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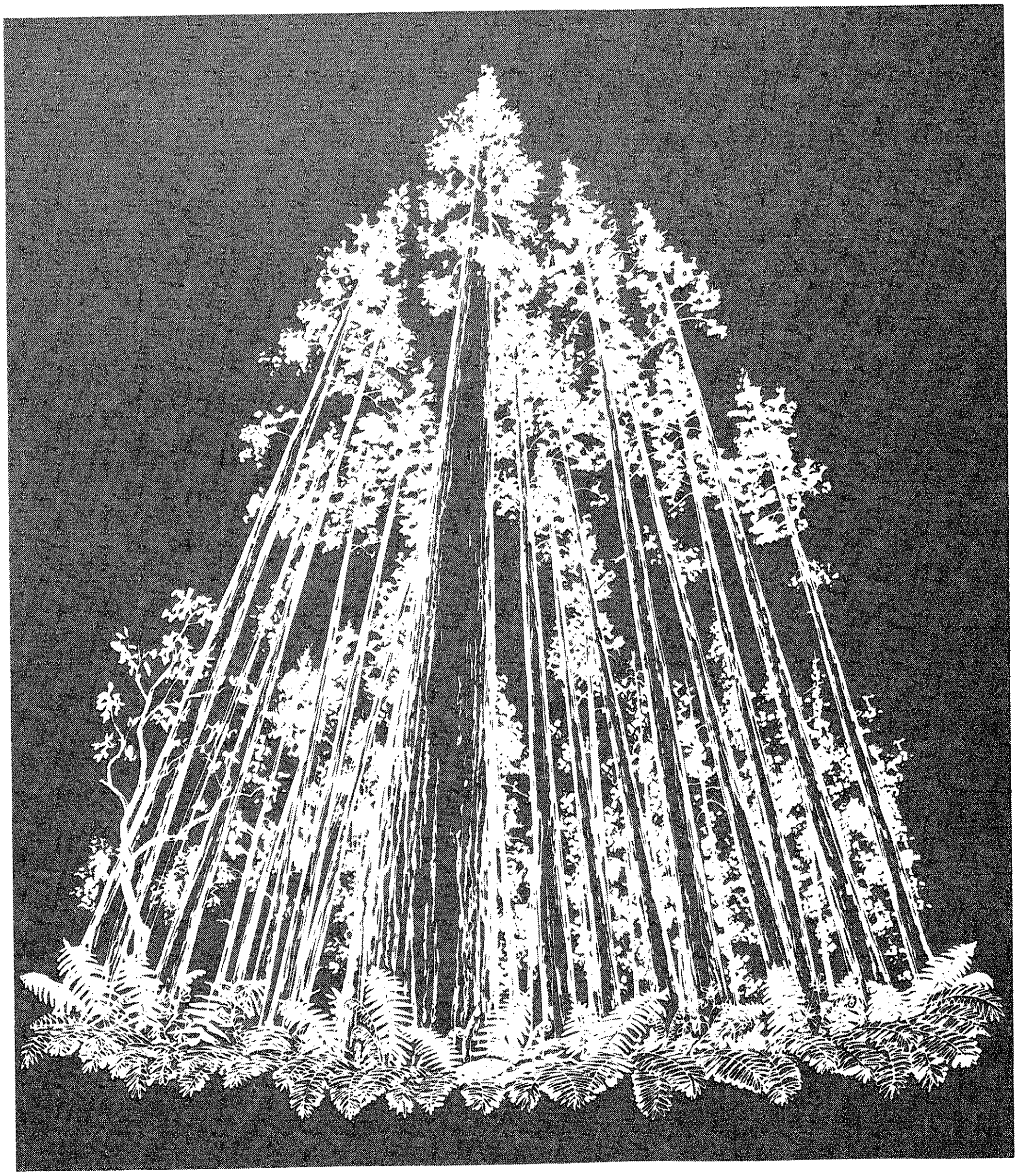
The Status of Forest Management Research in the United States

Donald G. Hodges, Pamela J. Jakes, and Frederick W. Cubbage



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Introduction

Evaluating the benefits and costs of forestry research has become an important task for forest economists and policymakers. Despite extensive literature on agricultural research evaluation (see, for example, Norton and Davis 1981, Ruttan 1982, and Bengston 1985a), widespread interest in the impacts of forestry research only began in this decade.

Examination of public forestry research was encouraged by the passage of RPA, the Forest and Rangeland Renewable Resources Planning Act of 1974 (PL 93-378). This legislation requires the USDA Forest Service to periodically evaluate the status of renewable natural resources and to propose programs, including research, for properly managing these resources.

The climate and concerns that led to the passage of the RPA have also resulted in more public participation in science and technology. Researchers and research managers are being held accountable for the impacts of their research. In agriculture, research managers have been widely criticized for not giving enough attention to the social consequences of their research (Sun 1984, Martin and Olmstead 1985). Forestry research managers also need to measure and predict the impacts of research to address public questions and concerns.

Interest in evaluating the impacts of forestry research has also been spurred by declining research budgets. Growth in the public research and development budget for natural resources in the U.S. has lagged far behind that for agricultural research and development (fig. 1). Agricultural research evaluations carried out over the past two decades have consistently shown high rates of return to agricultural research (Evenson *et al.* 1979). This has resulted in the widespread perception that investment in agricultural research benefits society, and may help to explain increasing research benefits (Fedkiw 1985). Although

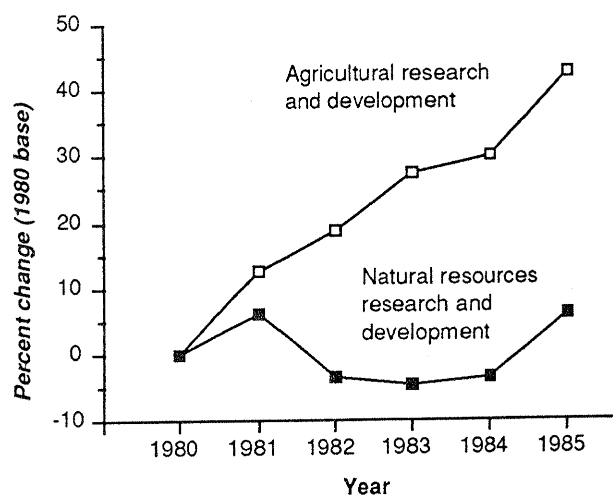

Figure 1.--*Percent change in federal research and development budgets for natural resources and agriculture, 1980-1985 (National Science Foundation 1986).*

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research in forestry and other natural resources may produce similar high payoffs, empirical evidence supporting this hypothesis has been lacking until quite recently.

