit in long-term projections can reverse the scarcity scenarios of contemporary outlook studies.

285. **U.S. Department of Agriculture, Forest Service. 1980.** An assessment of the forest and rangeland situation in the United States. Washington, DC. 631 p.

286. **Adams, D.M.; Haynes, R.W. 1979.** Changing patterns of location and wood use characteristics in the U.S. forest products industry: projections for 1980-2030. In: Timber supply: issues and options: Forest Products Research Society proceedings. Section P-79-24. Madison, WI: Forest Products Research Society: 52-60.

A recap of the 1980 timber situation report and the intensive-management and harvest-departure alternatives was:

Adams, D.M.; Haynes, R.W. 1981. The demand-supply-price outlook for U.S. timber. In: Timber demand: the future is now: Proceedings of a conference. Madison, WI: Forest Products Research Society: 43-55.

287. **U.S. Department of Agriculture, Forest Service. 1983.** America's renewable resources: a supplement to the 1979 assessment of the forest and range land situation in the United States. FS-386. Washington, DC. 113 p.

This was known as the 1983 update. A companion analysis was:

Haynes, R.W.; Adams, D.M. 1985. Simulations of the effects of alternative assumptions on demand-supply determinants on the timber situation in the United States: a supporting technical analysis to America's renewable resources—a supplement to the 1979 assessment of the forest and range land situation in the United States. Washington, DC: U.S. Department of Agriculture, Forest Service, Forest Resources Economics Research. 113 p.

288. **Haynes, R.W. 1986.** Future supply and demand for United States timber. In: Assessing timberland investment opportunities: Proceedings. Madison, WI: Forest Products Research Society: 27-32.

289. **U.S. Department of Agriculture, Forest Service. 1988.** The South's fourth forest: alternatives for the future. For. Resour. Rep. 24. Washington, DC: 256 p. [plus appendicies].

Adams, D.M.; Haynes, R.W. 1991. Softwood timber supply and the future of the Southern forest economy. Southern Journal of Applied Forestry. 15(1): 31-37.

290. **Haynes, R.W. 1987.** An assessment of the United States resources: the national perspective. In: North American wood/fiber supplies and markets, strategies for managing change: Proceedings of a conference. Madison, WI: Forest Products Research Society: 57-60.

Similar points were made and elaborated in:

Haynes, R.W. 1988. Timber supply prospects for the Pacific Northwest. In: Marketing logs, timber, lumber and chips to the Pacific Rim: Proceedings of a conference. Seattle: Jay Gruenfeld Associates, Inc.: 31-41.

Here Haynes warned that wood product costs would rise in the West, and there would be no comparative advantage in reconstituted panels in the region.

Haynes, R.W. 1988. Future forest product market opportunities for the Pacific Northwest and British Columbia. In: Merrifield, D.E.; Monahan, R.L.; Alper, D.K., eds. Growth and cooperation in the British Columbia and Washington state economies: new directions on the eve of the US/Canada Free Trade Agreement: Proceedings of a conference. Bellingham, WA: Western Washington University: 143-147.

This paper pointed out that the Southern study anticipated strong growth in U.S. consumption of solid and fiber wood products, limited growth in the domestic resource inventory, and 50 years of real growth in forest products prices.

Haynes, R.W.; Brooks, D.J.; Jackson, K.C. 1988. Current and prospective supply and demand factors affecting the future health of Oregon's forest industry. In: Lettman, G.J.; Stere, D.H., comps., eds. Assessment of Oregon's forests. Salem, OR: Oregon State Department of Forestry: 191-196.

This paper repeated the warning that the Northwest will have no economic advantage because of its relatively high raw material costs.

Haynes, R.W. 1989. The demand for wood products in the 21st century. In: Gasser, D.; Nakamura, G., eds. Growing wood for the 21st century markets: Proceedings of a symposium. Publ. 3325. Berkeley, CA: University of California, Cooperative Extension: 32-36.

Forest products consumption was seen as expanding in the next century as would timber inventories.

Haynes, R.W. 1989. Long-term demand for hardwoods in the United States. In: Hall, O.F.; McElwee, R.L., eds. Eastern hardwoods—an emerging forestry frontier: Proceedings of the 18th forestry forum. Blacksburg, VA: Virginia Cooperative Extension Service, Virginia Polytechnic Institute and State University: 6-19.

Key points were that U.S. hardwood harvests were expected to expand more than softwood harvests in future, with low-valued materials becoming the outlet for more of the harvest. Stumpage prices for hardwoods were expected to increase at historic (low) rates.

291. **Haynes, R.W. 1990.** An analysis of the timber situation in the United States: 1989-2040, a technical document supporting the 1989 USDA Forest Service RPA assessment. Gen. Tech. Rep. RM-199. Fort Collins, CO: U.S. Department Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 269 p.

A summary is in:

Haynes, R.W.; Adams, D.M. 1992. The timber situation in the United States—analysis and projections to 2040. Journal of Forestry. 90: 38-43.

292. **Alig, R.J. 1990.** Non-industrial private forests: timber supply for an uncertain future. Western Wildlands. 16(Fall): 11-14.

293. **Haynes, R.W.; Adams, D.M.; Mills, J.R. 1995.** The 1993 RPA timber assessment update. Gen. Tech. Rep. RM-259. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 66 p.

Underlying assumptions were discussed in:

Haynes, R.W.; Adams, D.M.; Mills, J.R. 1994. Major supply and demand assumptions for the TAMM projections. In: Yukutake, K.; Yoshimoto, A., eds. Environmental preservation issues and wood trades among Japan, U.S., and Canada: Proceedings of the SATT project symposium. Miyazaki, Japan: Miyazaki University: 204-218.

At the Miyazaki conference Haynes, Adams, and Mills also presented:

Haynes, R.W.; Adams, D.M.; Mills, J.R. 1994. TAMM projections for the SATT project. In: Yukutake, K.; Yoshimoto, A., eds. Environmental preservation issues and wood trades among Japan, U.S., and Canada: Proceedings of the SATT project symposium. Miyazaki, Japan: Miyazaki University: 95-133.

