As survival rate decreases, optimum initial stocking also increases. For example, for site index 80, if tree mortality of 60 rather than 80 percent is expected, best stocking is 600 trees rather than 400. In effect, 200 more trees should be planted to ensure full use of the site. There is another reason: should the number of surviving trees fail to meet forest practice standards, it would be costly to replant.

Judged by physical yields, the state minimum stocking standard of 300 trees appears reasonable. Moreover, if costs are disregarded, the simulations indicate that landowners will maximize yields with higher densities than the rules require.

Financial returns. Most owners will want to choose initial stocking levels using financial rather than physical yield criteria. *PIPOND* is designed to convert estimates of physical yields to estimates of present net worth, given data on stumpage values, site preparation and planting costs, and the discount rate of interest. **Present net worth**—a measure of investment efficiency—is the difference between future net receipts from the sale of timber and the cost of site preparation, planting, and such cultural treatments as thinning, all discounted to the present at a specified rate of interest.

Table 2 shows the effect of initial stocking on present net worth in dollars per acre for the simple situation where the only expenditures are for site preparation and planting. Stumpage is valued at $100 per thousand board feet. The two rates of interest—5 and 7 percent—span the *real* rate of return (net of inflation) that many private owners might reasonably expect on long-term investments. The cost of site preparation is set at $80 per acre and planting (trees and labor) at $0.15 per tree. Taxes have not been deducted because owner situations are so variable. Nonetheless, the financial simulations are useful for making *relative* comparisons of the financial efficiency of alternative stocking levels.

If stocking decisions are based on financial criteria, optimum stocking is less than if judged by physical yields. The reason is simple: as density is increased, diminishing yields "at the margin" are encountered. Economic efficiency requires that density be increased to the point where the incremental cost of planting one more tree just equals the incremental return. This point will always be reached short of the density that maximizes physical yields.

As seen in table 2, optimum density at the 5 percent rate of interest on sites 80 and 100 is 300 trees per acre, 100 and 200 trees less, respectively, than suggested by table 1. At 5 percent, investments on sites classes 40 and 60 will not pay their way, even before taxes are considered. This does not mean such land is unsuitable for tree growing and harvesting operations, but rather that clearcutting, followed by out-of-pocket investments for site preparation and planting, may not be economically feasible for growing trees. In such situations, other silvicultural systems should be considered. On the other hand, if a stand *is* harvested and then planted, the owner should select the initial stocking density that minimizes losses, subject to the constraint that at least 300 trees are required.

For sites where plantations pay their way, the state minimum stocking standards appear reasonable. In the case of poor quality sites, they may require unjustifiable investments. Moreover, there appears to be no financial incentive to exceed these standards, under the assumptions in table 2. The exception is the situation where fairly frequent commercial thinnings can be made. Our simulation studies then suggest higher initial stocking than required by the minimum standard.

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Economic importance of forest industries in northern California

William McKillop ☐ Kent Connaughton

California ranks second only to Oregon in the production of lumber and is a major producer of softwood plywood. Some 5.5 billion board feet of lumber and more than 0.5 billion square feet of softwood plywood were produced by California mills in 1977. Most of the plywood and more than 60 percent of the lumber go to rapidly growing markets within the state. The remainder is distributed nationally and internationally.

Lumber and wood products, together with the pulp and paper industries, are important to the California economy. They account for, respectively, 3.5 and 2.3 percent of employment and 2.9 and 2.8 percent of value added by manufacturing. Value added is the value of the output of an industry minus purchases of raw materials and other inputs. Each industry accounts for 3 percent of the value of shipments of manufactured goods from California businesses. In 1975, lumber and wood products employed some 54,000 persons; paper and allied products employed 35,000 persons. Value of shipments from each sector was approximately $2.7 billion.

The economic significance of the lumber and wood products industry is particularly evident in many northern California counties. The key to the economic strength of a county or region is the size of the "export base" (or economic base) which is that

California is second only to Oregon and Washington in the production of lumber and wood products.

section of the economy producing goods for shipment to other regions. Table 1 shows "dependency indicators" for selected counties. These represent the percentage of export-based employment attributable to employment in the lumber and wood products industry. While some counties do not depend heavily on the timber industry, it is clearly a vital component of the economies of Del Norte, Humboldt, Mendocino, Sierra and Siskiyou counties where it accounts for 50 to 60 percent of basic employment. It also accounts for more than 40 percent of the basic employment in Plumas, Shasta, and Tehema counties, and 39 percent in Trinity County.

Income and employment multipliers

Although dependency indicators provide information on the relative importance of lumber and wood products in regional economies, they do not answer the significant question: "By how much will total regional employment and income change as timber industry output employment and payrolls change?" The answer hinges on estimation of income and employment "multipliers" for a county or region. When output of lumber in a county increases, lumber company payrolls increase, and company purchases of supplies and services from other businesses increase also. Workers spend all or part of their income locally, thus generating additional demand for goods and services. Some expenditures by lumber companies and their employees undergo "leakage" from the local economy when goods from outside the county are imported. But the portion of expenditures that remains in the county generates further increases in local employment and payrolls. The result of this cycle of spending and respending is referred to as the "multiplier effect." It is generally expressed as the increase in total county employment or income generated by a one dollar increase in the output of a basic sector such as the lumber industry. An employment or income "multiplier" is the increase in total employment or income brought about by a one man-year increase in employment or a one dollar increase in payrolls in the industry of interest.