In response to the growing interest in evaluating the impacts of forestry research, the Forest Service has been conducting research at the North Central Forest Experiment Station on methods for evaluating forestry research. In addition to this effort, the Forest Service supports research on research evaluation methods at universities across the country.

Evaluating Forestry Research—Research Needs

Recent investments in forestry research evaluation have resulted in a growing body of literature evaluating the impacts of specific forestry research innovations (table 1). Despite these accomplishments, gaps remain in our knowledge and skills. First, agriculture and forestry research evaluations have almost exclusively analyzed completed research projects that have already produced innovations that are being, or have been, adopted. Evaluations of past efforts are of little value to research managers who must decide on current or future research programs. If evaluations are to be useful in research planning, management, and policymaking, *ex ante* (before research implementation) evaluation methods and case studies are needed.

Second, most of the forestry research evaluations that have been conducted are narrowly focused case studies that may not be representative of a broad research area or discipline. We need to conduct more aggregate-level evaluations that examine the relation between research in a broad area and the growth or productivity in an entire industry or sector of the economy.

Third, although research innovations produce a variety of impacts—including impacts on employment, trade, market structure, and the environment—most of the forestry research evaluations conducted thus far have measured just the economic efficiency of the research investment. Economic efficiency is seldom the only important criterion in evaluating research programs—other impacts should also be considered.

Finally, evaluations have focused primarily on forest products and utilization research. This focus on products is natural given that many existing forestry research evaluations use methods developed for agricultural research evaluation—evaluations that analyze, almost exclusively, agricultural commodities. Forestry's concentration on products can also be attributed to the availability of vital forest products market data, which are scarce or non-existent in other areas of forestry. However, by focusing on forest products and utilization research, we have ignored several major research disciplines, including forest management research.

Table 1.—*Evaluating the impacts of forestry research—results from case studies*

Study	Measure of economic efficiency
Percent rate of return	
Forest pest management research (Araji 1981)	60-87
Timber utilization research (Haygreen *et al.* 1983)	14-36
Structural particleboard research (Bengston 1984)	18-22
Forest nutrition research (Bare 1985)	9-12
Lumber and wood products research (Bengston 1985b)	34-40
Southern softwood forestry research (Newman 1986)	Negative to > 10
Containerized forest tree seedling research (Westgate 1986)	37-111
Softwood plywood research (Seldon 1987)	220-410
Other measures	
Tree improvement research in Michigan (Net Present Value) (Levenson 1984)	$262 million
Growth and yield models (Benefit:Cost Ratio) (Chang 1985)	16:1
Wood preservation (Benefit:Cost Ratio) (Brunner and Strauss 1987)	15-66:1

Evaluating Forest Management Research

Forest management research is research directed at increasing the biological or economic productivity of forest land. Although this area receives a large percentage of total forestry research funding, it has received little attention from individuals interested in research evaluation. This is due to several factors (fig. 2).

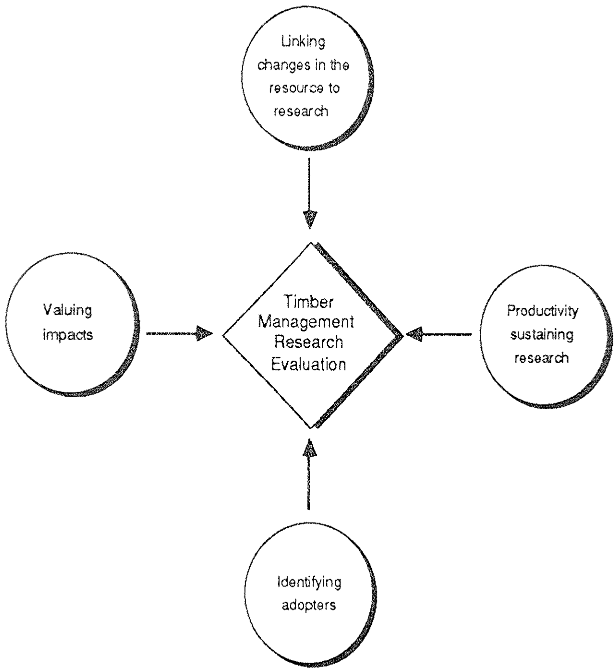


Figure 2.--*Factors complicating the evaluation of forest management research.*

First, it is often difficult to link changes in forest resource conditions directly to forest management research. Research evaluation requires a clear demonstration that changes in the resource are in response to the adoption of new management techniques or other technologies resulting from a research effort, rather than variations in climate, species composition, site, or other factors.

A related challenge in evaluating forest management research is the fact that a large share of this research may be classified as productivity sustaining research. Productivity sustaining research is research necessary to maintain current productivity levels. So, we must be able to identify not only the increases in productivity due to research efforts, but also the losses avoided because research has provided methods of maintaining soil productivity, managing insect populations, and other innovations.

Even if the impacts of a research innovation can be identified, there can be problems valuing these impacts. Unlike many areas of forest products research, innovations in the biological aspects of forest management lack direct consumer market prices—their values are reflected in timber stumpage prices, which vary widely among individual sales, species, regions, and by other factors.

Finally, an important step in evaluating research impacts is identifying potential adopters of a new technology and factors affecting their rate of adoption. Forest products research deals with an easily identifiable group of adopters—profit-maximizing companies, many of whom maintain direct, daily contact with researchers in their areas of interest. In contrast, forest management innovations may be adopted by public, industrial, or private nonindustrial forest land owners. Each of these ownership classes possesses different ownership and management objectives. Objectives differ widely within ownership classes as well.

These difficulties—of identifying impacts, accounting for productivity sustaining research, valuing impacts, and forecasting adoption—have discouraged many analysts from estimating the impacts of forest management research. However, despite these problems, some researchers have tested the use of existing methods on evaluating forest management research. Most case studies have found positive returns, although lower than those reported in evaluations of forest products and utilization innovations.

Levenson (1984) calculated the net present value of tree improvement research in Michigan to be $262 million. He further found that a typical pulp and paper company could derive a benefit of $1 million from this research. Benefits received by the State of Michigan's public forestry programs were estimated to exceed $5.5 million. Bare (1985) estimated internal rates of return of 9 to 12 percent for the Regional Forest Nutrition Research Program at the University of Washington. The range of values reflects varying assumptions on the percentage of total fertilized acres in the region attributable to nutrition research. An evaluation of biometrics research estimated a benefit-cost ratio of 16.3 for a recently developed growth and yield model for oaks in New England (Chang 1985). Similarly, investments in containerized forest tree seedling research yielded annual internal rates of return ranging from 37 to 111 percent, depending on the price differential between bare-root and containerized seedlings (Westgate 1986). In contrast Newman (1986) found average annual benefits of $1.3 to 5.4 million from aggregate technical change in southern softwood forestry compared to annual research expenditures of more than $6.5 million.