At a pulping conference Haynes alluded to prospective geographic shift of timbering to the South, only partly a result of habitat protection, roadless areas remaining roadless, and reductions in below-cost timber sales. He also cited a continuing shift to recycled fiber and more substitution of alternative building materials. The paper industry would become even more dependent on roundwood relative to residues in the West and rising costs in the face of relatively flat pulp and paper prices. His report, based on the 1993 timber assessment, was:

Haynes, R.W. 1994. One perspective of fiber supplies in the United States. In: 1994 pulping conference, book 2: Proceedings. Atlanta: TAPPI Press: 557-563.

294. **Brooks, D.J. 1993.** U.S. forests in a global context. Gen. Tech. Rep. RM-228. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 24 p.

Derivative publications were:

Brooks, D.J. 1993. International dimensions of U.S. forestry. In: Agriculture's changing horizon: Proceedings of the 69th annual outlook conference. [Place of publication unknown]: [Publisher unknown]: 239-253.

Brooks, D.J. 1993. International dimensions of U.S. forestry. Forests Today and Forever. 7(2): 10-14, 16.

Brooks, D.J. 1994. Global forestry issues: United States forests in an international context. In: Yukutake, K.; Yoshimoto, A., eds. Environmental preservation issues and wood trade among Japan, U.S., and Canada: Proceedings of the SATT project symposium. Miyazaki, Japan: Miyazaki University: 80-94.

295. **Johnson, E.R.; Strait, E.D. 1924.** Farming the logged-off uplands in western Washington. Bull. 1236. Washington, DC: U.S. Department of Agriculture. 36 p. In cooperation with: Agricultural Experiment Station, State College of Washington.

The authors noted that financial progress of the settlers, where it occurred, depended more on rising suburban real estate values than on income from poultry, small fruits, and dairying. Stump ranching in the hills above Puget Sound was tough.

296. **Kains, M.G. 1935.** Five acres and independence, a practical guide to the selection and management of the small farm. New York: Greenberg Publisher, Inc. 397 p.

297. **U.S. Senate. 1941.** Forest lands of the United States, report of the Joint Committee on Forestry. 77th Congress, 1st session, Document No. 32. Pursuant to Senate Concurrent Resolution 31 (75th Congress) and House Concurrent Resolutions 11, 23, and 51 (76th Congress). Washington, DC: Government Printing Office. 382 p.

In his transmittal letter, Chairman John Bankhead alluded to "transition from a philosophy of exploitation to one of planning and applying sustained yield management and orderly utilization." He mentioned "the worth whileness of forest conservation—the wise use of timber and the other products and services of the forest." He said, "[a forest economy] can help materially to increase rural employment and income, particularly in some of our most critical rural problem areas." "[The forest economy] can supply in reasonable abundance services which, though more intangible, are nonetheless of vital importance." And he said that, "the knowledge necessary to accomplish this transition is as varied and complex as are the forest conditions and their economic and social relations." These quotations probably reflect well the forestry ethic of the time, which persisted for at least 30 more years.

298. **Wall, B.R. 1981.** Trends in commercial timberland area in the United States by state and ownership 1952-77, with projections to 2030. Gen. Tech. Rep. WO-31. Washington, DC: U.S. Department of Agriculture, Forest Service. 26 p.

299. **Alig, R.J.; Brooks, D.J.; Ingram, D. 1987.** The role of land-use change in forest sector modeling. In: Cardellichio, P.A.; Adams, D.M.; Haynes, R.W. 1987. Forest sector and trade models, theory and applications: Proceedings of an international symposium. Seattle: University of Washington, College of Forest Resources: 267-273.

300. **U.S. Department of Agriculture, Forest Service. 1989.** An analysis of the land base situation in the United States: 1989-2040, a technical document supporting the 1989 USDA Forest Service RPA assessment. Gen. Tech. Rep. RM-181. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station. 77 p.

301. **Waddell, K.L.; Oswald, D.D.; Powell, D.S. 1989.** Forest statistics of the United States, 1987. Resour. Bull. PNW-RB-168. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 106 p.

302. **U.S. Department of Agriculture, Forest Service. 1989.** (See note 300).

A related publication was:

Alig, R.J.; Hohenstein, W.; Murray, B.; Haight, R. 1990. Changes in area of timberland in the United States, 1952-2040, by ownership, forest type, region, and state. Gen. Tech. Rep. SE-64. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 34 p.

303. **Alig, R.J. 1990.** Non-industrial private forests: timber supply for an uncertain future. Western Wildlands. Fall: 11-14.

Related publications were:

Alig, R.J.; Wear, D.N. 1992. Changes in private timberland, statistics and projections for 1952 to 2040. Journal of Forestry. 90(5): 31-36.

Alig, R.J. 1992. Projecting forest area changes in forest sector analysis. In: Haynes, R.; Harou, P.; Mikowski, J., comps. Forestry sector analysis for developing countries: Proceedings of working groups S6.12-03 and S6.11-00. Seattle: University of Washington, College of Forest Resources, CINTRAFOR: 91-97.

304. **Adams, D.M.; Alig, R.J.; McCarl, B.A. [and others]. 1996.** An analysis of the impacts of public timber harvest policies on private forest management in the United States. Forest Science. 42(3): 343-358.

A later publication reflecting the same approach was:

Alig, R.J.; Adams, D.M.; Chmelik, J.T.; Bettinger, P. 1999. Private forest investments and long-run sustainable harvest volume. New Forests. 17: 307-327.

305. **Zheng, D.; Alig, R.J. 1999.** Changes in the non-federal land base involving forestry in western Oregon, 1961-94. Res. Pap. PNW-RP-518. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

306. **Kline, J.D.; Alig, R.J. 1999.** Does land use planning slow the conversion of forest and farm lands? Growth and Change. 30(Winter): 3-22.

An earlier, related publication, covering national land use, was:

Alig, R.J.; Healy, R.G. 1987. Urban and built-up land area changes in the United States: an empirical investigation of determinants. Land Economics. 63(3): 215-226.

