Research Management for the Future

PROCEEDINGS OF A MEETING OF

IUFRO SUBJECT GROUPS S6.06/6.08, MANAGEMENT OF FORESTRY RESEARCH
IN CONJUNCTION WITH THE XIX CONGRESS OF THE
INTERNATIONAL UNION OF FOREST RESEARCH ORGANIZATIONS

AUGUST 7-9, 1990
MONTREAL, CANADA

Contents

Experiences in Developing a Strategic Plan for the 90's for USDA Forest Service Research

Jerry Sesco, Deputy Chief
U.S. Department of Agriculture, Forest Service
Washington, D.C.

Introduction

The previous paper which discussed strategic planning in public forestry research organizations set the stage for this paper. For the past two years, USDA Forest Service Research has been developing a strategy for its research programs. In this paper, I will discuss some of our experiences in the development of this strategy. Specifically,

- Why did we decide to prepare a strategic plan?
- What are the components of the plan?
- What lessons did we learn which may be useful to others?
- How do we plan to implement the plan?

At the outset, it might be useful if I defined what I mean by "strategy." "Strategy" is a much used and often misused word today. To understand what strategy is and how it relates to the operating side of an organization, consider two facets which are critical to the survival of all organizations:

What the organization wants to be

and

How it should get there.

These two facets are often confused. An organization's future self-definition--what it wants to be--and its planning and day-to-day operational decision making--how it gets there--are related, but separate, dimensions.

Unfortunately, the word strategy is used rather casually today--it confuses the what and the how.

Managers talk about "their pricing strategy," "their budget strategy," and "their recruitment strategy." But, these are all related to how an organization gets to where it wants to be. So, when I say "strategy" I mean the nature and direction of the organization, its basic purpose.

The clearest definition I've heard of strategic planning is in a quote by the great hockey player, Wayne Gretsky: When asked the secret of his success as a hockey player, he replied, "I skate to where I think the puck will be." So, the objective of developing a strategy for an organization is to provide direction which will confront the issues of the future.

Why did we decide to initiate the development of a strategic plan in the Forest Service Research organization? Organizations are somewhat like living organisms in that they, too, must be capable of adapting to changing environments if they are to survive. The environment of Forest Service Research changed and we needed to adapt.

The 1960's and 1970's were relatively successful years for Forest Service Research. Budgets were increasing and several new laboratories were constructed. But, the 1980's were a decade of decreased funding, compounded by efforts to reduce the Federal deficit. During the 1980's, we closed several laboratories and reduced the number of scientists by 25 percent. By the late 1980's, our budget in constant dollars was about the same as 10 years earlier. Needless to say, we had some concerns and decided to initiate some actions.

We hired an outside consultant to provide an objective assessment of our competitiveness in the overall research community and our responsiveness to customer's (user's) needs. Based on the results of the consultant's report, we undertook several actions--the most significant was the development of a strategic plan.

Developing the Strategy

The "Strategy for the 90's for USDA Forest Service Research" is the product of an assessment of our mission, program, organization, and cooperation. Senior executives in Forest Service Research were involved throughout the strategy development efforts. The process for developing the strategy included several 3-day discussion sessions which included the Deputy Chief, Associate Deputy Chiefs, Station Directors, and Staff Directors. The purposes of the sessions were to: develop a better understanding of the Forest Service Research mission; determine trends affecting natural resources; evaluate current strengths of Forest Service Research; define issues, problems, and research opportunities; and estimate the level of support for current and future programs. From these discussions, a draft strategy was developed and subjected to extensive internal and external review. From these review comments and further discussions, the Deputy Chief for Research finalized the strategy.

Based upon a shared agreement of trends, mission, goals, and research capabilities, a research program strategy consisting of three major components was selected for emphasis. The three major components are:

1. **Understanding ecosystems.** The focus of this component is on understanding the structure and function of forest and range ecosystems, including mechanisms that control processes and the interdependency among ecosystem components. It is intended to provide understanding of how ecosystems affect, and are affected by, natural and human-made environmental changes. The areas of concentration in this component include ecological processes, biological diversity, endangered species, global change, atmospheric deposition, surface and ground water pollution, reforestation, and tropical forestry.

2. **Understanding people and natural resource relationships.** The focus of this component is on how people perceive and value the protection, management, and use of natural resources. Areas of concentration will include socioeconomic factors associated with the wildland/urban interface, rural development, rural diversification, international trade, customer satisfaction,

value differences among user groups, and the influence of urban culture on forest uses and practices.

3. **Understanding and expanding resource options.** The goal of this component is to determine which protection and management practices and utilization systems are most suitable for the production and use of natural resources. Although all resources will be studied, increased concentration will be given to studying options for the production and uses of non-wood outputs, such as water, fish, wildlife, and recreation resources. Research on extending the use of wood as a raw material, including recycling, will also be increased.

Lessons Learned

Consultants were used sparingly, but effectively, to help develop the strategy. Consultants helped design the process, served as meeting facilitators, and critiqued meetings and documents. They were not, and we feel should not be, involved in the decision making processes involved in developing the strategy. They assisted by providing an outside perspective and by asking useful, pertinent, and piercing questions.