Objectives

The case studies cited above have helped identify the difficulties of using traditional methods to evaluate forest management research. New methods are needed to overcome these difficulties, and provide policy and decision makers with tools for evaluating forest management research.

As a first step in developing a new framework for evaluating forest management research, we have estimated the extent and distribution of the total U.S. forest management research effort. The analysis involved (1) defining forest management research; (2) describing and measuring inputs, outputs, and research in progress in the Forest Service, forest industries, and universities (to the extent possible); and (3) describing the distribution of forest management research benefits among geographic regions and ownership classes.

Methods

Defining Forest Management Research

The Forest Service conducts research identified as "Timber Management Research" (TMR). Forest Service TMR covers research related to silviculture, mensuration, genetics, and timber related resources. The Society of American Foresters (1983) defines forest management as "... that branch of forestry concerned... with the essentially scientific and technical aspects [of] silviculture, protection, and forest regulation". This definition encompasses forest regulation and protection research, areas missing from TMR. By combining these two definitions, we arrived at a third definition (used in this study) that defines forest management research as research related to silviculture (including prescribed burning), mensuration, genetics, and the economics of forest management. Protection research was not included in the analysis because extensive literature already addresses this topic (see, for example, Cleland *et al.* 1982, Rose 1983). Also, forest protection and atmospheric sciences (fire) research represents major costs and benefits that would cloud an evaluation of traditional forest management research. We included prescribed burning because it is a tool for managing the resource rather than protecting it.

Acquiring Data

Three principal sectors in the United States perform forest management research—the Forest Service, forest industries, and universities. Each sector's research efforts have unique characteristics, and the information available for each program differs greatly. The Forest Service has the most detailed records of research inputs, process, and outputs. Forestry schools keep modest records on expenditures. Much of the industry research information is proprietary.

USDA Forest Service

The Forest Service's research effort is directed from eight regional forest experiment stations across the country and the Forest Products Laboratory in Madison, Wisconsin. Each station has research work units, which conduct studies that help to solve problems identified in each research work unit's description.

We determined the inputs and outputs of Forest Service forest management research from the annual research attainment reports of each forest experiment station for fiscal years 1980 through 1985. Attainment reports summarize each work unit's accomplishments, including the number of active and inactive studies, personnel employed, funds expended, and publications and patents produced. We recorded this information for each work unit conducting forest management research.

Research is often described as being applied or practical as opposed to basic or theoretical. Although these terms have become value-laden, they are useful in describing the intended audience or immediate user of the research. Based on the information contained in the attainment reports, we classified each problem within a research work unit as practical or theoretical. Practical research was defined as research that is directly applicable in the field; theoretical research is conducted primarily to provide a basis for further theoretical or practical research.

From the problem descriptions, publication titles, and narratives in the attainment reports, we also determined the distribution of benefits resulting from research. Most research work units address research problems of interest primarily to the region in which the station is located, but much research provides benefits to adjacent regions or to the entire nation. We noted three geographical regions in the attainment reports: (1) North (including the Midwest), (2) South, and (3) West (including the Pacific Northwest, Pacific Southwest, Alaska, and Hawaii). We also noted whether the research was national or international.

From the problem descriptions, we were also able to identify the organizations, companies, or landowners benefiting from a research program. Research problems were classified as benefiting all owners, public forest land owners, forest industry, or nonindustrial private forest land owners.

Forest Industries

Determining the level of investment in forest management research by forest industry was difficult without published information. Therefore, we surveyed landholding forest products companies to obtain estimates of the dollars spent and personnel employed in research on silviculture, biometrics and mensuration, genetics, and resource economics. Because of the difficulty in collecting the information, we requested estimates for fiscal year 1985 only.

For proprietary reasons, several companies declined to provide research budget figures. So, with the help of industry officials, we identified a small group of companies who invest significantly in forest management research. Through mail surveys and personal interviews, we obtained reliable data on their dollars and number of scientist-years invested in forest management research.

We also identified a group of 25 companies making smaller investments in forest management research than the first group and obtained data from 10 firms, which were representative in size and location. Sample responses were used to calculate average forest management research budgets and average scientist-years. Industry officials and research administrators indicated that the averages were appropriate for the industry. We expanded the averages from the 10 firms to estimate the total dollars and number of scientist-years invested in forest management research in this second group.

Universities

Universities constitute the third major sector conducting forest management research in the United States. We surveyed forestry schools at 47 universities to estimate the number of scientist-years allocated to four areas of forest management research in fiscal year 1985: (1) biometrics and mensuration, (2) the economic, financial, and legal aspects of forest management, (3) genetics, and (4) silviculture. Forty-four schools (or nearly 94 percent) returned usable responses. Responding schools included 11 out of 12 universities in the North Central region, 8 out of 8 in the Northeast, 15 out of 16 in the South, and 10 out of 11 in the West (regions correspond to those used by the National Association of Professional Forestry Schools and Colleges (NAPFSC)). We expanded the number of scientist-years provided by our responding schools by region to estimate scientist-years for all forestry schools in a region.

To determine the total investment in timber management research conducted by universities, we multiplied the number of scientist-years by an adjusted average cost per scientist-year. NAPFSC provides annual estimates of regional research funds by scientist-year (National Association of Professional Forestry Schools and Colleges 1986). This cost estimate includes funds directly appropriated to the schools as well as private and public research funds awarded to the schools. To avoid double counting, we adjusted the NAPFSC estimates to include only those funds directly appropriated to the schools, and we eliminated funding that would be accounted for in the Forest Service and industry totals.

Extent and Distribution of Forest Management Research

Results

We found that the three forestry sectors maintain a substantial program of forest management research. During fiscal year 1985, more than 660 scientist-years were involved in forest management research, resulting in investments of approximately $66 million. Notable differences exist among the research programs. Trends in funding and personnel, and the outlook for future research programs also differed.

Forest Service Research

The Forest Service is the largest forestry research organization in the United States. In fiscal year 1985, it employed about 800 scientists at 75 locations throughout the States, Puerto Rico, and the Pacific Trust Islands. The agency has more than 2,800 studies in progress at any one time (USDA Forest Service 1986). It also helps coordinate forestry research in the U.S. by cooperating with forest industries and by providing research funds to scientists in other research organizations (called extramural research). For example, in fiscal year 1985, the Forest Service funded 373 extramural research grants for a total of nearly $7.5 million (table 2).