307. **Alig, R.J.; Zheng, D.; Spies, T.A.; Butler, B.J. 2000.** Forest cover dynamics in the Pacific Northwest west side: regional trends and projections. Res. Pap. PNW-RP-522. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

308. **Plantinga, A.J.; Mauldin, T.; Alig, R.J. 1999.** Land use in Maine: determinants of past trends and projections of future changes. Res. Pap. PNW-RP-511. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 20 p.

Mauldin, T.; Plantinga, A.J.; Alig, R.J. 1999. Land use in the Lake States region: an analysis of past trends and projections of future changes. Res. Pap. PNW-RP-519. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 24 p.

309. **Darr, D.; Glass, R.; Ellis, T.; Schmiege, D. 1977.** An overview of some economic options for southeast Alaskan timber. Juneau, AK: U.S. Department of Agriculture, Forest Service, Alaska Region; Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 219 p.

310. **Bell, E. 1977.** Distributional implications of stumpage markets in southern Alaska. In: Darr and others. 1977: 212-219 (see note 309).

311. **Lane, C.L. 1998.** Log export and import restrictions of the U.S. Pacific Northwest and British Columbia: past and present. Gen. Tech. Rep. PNW-GTR-436. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 61 p.

312. **Darr, D.R. 1978.** Potential impact of easing the log export restriction on the Tongass National Forest. Resour. Bull. PNW-77. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiement Station. 18 p.

313. **Fight, R.D.; Garrett, L.D.; Weyermann, D.L., tech. eds. 1990.** SAMM: a prototype southeast Alaska multiresource model. Gen. Tech. Rep. PNW-GTR-255. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 109 p.

Underlying studies were reflected in various chapters:

Garrett, L.D.; Fight, R.D.; McNamee, P.J. Development of SAMM: 1-7.

McNamee, P.J.; Garrett, L.D.; Fight, R.D.; Mehrkens, J.R. Specification of the model: 8-12.

Farr, W.A.; McNamee, P.J.; Gerdes, R.L. [and others]. The timber submodel: 13-27.

Swanston, D.N.; Webb, T.M.; Bartos, L. [and others]. The hydrology and soils submodel: 28-45.

Murphy, M.L.; Koski, K.V.; Elliot, S.T. [and others]. The fisheries submodel: 46-63.

Kirchhoff, M.D.; Hanley, T.A.; Schoen, J.W. [and others]. The deer submodel: 64-78.

Garrett, L.D.; Fight, R.D.; Weyermann;. D.L.; Mehrekns, J.R. 1 Using the model SAMM: implications for management: 79-89.

A how-to guide also was published:

Weyermann, D.L.; Fight, R.D.; Garrett, L.D. 1991. A users guide for SAMM: a prototype southeast Alaska multiresource model. Gen. Tech. Rep. PNW-274. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 50 p.

Derivative publications included:

Garrett, L.D.; Fight, R.D. 1988. Modeling multiresource response to forest management activities in southeast Alaska. In: Charles, A.T.; White, G.N., III, eds. Natural resource modelling and analysis: Proceedings of the first interdisciplinary conference on natural resource modelling and analysis. [Place of publication unknown]: Saint Mary's University; Bedford Institute of Oceanography: 71-74.

Garrett, L.D.; Fight, R.D.; Weyermann, D.L. 1990. SAMM: the southeast Alaska multiresource model. In: Wensel, L.C.; Biging, G.S., eds. Forest simulation systems: Proceedings of the IUFRO conference. Bull. 1927. [Place of publication unknown]: University of California Division of Agriculture and Natural Resources: 355-360.

Garrett, L.D.; Fight, R.D.; Weyermann, D.L. 1992. SAMM: the southeast Alaska multiresource model. In: Adams, D.; Haynes, R.; Lippke, B.; Perez-Garcia, J., comps. Forest sector, trade and environmental impact models—theory and applications: Proceedings of an international symposium. Seattle: University of Washington, College of Forest Resources, CINTRAFOR: 179-186.

314. **Maki, W.R.; Olson, D.; Schallau, C.H. 1985.** A dynamic simulation model for analyzing the importance of forest resources in Alaska. Res. Note PNW-432. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 12 p.

315. **Flora, D.F.; Vlosky, R.P. 1986.** Potential Pacific Rim demand for construction-grade logs. Res. Pap. PNW-364. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 32 p.

316. **Flora, D.F.; McGinnis, W.J. 1989.** Alaska midgrade logs: supply and offshore demand. Res. Pap. PNW-RP-411. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 13 p.

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The maps are in:

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Greeley, W.B. 1917. Some public and economic aspects of the lumber industry. Rep. 14. Washington, DC: U.S. Department of Agriculture.

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367. **Mead, W.J.; Hamilton, T.E. 1968.** Competition for federal timber in the Pacific Northwest—an analysis of Forest Service and Bureau of Land Management timber sales. Res. Pap. PNW-64. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 63 p.

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373. **Haynes, R.W. 1980.** Competition for national forest timber in the Northern, Pacific Southwest, and Pacific Northwest Regions. Res. Pap. PNW-266. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 72 p.

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Fight, R.D.; Fahey, T.D.; Briggs, D.G. 1989. Growing Douglas-fir for a “quality” market. Unpublished document. On file with: Roger Fight, U.S. Department of Agriculture, Pacific Northwest Research Station, Forestry Sciences Laboratory, P.O. Box 3890, Portland, OR 97208-3890.

Fight, R.D. 1989. Western forests in transition: national forests. In: Forestry on the frontier. Proceedings of the 1989 SAF national convention. Bethseda, MD: Society of American Foresters: 257-259.

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Vincent, J.R.; Haynes, R.W.; Cardellichio, P.A.; Brooks, D.J. 1990. Modeling forest sector dynamics: challenges for future analysis. In: Haynes, R.; Lonnstedt, L.; Mikowski, J., eds. Proceedings of a working group S4.08, 19th IUFRO world congress. [Place of publication unknown]: [Publisher unknown]: 12-16.

Vincent, J.R.; Haynes, R.W.; Cardellichio, P.A.; Brooks, D.J. 1990. Modeling forest sector dynamics: challenges for future analysis. In: Proceedings division 4, 19th IUFRO world congress. Montreal: IUFRO: 445-449.