Table 1 also presents income multipliers for the lumber and wood products industry in 15 selected counties. Multipliers were estimated by econometric models which related total income in each county to income generated in individual sectors of the county's economic base such as agriculture, nonlocal government, transfer payments, lumber and wood products, and other manufacturing using data for 1959, 1962, and 1965-1974. The values of multipliers shown in table 2 are subject to estimation error. Standard errors and confidence intervals are provided as a means of gauging their accuracy. Multiplier estimates are of satisfactory accuracy for counties where wood processing is a dominant sector. In certain other cases the estimates are also useful because the confidence intervals place limits on the probable magnitudes of the multiplier. It is anticipated that additional

TABLE 1. Lumber and Wood Products Dependency Indicators and Income Multipliers for Selected Northern California Counties

County	Dependency indicator (%)	Estimate of multiplier	95% Confidence interval
Butte	8.4	1.5936	-1.514 to 4.3407
Del Norte	63.6	2.2610	1.9549 to 2.5671
El Dorado	5.4	4.2417	-7.1987 to 15.6820
Humboldt	66.3	2.3685	1.9404 to 2.7965
Lassen	14.9	1.8646	.6221 to 3.1071
Mendocino	55.9	1.7364	1.3454 to 2.1274
Modoc	13.2	1.9378	.7124 to 3.1627
Nevada	14.3	.8480	-1.1331 to 2.8291
Plumas	42.5	1.3075	.1569 to 2.7719
Shasta	40.4	3.2858	1.4553 to 5.1163
Sierra	50.2	1.3281	1.0684 to 1.5877
Siskiyou	49.9	2.4155	1.744 to 3.0866
Tehema	39.0	1.6083	-2.6985 to 5.9152
Trinity	43.7	1.9175	1.064 to 2.7710
Yuba	7.7	1.2707	-2.0535 to 4.5949

SOURCE: Kent P. Connaughton and William McKillop (1979). Estimation of small area multipliers for the wood processing sector—an econometric approach. *Forest Science* (forthcoming).

data will become available in the near future, permitting improved accuracy of estimates.

Discussion

Traditional methods of deriving multiplier estimates are input-output analysis and export-base analysis. Input-output analysis is a potentially costly procedure if accurate estimates are desired. Export-base analysis is less costly, but is of limited usefulness because it is not capable of deriving multipliers for individual sectors. The econometric method employed in this study appears to have strong advantages, in terms of cost and flexibility, when dealing with small areas such as counties.

As forests and other natural resources receive increasing use and as competition among alternative uses intensifies, it becomes necessary to develop analytical methods to assess the impacts of resource management activities on local economies. The multipliers provided by this study are a useful means of measuring the impacts on local employment and income of altering timber harvest levels in northern California. For example, the multiplier for Humboldt County indicates that for every one dollar reduction in payrolls of the lumber and wood products industry, total regional income decreases by $2.37. Furthermore, because of the close correspondence between income and employment effects, the multiplier indicates that for every job lost in the wood processing sector, total employment in the county will decrease by approximately 2.4 man-years. This type of information is particularly important in analyzing impacts on the economy of the North Coast counties because of their persistently high rates of unemployment.

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Wildlife research

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A long-term study of the California quail, the state bird, has recently been completed.

Wildlife management research is part of the research program in the University of California Department of Forestry and Conservation. Currently under study are methods for assessing the effects of land management practices on the entire vertebrate community and for analyzing habitat preferences and population dynamics of selected wildlife species. Field projects include:

(1) Determining the value of oaks and other hardwoods to wildlife in a mixed conifer forest at Blodgett Research Station;

(2) Determining the short- and long-term impacts of herbicides on vertebrate populations at Blodgett Forest and at Sagehen Field Stations;

(3) Learning the importance of snags (dead trees) for maintaining forest birds in the Sierra;

(4) Studying the impact of air pollution on small mammal communities in the San Bernardino Mountains; and

(5) Determining the influence of water developments on livestock, pronghorn, mule deer, sage grouse, and waterfowl on the Modoc National Forest.

Considerable effort also has been spent assisting the U.S. Forest Service in compiling Wildlife-Habitat Guidelines for the western slope of the Sierra.

Studies of individual species include a survey of the distribution and status of selected furbearers in California. A study of the black bear in Yosemite and Sequoia National parks is near completion, and an intensive study of pine marten is underway in the Tahoe National Forest. Long-term studies of mammals such as beavers, chipmunks, and deer mice continue at Sagehen. Long-term studies of California quail are now completed as are studies of the mountain lion and of the garter snake. A long-term study of wild pigs continues at Dye Creek Ranch in Tehama County, and a state-wide survey of wild pigs has begun in San Benito County. Finally, a study of the introduced fallow and axis deer at Point Reyes National Seashore is in progress in cooperation with the Department of Agronomy and Range Science at U.C., Davis.

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