Table 2.—*Forest Service extramural research, number of grants and funding, 1985 (USDA Forest Service 1986)*

Recipient	Number of grants	Thousand dollars
Domestic		
Universities and colleges	325	6,623
Federal, State, and local governments	20	315
Small business innovation research	11	302
Nonprofit institutions and organizations	8	149
Other domestic	6	74
Total domestic	370	7,463
Foreign grantees	3	15
Total	373	7,478

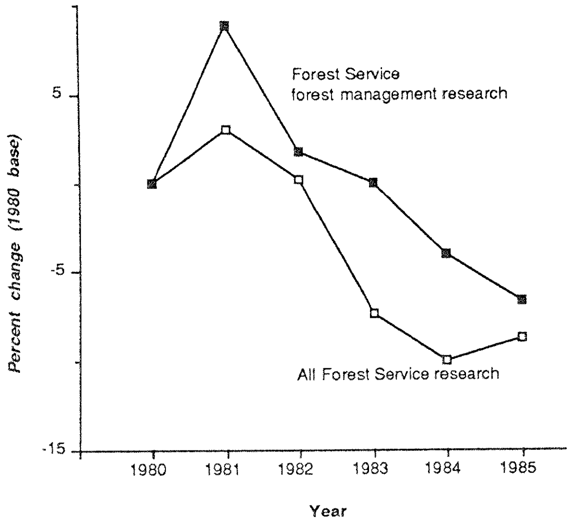


Figure 3.--*Percent change in the Forest Service research budget and the forest management research budget, 1980-1985 (USDA Research and Education Committee 1986).*

Table 3 summarizes the agency's forest management research efforts in terms of funding levels, number of personnel, and number of publications.

Research Funding.—Total funds allocated to forest management research increased in nominal terms from 1980 to 1985 but declined in real terms (fig. 3). The decline appears to be the result of a decline in the total Forest Service research budget rather than a shift in research priorities—between 1981 and 1986, forest management research consistently received 25 to 27 percent of the total research budget.

Funds for Forest Service forest management research flow from several accounts (called functional accounts) within the research budget. The Timber Management Research (TMR) functional account contributes the most forest management research funds, nearly 77 percent of the total annual budget (fig. 4). Several other functional accounts provide the balance of the forest management research budget, although none contributes more than 10 percent of the total. Although they contribute little to the forest management research budget, these other accounts fund research that is vital to the management of forest land.

Table 3.--*Inputs to and outputs from Forest Service forest management research, 1980-1985*

Year	Funding: Nominal (Thousand dollars)	Funding: Real[1] (Thousand dollars)	Total scientist-years	Funding/ scientist-year[1]	Total publications	Publications/ scientist-year
1980	24,180.0	24,180.0	275	88,007	518	1.9
1981	28,878.3	26,324.8	273	96,287	630	2.3
1982	28,707.6	24,595.1	268	91,876	533	2.0
1983	29,311.0	24,169.4	258	93,825	604	2.3
1984	29,213.7	23,207.3	250	92,848	641	2.6
1985	29,372.2	22,587.9	243	93,031	663	2.7
6-year average	28,277.1	24,177.4	261	92,646	598	2.3

[1] Real dollars, 1980 base.

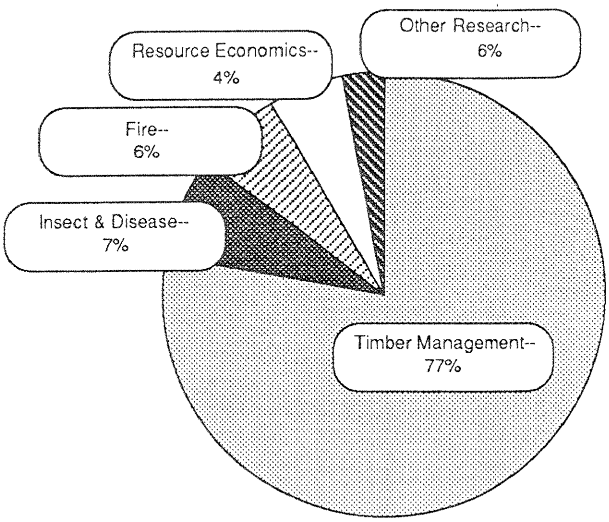


Figure 4.--*Average annual contribution of Forest Service functional accounts to the forest management research budget, 1980-1985.*

Figure 5 depicts the distribution of research funds among the four principal forest management research disciplines. Silviculture received the largest share of the annual budget, followed by genetics, economics, and mensuration. Several research disciplines shared the remaining forest management research budget, including hydrology, fire and atmospheric sciences, and wildlife management.

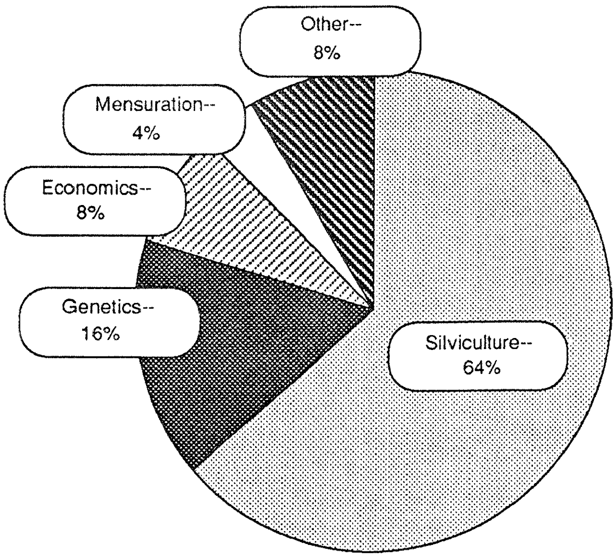


Figure 5.--*Average annual distribution of Forest Service forest management research funds among research disciplines, 1980-1985.*

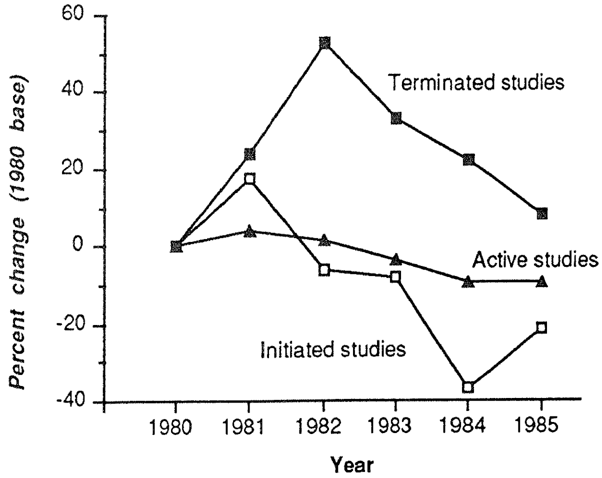


Figure 6.--*Percent change in the number of active, terminated, and initiated Forest Service forest management research studies, 1980-1985.*

Research Projects.—The annual attainment reports provided by each experiment station list the number and status of research projects for each work unit. In any given year, a project may be active, initiated, or terminated. Following a peak in fiscal year 1981, the number of studies has declined in each category in three of the four major research disciplines (fig. 6). Only genetics research has experienced a net gain in the number of initiated and active projects.