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392. **Talmadge, H.E. 1977** (25 October). Letter to George Craig, executive vice president, Western Timber Association. On file with: Pacific Northwest Research Station, Forestry Sciences Laboratory, P.O. Box 3890, Portland, OR 97208-3890.

393. **Haynes, R. 1977.** A derived demand approach to estimating the linkage between stumpage and lumber markets. Forest Science. 23(2): 281-288.

394. **Haynes, R.W.; Connaughton, K.P.; Adams, D.M. 1980.** Stumpage price projections for selected western species. Res. Note PNW-367. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 14 p.

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Adams, D.M.; Haynes, R. 1982. Arriving at departures. Forest Planning. (September): 8-11.

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397. **Jackson, K.C. 1988.** Recent changes in costs of shipping forest products by rail. Res. Note PNW-RN-471. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 13 p.

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Cubbage, F.W.; Haynes, R.W. 1988. Forest resources, free markets, and public policy. Forum for Applied Research and Public Policy. 3(1): 39-46.

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The southern document is:

U.S. Department of Agriculture 1988 (see note 289).

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Adams, D.M.; Haynes, R.W. 1991. National forest timber supply and stumpage markets in the Western United States. Res. Pap. PNW-RP-435. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 55 p.

403. **Haynes, R.W.; Fight, R.D. 1992.** Price projections for selected grades of Douglas-fir, coast hem-fir, inland hem-fir, and ponderosa pine lumber. Res. Pap. PNW-RP-447. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 20 p.

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National Commission on Materials Policy. 1973. Material needs and the environment today and tomorrow. Washington, DC: Government Printing Office; final report of the National Commission on Materials Policy. 819 p.

Cliff, E.P. 1973. Timber, the renewable material: perspective for decision. Washington, DC: U.S. Government Printing Office.

An entire issue of the journal Science (191:4228) was devoted to materials policy in February 1976. Of 11 papers, 6 dealt with wood products:

Abelson, P.H.; Hammond, A.L. The new world of materials: 633-636.

Radcliffe, S.V. World changes and chances: some new perspectives for materials: 700-707.

Bethel, J.S.; Schreuder, G.F. Forest resources: an overview: 747-752.

Spurr, S.H.; Vaux, H.J. Timber: biological and economic potential: 752-756.

Jahn, E.C.; Preston, S.B. Timber: more effective utilization: 757-761.

Clawson, M. The national forests: 762-767.

406. **Manthy, R.S. 1977.** Scarcity, renewability, and forest policy. Journal of Forestry. 75(4): 201-205.

407. **Flora, D.F. 1977.** Long-term strategic objectives of the Nation as a factor in public timber policy. In: Background reports to timber harvest scheduling issues study. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 31 p. Vol. 1.

A tighter version was:

Flora, D.F. 1973. Timber as a strategic resource. Journal of Forestry. 71(7): 396-398.

This was the first article ever specifically solicited by the Forestry Sciences Board of SAF.

408. **Adams, T.C.; Hamilton, T.E. 1965.** Value and employment associated with Pacific Northwest log exports to Japan. Res. Pap. PNW-27. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 15 p.

409. Darr 1975 (see note 334).

410. **Hamilton, T.E. 1971.** Log export policy: theory vs. reality. Journal of Forestry. 69(8): 494-497.

411. **Austin, J.W. 1969.** Log export restrictions of the western states and British Columbia. Res. Pap. PNW-91. 13 p.

The federal constraint was the then-famous Morse Amendment to the Foreign Assistance Act of 1968.

412. **Lindell, G.R. 1978.** Log export restrictions of the western states and British Columbia. Gen. Tech. Rep. PNW-63. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 14 p.

413. **Beuter, J.H. 1969.** Webb-Pomerene export trade associations and the wood products industries, or Can the Webb-Pomerene Act help the U.S. sell more processed wood to Japan? Res. Pap. PNW-74. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 14 p.

414. **Haynes, R.W. 1976.** Price impacts of log export restrictions under alternative assumptions. Res. Pap. PNW-212. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 25 p.

415. **Darr, D.R. 1976.** Effects of national forest timber flows on international trade patterns. In: Background reports to timber harvest scheduling issues study. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 53 p. Vol. 1.

416. **Darr, D. 1979.** The Japanese market for softwood logs: a status report. Wood Review. 2(19): 1.

417. **Darr, D.R. 1979.** World wood fiber resources. In: Future technical needs and trends in the paper industry. III: Presentations at the TAPPI annual meeting. Atlanta: Technical Association of the Pulp and Paper Industry: 23-33.

418. **Darr, D.R. 1979.** The impacts of international trade in domestic markets. In: The impact of change on the management of private forest lands in the Northwest: Proceedings. [Place of publication unknown]: [Publisher unknown]: 25-34.

419. **Darr, D.R. 1978.** World markets for timber and forest products. In: North America's forests: gateway to opportunity: Proceedings of the 1978 Society of American Foresters convention. Washington, DC: Society of American Foresters: 32-37.

420. **Lindell, G.R. 1978.** Log export restrictions vary between western jurisdictions. Forest Industries. 105(5): 48-50, 76.

421. **Lindell, G.R. 1979.** World softwood lumber trade: patterns, trends, and prospects. Forest Products Journal. 29(7): 43-48.

422. **Darr, D.W. 1979.** The softwood log export issue: options and consequences. RPA Issue 5. 74 p. Unpublished report: On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

423. **Lindell, G.R. 1980.** Substitution and the USDA Forest Service log export restrictions. Res. Note PNW-355. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 6 p.

424. **Darr, D.R.; Haynes, R.W.; Adams, D.M. 1980.** The impact of the export and import of raw logs on domestic timber supplies and prices. Res. Pap. PNW-277. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 38 p.

425. **Darr, D.R. 1980.** Softwood log export policy: the key questions. Journal of Forestry. 78(3): 138-140, 151.

426. **Darr, D.R.; Lindell, G.R. 1980.** Prospects for U.S. trade in timber products: the setting. Forest Products Journal. 30(3): 17-21.