Staffing.—The number of scientists employed by the Forest Service in forest management research declined faster than the forest management research budget in each of the 6 years examined (fig. 7).

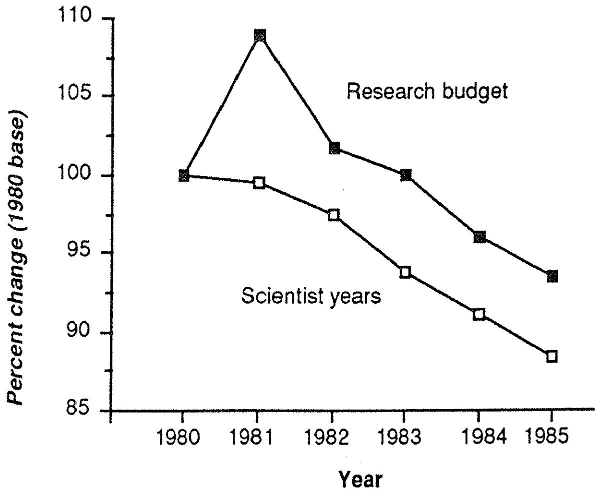


Figure 7.--*Percent change in scientist-years and budget for Forest Service forest management research, 1980-1985.*

The distribution of personnel among research disciplines was similar to the distribution of research funds, as would be expected. The relative order remained the same: silviculture employed the most personnel, followed by genetics, economics, and mensuration.

We used funding and personnel data to calculate funding per scientist-year for the 6 years. Nominal dollars per scientist-year increased annually; real dollars remained fairly stable (fig. 8). We found no pattern in funding per scientist-year for the four major disciplines. Silviculture research made up the largest portion of forest management research, so its yearly funding levels ($124,177 per scientist in 1985) had the greatest impact on the aggregate scientist-year funding estimates.

Publications.—Publications are the principal quantifiable output of the research process. The annual attainment reports list the total number of intramural and extramural publications and patents for each research work unit. Intramural publications are documents for which the research work unit claims senior authorship; extramural publications are those published by cooperators for which the work unit claims junior authorship or has contributed significant time, talent, and/or funds. The total number of publications for each year is shown in figure 9. In any one year, one-fourth of the publications are extramural.

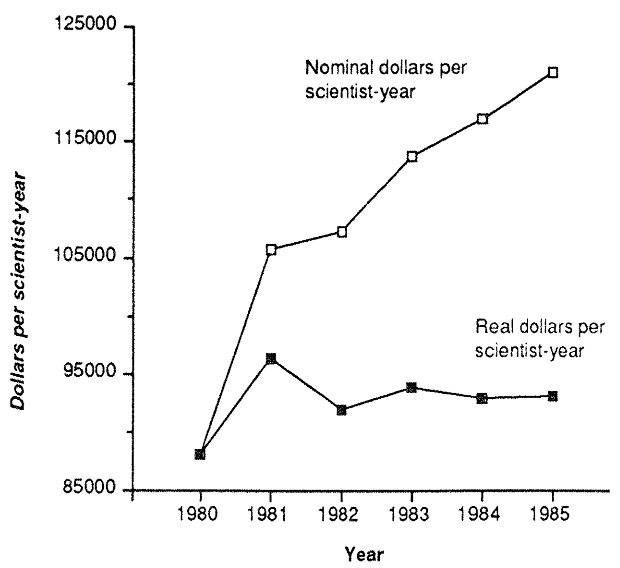


Figure 8.--*Trends in dollars per scientist-year for Forest Service forest management research, 1980-1985.*

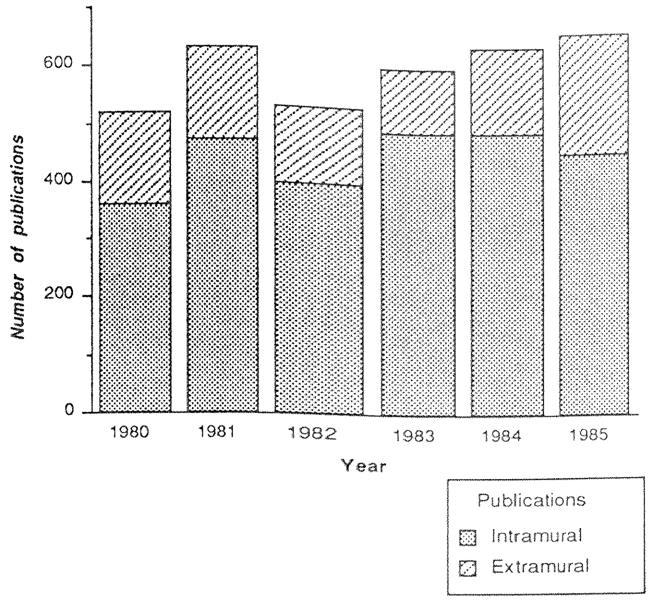


Figure 9.--*Number of intramural and extramural publications, Forest Service forest management research, 1980-1985.*

During the 6 years examined, the annual number of intramural publications rose by 27 percent and extramural publications increased by 31 percent. Similar increases have been found previously for Forest Service researchers. Jakes and Fege (1986) reported an 18-percent increase in the number of publications for the North Central and Northeastern Forest Experiment Stations between fiscal year 1980 and 1984. A more informative measure of research productivity is publications per scientist-year. Intramural publications per scientist-year averaged 1.7 during the 6 year period, extramural publications averaged 2.3. These rates compare favorably with other reported productivity ratios. Jakes (1985) reported a publication rate of 1.2 publications per scientist-year for all Forest Service researchers during fiscal years 1980 and 1981, noting that this was low because only senior-authored work was considered. The average 1980-1981 rate of senior-authored forest management publications (intramural and extramural) for those two fiscal years was 1.5 per scientist-year. Thus, on average, researchers in forest management appear to publish more than other Forest Service researchers.

The 6-year average publication rates for the four major disciplines were economics 2.0, genetics 1.9, silviculture 1.8, and mensuration 1.2 (table 4). Jakes (1985) also analyzed researcher productivity by research discipline, noting that geneticists averaged the most publications per scientist-year.

Table 4.—*Publications per scientist-year by research discipline, Forest Service forest management research, 1980-1985*

Year	Research discipline			
	Silviculture	Genetics	Economics	Mensuration
1980	1.4	1.3	1.0	1.2
1981	1.8	1.9	1.6	1.1
1982	1.4	1.5	2.1	1.7
1983	2.0	2.5	2.3	0.6
1984	2.0	2.3	1.9	1.3
1985	1.9	1.8	3.1	1.0
6-year average	1.8	1.9	2.0	1.2

Practical versus Theoretical Research.—Research is commonly classified by the nature of the research effort or potential applications of research findings. O'Laughlin and his colleagues (1986) classed Forest Service research as productivity sustaining or productivity enhancing. They found that productivity sustaining research received about 43 percent of the Forest Service research budget, and productivity enhancing research received the rest.

Most forest management work units conducted practical research. On the average, more than 87 percent of the annual forest management research budget supported practical research and 12.4 percent supported theoretical research. Similar patterns existed in the allocation of personnel (87.3 percent of scientist-years to practical, 12.7 to theoretical) and in publications (89.1/10.9).

Distributional Considerations.—We examined the distribution of Forest Service research funding among geographical regions and ownership classes. Because the distribution of scientist-years and publications among geographic regions follows the distribution of funds, we will discuss only funding here.

Although research findings clearly have significant spillover effects, we can still determine the region primarily benefiting from a research project. Figure 10 depicts the average annual distribution of funds among the three geographic regions examined (North, South, and West), as well as among national and international clients.

As might be expected, forest management research funds were concentrated in the areas of intensive timber management. Research work units addressing western or southern forest management problems accounted for an average of more than 66 percent of the research funds. Most western funds were concentrated on projects involving the major timber producing areas of California, Oregon, and Washington. Most southern funds were allocated to projects focusing on the management of the economically important southern pines, although a large portion was spent on hardwood management research. Research projects addressing forest management in the Northeast annually received about one-quarter of the total forest management budget. An average of 7 percent of the total budget was directed to projects that involve all regions, and 4 percent had international applications.

We also classified the forest management research variables according to the ownership classes benefiting from the research. Research inputs and outputs were classified as applying to all owners, or to one or two of the following: government, industry, and/or nonindustrial private.

Nearly half of the research funds supported research benefiting all owners (fig. 11). Public owners benefited from more than 90 percent of the Forest Service forest management research (including research benefiting all owners). From fiscal year 1980 through fiscal year 1983, industrial forest managers benefited from the second largest share of funds. Beginning with a high of 82.7 percent in fiscal year 1980, industry's share of research funds declined to 62.0 in fiscal year 1984. In contrast, research benefiting NIPF's increased steadily from fiscal year 1982, and received the second largest share of funds in fiscal years 1984 and 1985.

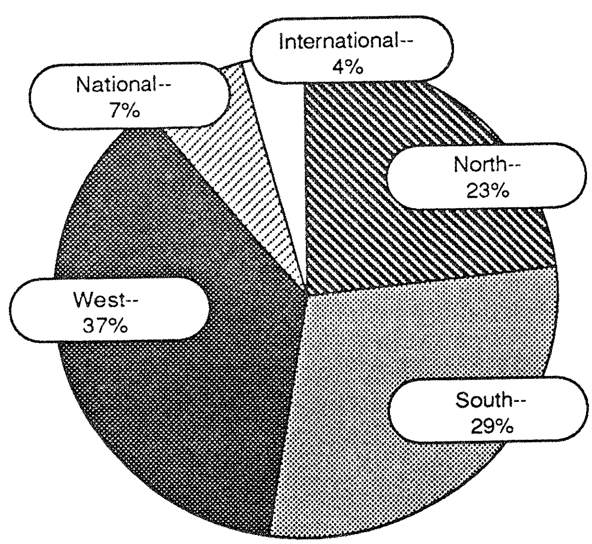


Figure 10.--*Average annual distribution of benefits among regional, national, and international clients, Forest Service forest management research, 1980-1985.*

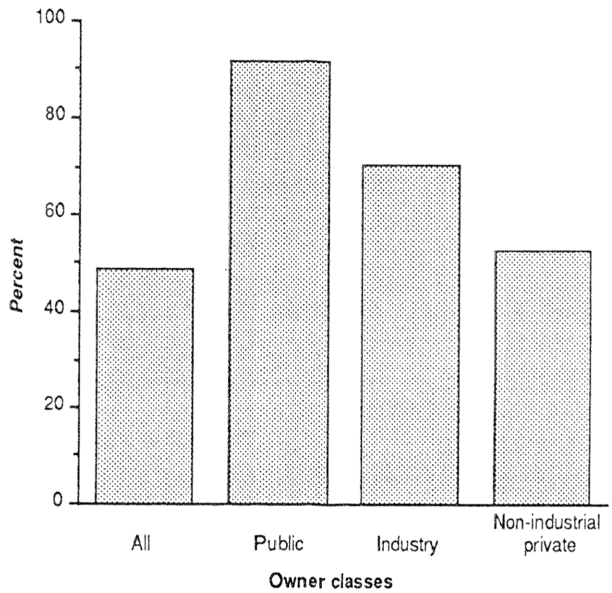


Figure 11.--*Average percent of research benefiting owner classes, Forest Service forest management research, 1980-1985.*

Forest industries

The forest management research effort by forest industry has declined significantly in the past 15 years. To cut corporate costs during the recession of the late 1970's and early 1980's and also to avoid corporate takeovers, industry managers have taken actions to improve short-term profits. As a result, research departments have been severely reduced. Most companies have made significant cuts; others have eliminated substantial forest management research efforts. Giese (1987) reports estimates by the American Forest Council that place the reduction in forest industry research between 30 and 50 percent since the early 1980's.

The remaining industrial forest management research consists largely of field tests to apply existing technology to the companies' specific situations. This is being conducted primarily by in-house researchers or through industry-university research cooperatives. The bulk of this work has involved investigations of site preparation techniques, tree improvement, and vegetation control. Predictably, most industrial research is done in the South and West.

As mentioned earlier, a few companies conduct most of the current industrial forest management research. In fiscal year 1985, these firms invested about $9.7 million in forest management research projects requiring 90 scientist-years.

The 25 firms conducting more limited forest management research programs invested an estimated $9.7 million and approximately 87 scientist-years. The averages for the reporting firms equaled $388,400 and 3.5 scientist-years per firm. Adding these estimates to the figures reported by a few major research firms results in a total forest management research effort by industry of about $19.4 million and 177 scientist-years—or $109,400 per scientist-year. Because much of the information produced by industry research is proprietary and because the few publications produced provide a poor gauge of research productivity, we do not discuss productivity measures for industry research here.

Universities

Forest management research constitutes a major portion of all research conducted at forestry schools throughout the United States. These schools perform most basic research pertaining to forest management, although they conduct much practical research as well. Similar to Forest Service and industry research, most university forestry research is conducted in the regions of intensive forestry.