Darr, D.R.; Lindell, G.R. 1980. Prospects for U.S. trade in timber products: imports. Forest Products Journal. 30(4): 16-20.

Darr, D.R.; Lindell, G.R. 1980. Prospects for U.S. trade in timber products: exports. Forest Products Journal. 30(5): 21-27.

Darr, D.R.; Lindell, G.R. 1980. Prospects for U.S. trade in timber products: implications. Forest Products Journal. 30(6): 16-20.

Work for the 1979 assessment was also the foundation for a conference paper by Darr:

Darr, D.R. 1980. U.S. exports and imports of some major forest products—the next fifty years. In: Sedjo, R.A., ed. Issues in U.S. international forest products trade: Proceedings of a workshop. Res. Pap. R-23. Washington, DC: Resources for the Future: 54-83.

At the same conference Haynes, Darr, and Darius Adams presented TAMM-based domestic impacts of a total ban on log exports. They pointed out that previous analysts differed on whether a ban would lower or raise domestic lumber prices (down if more logs led to more lumber, up if that lumber were exported to replace logs). They compared two extreme scenarios, in which Japan would replace either all or none of the lost log supply by turning to Canadian lumber. Given time for regional lumber production to increase, there was little difference between the two scenarios. This was:

Haynes, R.; Darr, D.; Adams, D. 1980. U.S.-Japanese log trade—effect of a ban. In: Sedjo, R.A., ed. Issues in U.S. international forest products trade: proceedings of a workshop. Res. Pap. R-23. Washington, DC: Resources for the Future: 216-232.

427. **Ueda, M.; Darr, D.R. 1980.** The outlook for housing in Japan to the year 2000. Res. Pap. PNW-276. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 25 p.

428. Haynes 1976 (see note 414) and Darr 1976 (see note 415).

429. **Darr, D.R. 1981.** Interactions between domestic and export markets for softwood lumber and plywood: tests of six hypotheses. Res. Pap. PNW-293. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 22 p.

430. **Darr, D.R. 1982.** Pacific Northwest timberlands. In: English, H.E.; Scott, A., eds. Renewable resources in the Pacific: Proceedings, 12th Pacific trade and development conference. Vancouver, BC: International Development Research Centre: 103-116.

431. **Darr, D.R.; Lindell, G.R. 1982.** International trade in forest products. In: An analysis of the timber situation in the United States, 1952-2030. For. Resour. Rep. 23. Washington, DC: U.S. Department of Agriculture, Forest Service: 73-103.

432. **Darr, D.R. 1983.** How export promotion programs influence trade. Forest Products Journal. 33(4): 15-20.

433. **Darr, D.R. 1983.** Methods of analysis of bilateral and multilateral trade among major forest product trading partners. In: Seppala, R.; Row, C.; Morgan, A., eds. Forest sector models: Proceedings, first North American conference. Berkhamsted, England: A B Academic Publishers: 287-299.

434. **Darr, D. 1984.** U.S. trade in timber products: a background report. Washington, DC: U.S. Department of Agriculture, Forest Service. [Unnumbered pages].

435. **Darr, D.R. 1984.** Conversion factors can affect forest products trade policies. Journal of Forestry. 82(8): 489-492.

436. Haynes and Adams 1985 (see note 287).

437. **Haynes, R.W.; Adams, D.M. 1985.** Trade related issues shaping U.S. forest policies in the 1980s. In: Proceedings, 3rd North American IIASA network meeting. Vancouver, BC: Forest Economics and Policy Analysis Project, University of British Columbia: 213-225.

438. **Flora, D.F.; Vlosky, R.P. 1986.** Potential Pacific Rim demand for construction-grade softwood logs. Res. Pap. PNW-364. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 29 p.

A paper using the same approach to answer the same questions but from a Canadian perspective was:

Flora, D.F. 1986. An equilibrium model of Pacific Rim trade in small softwood logs. Canadian Journal of Forestry Research. 16: 1000-1006.

439. Flora and McGinnis 1989 (see note 316).

440. **Flora, D.F.; Anderson, A.L.; McGinnis, W.J. 1991.** Future Pacific Rim flows and prices of softwood logs, differentiated by grade. Res. Pap. PNW-RP-433. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

441. **Flora, D.F.; McGinnis, W.J. 1989.** Embargoes on and off: some effects of ending the export ban on federal logs and halting exports of state-owned logs. Western Journal of Applied Forestry. 4(3): 77-79.

442. **Flora, D.F.; Anderson, A.L.; McGinnis, W.J. 1991.** Pacific Rim log trade: determinants and trends. Res. Pap. PNW-RP-432. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 72 p.

443. **Flora, D.F.; McGinnis, W.J. 1991.** An analysis of the effects of northern spotted owl conservation, harvest replanning, a log embargo, and recession on the Northwest log and lumber trade. Western Journal of Applied Forestry. 6(4): 87-90.

A collateral publication was:

Flora, D.F.; McGinnis, W.J. 1992. Effects of new export rules, a spotted owl plan, and recession on timber prices and shipments from the Douglas-fir region. Res. Pap. PNW-RP-445. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 15 p.

444. **Flora, D.F.; McGinnis, W.J.; Lane, C.L. 1993.** The export premium: why some logs are worth more abroad. Res. Pap. PNW-RP-462. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 p.

445. **Flora, D.F. 1993.** Timber trade: Is there a tomorrow? some assessments of the declining timber base, trade policy, foreign competition and offshore opportunities. The Oregon Certified Public Accountant. August: 1, 4, 5, 12, 13.

446. **Flora, D. 1994.** Timber trade forecasting with non-optimizing models. [Presentation]. Current issues in international trade. Conference organized by Oregon State University Graduate Faculty of Economics. February 24-25. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

447. Examples were:

Flora, D.F. 1990. Economic policy changes in mainland China and U.S.S.R.: some implications for wood products trade [Presentation]. 1990 joint international conference on forest products, National Taiwan University, Taipei, Taiwan, June 13. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

Harmonizing command economies with price signals, business cycles, and debt would spawn problems including economic retrenchment.