The 44 schools responding to our survey reported 226 scientist-years conducting forest management research. We expanded this finding to represent 242 total scientist-years for all university forest management research programs. The largest number of university researchers, both nationally and regionally, were conducting silvicultural research (table 5). Nationally, economics research employed the second largest number of researchers, followed by biometrics/mensuration and genetics. These trends hold for all regions, except the North Central United States, where genetics research is more prevalent than biometrics/mensuration.

In all, universities spent more than $17 million in State and Federal funds on forest management research. Of the $17 million, almost one-half was spent in the South ($7.9 million), and about $3.5 million was spent in each of the West and North Central regions. An additional $14 million derived from non-appropriated sources such as grants, timber sales, or other sources was also spent on university forest management research.

Of course, all the schools reporting did not necessarily conduct research in each forest management research discipline—certain universities within a region specialize in specific

Table 5.—*Number of scientist-years invested in forest management research at U.S. forestry schools responding to the survey, 1985*

Region	Respondents/ total number of schools	Research discipline			
		Silviculture	Genetics	Economics	Mensuration
North Central	11/12	20.0	9.9	11.5	9.0
Northeastern	8/8	11.3	6.0	7.8	7.3
South	15/16	34.6	17.0	18.8	16.4
West	10/11	17.8	4.6	20.7	13.5
Total	44/47	83.7	37.5	58.8	46.2

disciplines. Research cooperatives provide a good example of this concentration—North Carolina State University has a major cooperative in genetics, the University of Georgia's Plantation Management Research Cooperative emphasizes growth and yield modeling, and the University of Washington's Regional Forest Nutrition Research Program is one of the oldest cooperatives in the West. A recent survey estimated that these research cooperatives represent $5.4 million and 53 scientist-years of forestry research (American Forest Council 1986). As a result, some individual schools accounted for one-half of the total regional scientist-years reported in table 5.

Discussion

Research Funding

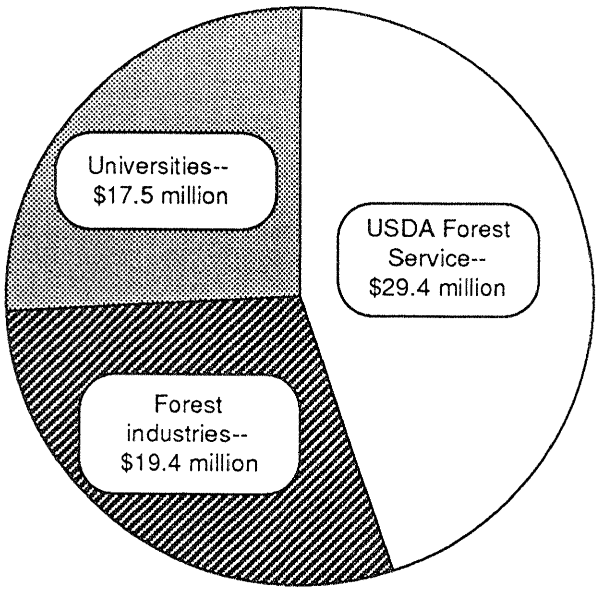
Figure 12 summarizes the forest management research funding and personnel for each of the three major forestry research sectors. Together, the three expended approximately $66 million in 1985 on forest management research requiring more than 660 scientist-years. These totals should be conservative, as only direct State and Federal appropriations to university research were considered. A similar survey of Forest Service and university forestry research in the South supports this study's estimates. The Southern Industrial Forestry Research Council (SIFRC) (1986) estimated that total forestry research in the South involved 310.8 scientist-years and $39.9 million in 1985. The SIFRC found that forest management research in the South involved 143 scientist-years and $17.5 million. The regional results of our study indicated that 166.5 scientist-years and $18.1 million were involved in southern forest management research.

Real dollars appropriated for all Forest Service research, and specifically forest management research, have declined since fiscal year 1981. Scientist-years for forest management research declined in each year we examined. The decline in industrial forest management research has been even greater; many major companies have even dismantled entire forestry research departments. Although no data were collected to determine trends in university research, it is likely that this sector may reduce its research effort as well, if it has not already done so. Declining student enrollment, reduced Forest Service extramural funds, and shrinking industry research funds probably have forced some cutbacks in research personnel. Two bright spots may be an increased industry reliance on universities to perform some of the research that the companies have traditionally conducted themselves, and the availability of funds in various competitive grant programs. Still, the net impact over all sectors has been a decline in research funding and personnel.

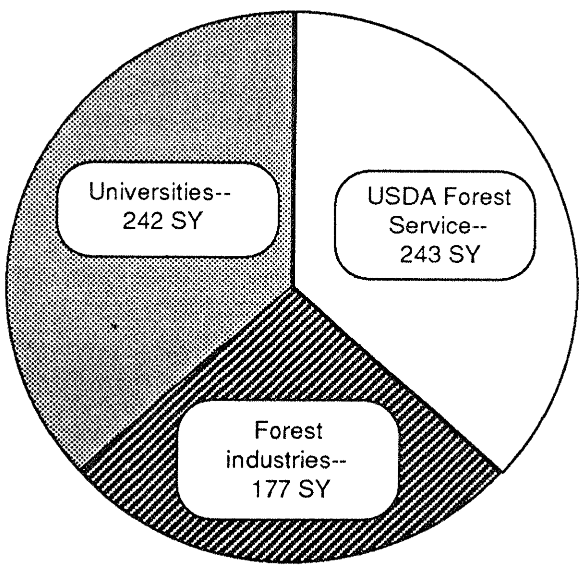
Productivity

The trends in research productivity may differ substantially from those described for funding and personnel. Because we calculated productivity measures for Forest Service researchers only, this discussion deals with trends in only that agency's forest management research productivity. However, much of academia is facing pressure to be more productive, both in research and teaching, while industrial research administrators are often asked to maintain the present level of productivity with reduced resources. Therefore, the trends observed within the Forest Service may be similar to those of all forest management research organizations.

Publications per Forest Service scientist-year in forest management research have increased significantly, as described earlier. Although they declined during the last year we examined, the publications per scientist were still 42 percent higher



a. Distribution of the $66 million U.S. forest management research effort among participants



b. Scientist-years contributed to the U.S. forest management research effort

Figure 12.--*Funding and personnel invested in U.S. forest management research by participant, 1985.*

than during the first year we examined. These figures suggest that the written productivity of those scientists conducting forest management research has greatly improved. Average figures may be misleading, however, Jakes found that in fiscal years 1980 and 1981, 20 percent of all Forest Service researchers produced 58 percent of all senior-authored agency publications. A similar ratio for forest management research in 1985 would imply that 49 scientist-years were responsible for 264 publications—a publication ratio of 5.4 per scientist-year. Although this cannot be determined with current data, it shows the potential variability in researcher productivity.