Flora, D.F. 1991. The several effects of timber supply trends and economic cycles on softwood product prices in the Republic of Korea and beyond [Presentation]. International trade in forest products around the Pacific Rim, an international symposium, Seoul, Korea, October 10. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

Prices of log grades that had been specific to Korea were projected in response to owl habitat protection, forest replanning, and Korea's economic recession.

Brooks, D. 1994. Global forestry issues: United States forests in an international context. In: Proceedings, Symposium on environmental preservation issues and wood trade among Japan, the U.S., and Canada. Miyazaki, Japan: Miyazaki University: 80-94.

There is increased awareness of international effects of domestic resource policy, including difficulties in judging environmental impacts of alternative policies.

Brooks, D.J. 1994. Tropical timber markets: policy issues and modeling. Journal of Forest Economics (Japanese Forest Economic Society). 126 (November): 19-27.

An example of U.S. hardwood plywood imports and consumption illustrates the need to recognize prices of substitutes.

Flora, D.; Lane, C. 1994. Russian timber and the Pacific Rim [Presentation]. Pacific Northwest regional economic conference, Seattle, April 30. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

Three options for timber as seen from the Russian Far East: true excess supply, an export push (by the trade ministry), and a free-market scenario.

Flora, D.; Lane, C. 1994. Equilibrium modeling of Pacific Rim trade in logs and lumber. Journal of Forest Economics (Japanese Forest Economic Society). 126 (November): 9-11.

Simultaneous equations as a relatively friendly way to do trade analyses.

Flora, D. 1994. Short-run trade effects of changes in U.S. public harvests. In: Proceedings, Symposium on environmental preservation issues and wood trade among Japan, U.S., and Canada, July 12-13. Miyazaki, Japan: Miyazaki University: 134-135.

How wood market effects of the U.S. spotted owl situation might affect Japan's trading partners and competitors.

Haynes, R.W. 1994. Modeling the United States forest sector. Journal of Forest Economics (Japanese Forest Economic Society). 126 (November): 2-8.

North American modeling's evolution as environmental questions have increased.

448. **Austin, J.W.; Darr, D.R. 1975.** The Jones Act and the Douglas-fir region softwood lumber industry in perspective. Journal of Forestry. 73(10): 644-648.

449. **Darr, D.R. 1975.** U.S. forest products trade policies: What are the options? Gen. Tech. Rep. PNW-41. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 36 p.

An expanded version of this report became a policy paper for the Secretary of Agriculture's office.

450. **Adams, D.; Haynes, R. 1980.** U.S.-Canadian lumber trade: the effect of restrictions. In: Sedjo, R.A., ed. Issues in the U.S. international forest products trade: Proceedings of a workshop. Res. Pap. R-23. Washington, DC: Resources for the Future: 101-132.

451. **Jackson, K.C.; McKetta, C.W. 1986.** Impacts of the Jones Act on the Alaska forest products trade. Gen. Tech. Rep. PNW-196. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 39 p.

452. **Flora, D.F. 1995.** Timber management, production, and trade in the U.S. Pacific Northwest [Statement]. To: Softwood lumber consultative process plenary meeting; 1995 July 11-12, Kelowna, BC.

453. **Haynes, R.W. 1983.** U.S. goals for the IIASA forest sector project and experience with forest sector models [Discussion paper]. For: IIASA/FSP network meeting; 1983 August 29-September 2; Sopron, Hungary. On file with: Pacific Northwest Research Station, Forestry Sciences Laboratory, Forest Policies and Markets Team, 3200 SW Jefferson Way, Corvallis, OR 97331.

Haynes and Adams 1983 (see note 284).

Brooks, D.J. 1983. The U.S. regional component of the IIASA global trade model. In: Proceedings of the 2nd North American IIASA meeting. [Place of publication unknown]: [Publisher unknown]: 237-247.

454. **Brooks, D.J. [N.d.].** United States involvement in an international research program: the IIASA forest sector project. [Place of publication unknown]: [Publisher unknown]; final report; cooperative agreement PNW 83-285. 14 p. On file with: Pacific Northwest Research Station, Forestry Sciences Laboratory, Forest Policies and Markets Team, 3200 SW Jefferson Way, Corvallis, OR 97331.

The text on the Forest Sector Project (FSP) is based on this report.

455. **Brooks, D.J. 1985.** Building on the IIASA experience: the world assessment market model. In: Proceedings of the 3rd North American IIASA meeting. [Place of publication unknown]: [Publisher unknown]: 237-247.

Brooks, D.J. 1987. A model of world trade in forest products for use in the 1990 RPA assessment. In: Dress, P.E.; Field, R.C., eds. The 1985 symposium on systems analysis in forest resources. Athens, GA: Georgia Center for Continuing Education: 129-144.

Adams, D.M.; Haynes, R.W. 1987. Interregional modeling. In: Binkley, C.S.; Dykstra, D.P.; Markku Kallio, M., eds. The global forest sector: an analytical perspective. New York: John Wiley and Sons: 391-413.

Brooks, D.J. 1987. Alternative approaches to trade modeling: the world assessment market model. In: Proceedings of a symposium on forest sector trade models, theory and applications. Seattle: University of Washington, College of Forest Resources: 139-147.

Brooks, D.J. 1987. Issues in trade modeling: aggregation of products. In: Proceedings of a symposium on forest sector trade models, theory and applications. Seattle: University of Washington, College of Forest Resources: 111-120.

456. **Brooks, D.J.; Kincaid, J. 1987.** REACTT: an algorithm for solving spatial equilibrium problems. Gen. Tech. Rep. PNW-GTR-204. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 37 p.

Consumer surplus is the difference between the amount a consumer is willing to pay for a good and the amount actually paid. There is a counterpart notion of producer surplus.

457. **Adams, D.; Haynes, R.; Lippke, B.; Perez-Garcia, J. 1992.** Forest sector, trade and environmental impact models–theory and applications: Proceedings of an international symposium. Seattle: CINTRAFOR, University of Washington, College of Forest Resources. 237 p.

Haynes, R.; Harou, P.; Mikowski, J., eds. 1992. Forestry sector analysis for developing countries: proceedings of working groups, 10th world forestry congress. CINTRFOR SP-10. Seattle: College of Forest Resources, University of Washington. 241 p.