We must note that the number of publications provides only an indication of true research productivity. The productivity of any research effort must be based on its ultimate impact on the resource and its users. Numerous factors are involved in determining the impact of forest management research. Of particular significance are factors affecting the degree and rate of the adoption of research findings. The importance of these factors may differ by owner and region. For example, altering the pattern of adoption may be crucial to enhancing the utility of forestry research in the South, where most timberland is owned by individuals who traditionally have been slow to adopt new management practices. Conversely, forest management research findings may be adopted quickly where the major land holders are large forest products companies or the Forest Service. Therefore, the entire research and technology transfer process must be understood before the impact, or productivity, of forest management research can be calculated—a much more complex effort than counting publications.

Distributional Factors

Several issues are involved in the distribution of research resources and benefits. This study examined how the resources and products of Forest Service forest management research were distributed among geographic regions and ownership classes. We can consider several additional issues concerning the distribution of benefits from public forest management research.

The distribution of forest management research funding and personnel by geographic region suggests that they are allocated in an economically rational manner. Most research funds and personnel were committed to those areas of intensive forestry—the South and major timber regions of the West—where return to research investments should be the greatest. Another issue in the regional distribution of research resources and benefits concerns the equity of the distribution. Although favoring more productive regions may be economically efficient, the resulting distribution may not be completely equitable. Allocating most resources to the South may preclude developing innovations in the Northeast that would make it a more competitive supplier of forest products. Examples of "regionally biased" innovations include genetically superior southern pine seedlings and improved site preparation techniques for southern forest management.

The efficiency and equity of the distribution of resources and publications among ownership classes are difficult to quantify. Bengston and Gregersen (1986) note that the two most important factors in determining the distribution of research benefits among large (in this instance industry and, to a lesser extent, government) and small (NIPF) producers are innovator's rent and the scale bias of new technologies. Inventor's rent refers to the temporary advantages early adopters of a new technology receive because they have lower production costs than late adopters. Industry probably receives innovator's rent on most forest management innovations because it normally adopts such new technologies earlier than NIPF landowners. Bengston and Gregersen (1986) further note that innovator's rent may be the only benefit for producers if the commodity has an inelastic demand and adoption is widespread. Scale bias occurs when a new technology benefits primarily large producers, with little or negative impact on small producers.

The distribution of benefits between producers and consumers was not explicitly covered in this study. However, some conclusions can be drawn based on previous work on this area. Bengston and Gregersen (1986) note that the main determinant of the distribution between producers and consumers is the price elasticity of demand for the commodity in question. Consumers benefit most from research on those commodities with inelastic demands; producers receive the most benefits from research conducted on commodities with elastic demands. Given the inelastic demand for most primary wood products, consumers (e.g., forestry industry) should capture the bulk of benefits arising from forest management research. Newman (1986) found that consumers of southern solidwood markets receive 90 percent of the total benefits of technical change, but 150 percent of the total benefits of technical change in southern pulpwood markets. Thus, Newman observes that NIPF landowners are unlikely to adopt research findings because they gain little from such innovations. One way to increase NIPF productivity, therefore, is through use of subsidies. In contrast, forest products firms will adopt new technology because the benefits they do not receive as producers will be recaptured through reduced prices for raw materials for their processing plants.

Two additional issues identified by Bengston and Gregersen (1986) concern the distribution of benefits among labor and capital between generations. Stier (1980) found that technological change in eight U.S. forest products industries was labor-saving. Similar results are likely for most forest management innovations, because the work force involved in forest management has probably declined significantly in the past 25 years.

Finally, forest management research benefits are probably distributed evenly among the present and future generations. Numerous forest management research topics, such as financial and legal considerations of forestry, provide immediate benefits. Conversely, other research, specifically biological research on tree species with long growing periods, provides benefits to future generations (Bengston and Gregersen 1986).

Conclusions

Forest management research is a big part of forestry research in the United States. In 1985, the Forest Service invested nearly $30 million in forest management research, forestry industry invested $19 million, and universities invested at least $17 million. Investments in this research, however, have been declining since then. Forest Service funding has decreased modestly in real terms, and total industry research has decreased drastically in nominal and real terms. University forest management research budgets have probably declined in many States because of State budget shortfalls or declining forestry school enrollments (and university budget payments). However, some other schools have increased research funds substantially in recent years. Total university research budgets have probably maintained their real funding levels in the 1980's. Continuing to do so in the future, with consistently low student enrollment levels, may be difficult.

Although budget and personnel levels for forest management research are apt to decline, productivity is likely to increase. In the face of budget and personnel reductions, the remaining Forest Service researchers undoubtedly feel more pressure to justify their existence through publishing. Industry researchers, too, will certainly want to demonstrate to their corporations the value of their research to the bottom line. Academic researchers are also likely to feel increasing pressure to perform and publish as student enrollments wane. Most university systems have more tenured faculty but fewer students. These factors will undoubtedly lead to stricter promotion and tenure standards, which will spur greater productivity by all faculty.

The distribution of research benefits by Forest Service researchers indicates that the public sector is the largest beneficiary, being able to use more than 90 percent of the forest management research. Forest industry and the nonindustrial private forest sector are the intended beneficiaries of about 70 percent of Forest Service forest management research. Industry research is designed primarily for their own use, but probably much of their contributions to university cooperatives may be published in a form useful for public and NIPF owners. Data are not available on the beneficiaries of university research. Certainly one might expect that the NIPF sector and forest industry sectors, which pay taxes for State budgets, would be the principal beneficiaries.

In the United States, the Pacific Northwest and the South received the greatest share of Forest Service and industry forest management research benefits. This seems logical, because these two regions account for at least two-thirds of the U.S. timber harvests and values. They also had the largest amount of university research, followed closely by the North Central region. The Northeast region, whose predominantly hardwood forests are less valuable for timber and less profitable to manage intensively, might be expected to have less forest management research.

This overview of United States forest management research has shown that the Forest Service contributes the most to forest management research in terms of annual budgets and scientists employed. Its research efforts are dwindling, however, due to budget constraints. Industry research has declined even more, while universities have remained stable, at least to date. Our challenge is to justify and obtain the level of funding necessary for a forestry research program that addresses the Nation's needs.

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In 1985, the USDA Forest Service invested nearly $30 million in forest management research, forest industry invested $19 million, and universities invested at least $17 million. Investments in this research have been declining since then. Forest Service data indicate that the public sector is the largest beneficiary of forest management research.

KEY WORDS: Research investments, research benefits, forest management research.

FINDING OUT AND TELLING

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it--in short, "finding out and telling." As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager to meet these challenges while protecting the environment is what research at North Central is all about.

NORTH CENTRAL FOREST EXPERIMENT STATION