Haynes was involved in three parts of the session:

> Haynes, R.W.; Adams, D.M. TAMM—a forestry sector model for the U.S. and as an example for other countries: 55-63.
>
> Haynes, R.W. Evolution of forest sector analysis in the USA: 16-21.
>
> Haynes, R.; Harou, P. Forestry sector analysis for developing countries: a summary of the discussions that took place after the presentation of the papers: 233-239.

Haynes, R.W. 1993. Forestry sector analysis for developing countries: issues and methods. Gen. Tech. Rep. PNW-GTR-314. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 47 p.

458. **Brooks, D.J.; Baudin, A.; Schwarzbauer, P. 1995.** Modeling forest products demand, supply and trade. Work. Pap. ECE/TIM/DP5; UN-ECE/FAO timber and forest discussion papers. Geneva: United Nations Economic Commission for Europe, and Food and Agriculture Organization of the United Nations. 37 p.

    Baudin, A.; Brooks, D.J. 1995. Projections of forest products demand, supply and trade in ETTS V. Work. Pap. ECE/TIM/DP6; UN-ECE/FAO timber and forest discussion papers. Geneva: United Nations Economic Commission for Europe, and Food and Agriculture Organization of the United Nations. 39 p.

459. **Brooks, D.J. 1995.** European timber trends: issues and priorities for further research. EFI Work. Pap. 6. Joensuu, Finland: European Forest Institute. 19 p.

460. **Alig, R.J.; Adams, D.M. 1996.** Timber supply analysis in the U.S.: TAMM, FASOM, and related models. In: Paivinen, R.; Roihuvuo, L.; Siitonen, M., eds. Large-scale forestry scenario models: experiences and requirements. Res. Rep. 5. Jonesuu, Finland: European Forest Institute: 111-132.

461. **Brooks, D.J. 1996.** New developments in policy and planning and their implications for national and international forestry statistics. In: Proceedings of the FAO working group on forestry statistics. Rome, Italy: Food and Agriculture Organization of the United Nations, Forestry Policy and Planning Division: 319-328.

462. **Brooks, D.J. 1993.** Market conditions for tropical timber products. Disc. Pap. DP 93-04. London: International Institute for Environment and Development, Environmental Economics Centre. 38 p.

    Based on research for the International Tropical Timber Organization under a contract, “Economic linkages between the international trade in tropical timber and the sustainable management of tropical forests.”

463. Brooks 1993 (see note 462).

464. **Brooks, D.J. 1994.** Tropical timber markets: policy issues and modeling. Journal of Forest Economics [Japan]. 126: 19-27.

Baudin, A.; Brooks, D. 1992. Modelling forest products demand and supply in Europe. In: Lonnstedt, L., ed. Forest sector analysis: Proceedings of P06.02 FORESEA-Forest Sector Analysis at the IUFRO centennial congress. Uppsala: Swedish University of Agricultural Sciences, Forest-Industries-Market Studies: 15-23.

465. **Brooks, D.J. 1995.** Federal timber supply reductions in the Pacific Northwest: international environmental effects. Journal of Forestry. 93(7): 29-33.

466. **Tomberlin, D.; Buongiorno, J.; Brooks, D. 1998.** Trade, forestry, and the environment: a review. Journal of Forest Economics. 4(3): 177-206.

467. **United States Trade Representative and Council on Environmental Quality. 1999.** Accelerated tariff liberalization in the forest products sector: a study of the economic and environmental effects. Washington, DC: Executive Office of the President. 17 p. [plus appendicies].

468. **Vincent, J.R.; Brooks, D.J.; Gandapur, A.K. 1991.** Substitution between tropical and temperate sawlogs. Forest Science. 37(5): 1484-1491.

Vincent, J.R.; Gandapur, A.K.; Brooks, D.J. 1990. Species substitution and tropical log imports by Japan. Forest Science. 36(3): 657-664.

469. **Sedjo, R.A.; Wiseman, A.C.; Brooks, D.J.; Lyon, K.S. 1994.** Changing timber supply and the Japanese market. Disc. Pap. 94-25. Washington, DC: Resources for the Future. 31 p.

470. Brooks 1993 (see note 462).

471. Brooks 1993 (see note 462).

472. **Cipeta, M.; Brooks, D.; Whiteman, A. 1998.** Review of social and economic developments in the Asia-Pacific region with projections to 2010. Work. Pap. APFSOS/WP/49. Rome, Italy; Bangkok: Food and Agriculture Organization of the United Nations, Forestry Policy and Planning Division; Regional Office for Asia and the Pacific. 137 p.

473. **Darr, D.R. 1977.** Floating exchange rates and log export policy. Journal of Forestry. 75(2): 88-90.

474. **McCarl, B.A.; Haynes, R.W. 1985.** Exchange rates influence softwood lumber trade. Journal of Forestry. 83(6): 368-370.

475. **Flora, D.F. 1995.** Currency exchange rates and timber trade [Abstract]. In: Proceedings, Western Economics Association. [Place of publication unknown]: [Publisher unknown]: [Pages unknown].

476. **Brooks, D.J. 1997.** The outlook for demand and supply of wood: implications for policy and sustainable management. Commonwealth Forestry Review. 76(1): 31-36.

The global situation summary was similarly portrayed in:

Lyke, J.; Brooks, D.J. 1995. World supply and demand for forest products services: issues, trends, and prospects. Journal of Forestry. 93(10): 22-26.

477. **Brooks, D.J.; Grant, G.E. 1992.** New perspectives in forest management: background, science issues, and research agenda. Res. Pap. PNW-RP-456. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 17 p.

Brooks, D.J.; Grant, G.E. 1992. New approaches to forest management: background, science issues, and research agenda: Part 1. Journal of Forestry. 90(1): 25-28.

Coufal, J.; Webster, D. 1996. The emergence of sustainable forestry. In: McDonald, P.; Lassoie, J., eds. The literature of forestry and agroforestry. Ithaca, NY; London: Cornell University Press: 147-167.

478. **Brooks, D.J. 1993.** Multiple benefits and global modeling: review of papers by Wear and Swallow, and Lyon and Sedjo. In: LeMaster, D.C.; Sedjo, R.A., eds. Modeling sustainable forest ecosystems: Proceedings of a conference. Washington, DC: American Forests, Forest Policy Center: 122-126.

479. Articles appeared with titles such as “Forestry word games: sustain” (*Journal of Forestry*), and “Sustainable development: what does it really mean?” (*Forestry Chronicle*).

480. **Solberg, B., ed. 1996.** Long-term trends and prospects in world supply and demand for wood and implications for sustainable forest management. Res. Rep. 6. Joensuu, Finland: European Forest Institute. 150 p.

This book, developed in 1995-96, comprises five chapters, by the same five authors but in different combinations. The author cluster is David Brooks, Heikki Pajuoja, Tim Peck, Birger Solberg, and Philip Wardle. The chapters are:

Long-term trends and prospects in world supply and demand for wood and implications for sustainable forest management—a synthesis: 7-42.

An overview of factors affecting the long-term trends of non-industrial and industrial wood supply and demand: 43-74.

Long-term trends and prospects in world supply and demand for wood: 75-107.

Extending to the longer term future—a qualitative review: 121-150.

Implications for sustainable forest management.

Companion publications were:

Pajuoja, H.; Brooks, D. 1997. Long term forecasts of world consumption and production of roundwood and forest products. In: Saastamoinen, O.; Tikka, S., eds. Proceedings of the biennial meeting of the Scandinavian Society of Forest Economics. Scandinavian Forest Economics. 36: 295-305.

Solberg, B.; Brooks, D.; Pajuoja, H. [and others]. 1996. World supply and demand for wood: implications for management. Policy Options. 17(9): 7-10

Followup reports were:

Brooks, D.J. 1997. Demand for wood and forest products: macroeconomic and management issues. In: Proceedings of the 11^{th} world forestry congress. [Place of publication unknown]: [Publisher unknown]: 93-102. Vol. 4.

Brooks 1997 (see note 476).

481. **Flora, D.F. 1993.** Forest sustainability and the Pacific Rim [Presentation]. In: Sustainable development in the Pacific Rim, international exchange conference. October 14. Portland, OR. On file with: Don Flora, 12877 Manzanita Road, Bainbridge Is., WA 98110.

482. **List, P.; Brooks, D.J. 1998.** Issues of equity and ethics in the Pacific Rim timber market. In: Proceedings of forests and society: implementing sustainability. Corvallis, OR: Oregon State University: 19-30.

483. **Adams, T.C. 1968.** Price trends of open-market Douglas-fir in the Pacific Northwest. Res. Note PNW-74. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 6 p.

Adams, T.C. 1970. Log prices in western Washington and northwest Oregon, 1963-69. Res. Note PNW-127. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 12 p.

Adams, T.C. 1974. Log prices in western Washington and northwestern Oregon, 1963-73. Res. Note PNW-235. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 12 p.

484. **Haynes, R.W. 1991.** Monthly stumpage prices for the Pacific Northwest. Res. Pap. PNW-RP-436. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 14 p.

Haynes, R.W. 1998. Stumpage prices, volume sold, and volumes harvested from the national forests of the Pacific Northwest Region, 1984 to 1996. Gen. Tech. Rep. PNW-GTR-423. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 91 p.

485. **Adams, D.M.; Haynes, R.W.; Mills, T.J. [and others]. 1979.** Production, consumption, and prices of softwood products in North America–regional time series data, 1950-1976. Res. Bull. 27. Corvallis, OR: Oregon State University, School of Forestry. 43 p.

486. **Adams, D.M.; Jackson, K.C.; Haynes, R.W. 1988.** Production, consumption, and prices of softwood products in North America: regional time series data, 1950-85. Resour. Bull. PNW-RB-151. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 49 p.

487. **Haynes, R.W. 1986.** Inventory and value of old-growth in the Douglas-fir region. Res. Note PNW-437. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 p.

488. **Ruderman, F.K.; Haynes, R.W. 1986.** Volume and average stumpage price of selected species on the national forests of the Pacific Northwest Region, 1973 to 1984. Res. Note PNW-446. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 37 p.

489. **Haynes, R.W.; Warren, D.D. 1989.** Volume and average prices of stumpage harvested from the national forests of the Pacific Northwest Region, 1974 to 1987. Res. Note PNW-488. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 19 p.

490. **Waddell, K.L. and others 1989.** (see note 301).

491. **Sohngen, B.L.; Haynes, R.W. 1994.** Hardwood price reporting. Res. Pap. PNW-RP-470. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 16 p.

A counterpart report was:

Sohngen, B.L.; Haynes, R.W. 1995. In: Western hardwoods value-added research and demonstration program. Gen. Tech. Rep. FPL-GTR-85. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory: 36-37.

492. **Brooks, D.J. 1995.** Temperate forests in a global context. In: McIntire, J.L., ed. The new eco-order: economic and ecological linkages of the world's temperate and boreal forest resources. Seattle: University of Washington, Northwest Policy Center, International Northern Forests Organization Project: 21-57.

493. **Chmelik, J.T.; Brooks, D.J.; Haynes, R.W. 1989.** Unites States trade in forest products, 1978 to 1987. Gen. Tech. Rep. PNW-GTR-240. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 102 p.

494. **Buckman, R.E.; Fight, R.D. 1974.** Multi-resource inventories—resolving conflicts. In: Frayer, W.E. [and others], eds. Inventory design and analysis. [Place of publication unknown]: Society of American Foresters: 181-185.

495. **Joyce, L.; Haynes, R.W. 1992.** Integrating resource projections with timber projections. In: Adams, D.; Haynes, R.; Lippke, B.; Perez-Garcia, J., comps. Forest sector, trade and environmental impact models–theory and applications: Proceedings of an international symposium. Seattle: CINTRAFOR, University of Washington, College of Forest Resources: 4-14.

496. Later renamed Pacific Resource Inventory, Monitoring, and Evaluation (PRIME) and currently named Forest Inventory and Analysis (FIA).

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Index

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