The process for developing the strategic plan was deliberate. We asked the senior management team to be fully involved in the entire process, and to "buy-in" to the planning steps outlined by Bryson (1988)[1/]. There was general agreement that the steps outlined were acceptable. However, the mention of "processes" had negative connotations to some of the senior executives, who perceived "processes" as getting in the way of "dealing with substantive issues". We recommend keeping the strategic planning steps simple and transparent, but to emphasize the objectives and interrelationships of the various steps of the effort. Excessive detail may turn off some participants, and encourage participants to be detail-oriented, which is generally not needed or even desirable in strategy development. Striking a balance between those who want the processes and interrelationships laid out and defined in detail and those who want only general concepts is the challenge.

It is important to re-emphasize the need for full involvement of senior managers in strategy development. All senior managers in Forest Service Research (Deputy Chief and Staff, Station Directors, and Staff Directors) were involved on the strategy development team. This is helpful as the team works toward consensus on issues. Our experience suggests that the highly intuitive team members, who can offer insights and long-range views on diverse issues, should be encouraged to freely express their views and to challenge others to be proactive in their thinking.

It should be recognized that at various times in the strategy development process participants may be asked to think about issues at different levels of the organization. At times, managers will need to think about issues relating to the total organization, and at other times they will need to think about issues at lower organizational levels. This appeared to be difficult for most managers because of their parochial interests. We recommend that it be made clear which level of emphasis is needed for each planning session. In addition, from time to time managers should be asked to explain whether their statements are coming from a corporate or a position-dependent point of view.

Acknowledging the mode and discussing it should help in building a team, reaching consensus, and setting direction for the future.

It took longer than anticipated to move through the strategy development process and prepare a plan. Our intention was to have a plan completed in a year, but it took more than a year and a half. We recommend the process not be rushed. When a research program direction is first drafted, participants need time to understand and refine the proposed direction. Revisions and enhancement of the draft document proceeded slowly. There was a need to recycle significant changes in the document through the group of participants. It also took time to collect and assimilate review comments from people inside and outside the organization. We feel it is important to have patience in these phases.

One of the most difficult aspects of research strategic planning falls in the area of futuring or defining potential future problems. It involves extrapolating beyond the current trends to project what might be future problems and areas of fruitful research. It was difficult for managers to become futurists--to define broad-scale future problems. While brainstorming and nominal group techniques are useful for this phase, we think that futurist specialists should be brought in to make these sessions more effective in defining future problems, thinking strategically and being more proactive.

We believe there are some management philosophies and approaches that can help a research organization to be more proactive. Scientists need to be encouraged and rewarded for addressing high-risk, potential problems. They also need to be encouraged to work in small teams (skunkworks) to generate new ideas. Potential future problems are more likely to be identified and revealed (filtered up) in this type of an environment.

Developing the strategy per se is only part of the goal. Perhaps the greatest value from developing a strategy comes from the improved ability to think and act strategically. Only when that takes place will it fully serve its intended purpose.

How Do You Make A Strategy Happen?

A full discussion of implementation of a strategic plan is a subject which would require another paper in itself. Briefly, strategic management is a continuing process. Putting a strategy in place requires linking what the organization wants to become with how it should get there. Nowhere is the perseverance of an organization management tested more acutely than in the area of implementing strategy. A well formulated strategy is the first step toward effective implementation, because every plan that must be developed, and every decision that must be made, can be tested against this mental picture of what you want the organization to be.

1/ Bryson, John M. 1988. Strategic Planning for Public and Nonprofit Organizations. Jassey-Boss Publishers. San Francisco, CA. 311 pages.

THE INTERNATIONAL FOREST PRODUCTS PROGRAM AT THE FOREST PRODUCTS LABORATORY: ROLE FOR THE UNITED STATES IN PROMOTING FOREST PRODUCTS INTERNATIONALLY

JOHN R. ERICKSON and GARY R. LINDELL
U.S. Department of Agriculture, Forest Service
Forest Products Laboratory[1]
Madison, Wisconsin 53705–2398 USA

SUMMARY

The U.S. Department of Agriculture, Forest Service, Forest Products Laboratory (FPL), has promoted international cooperation since it was established in 1910. A new work unit supporting an International Forest Products Program was recently initiated at FPL. This new unit, along with other units of the Forest Service and our research colleagues in the academic and industrial sectors, could take a lead role in promoting forest products utilization internationally.

Keywords: Forest products, International Forest Products Program, forest products research

INTRODUCTION

Although the USDA Forest Service, Forest Products Laboratory (FPL), in Madison, Wisconsin, was established primarily to serve U.S. research needs, it has always had an international dimension as well. Established in 1910, FPL began receiving international recognition and foreign visitors during its first decade (Youngs 1987). FPL regularly receives requests for information and advice from all over the world. However, most of these requests are from industrialized countries (Ingram et al. 1987). We must find more effective ways of transmitting information to our colleagues in less developed countries as well. The Bellagio II Conference recognized this need by endorsing utilization and market research as one of five areas requiring additional support (Rockefeller Foundation et al. 1988).

In the several decades after it was established, FPL broadened its international involvement through international contacts with staff scientists. For example, after his retirement, a former FPL Director became co-director (with a Filipino counterpart) of the Philippine Forest Products Laboratory (now the Forest Products Research and Development Institute). He was instrumental in establishing its research program and a program to send scientists to FPL and the University of Wisconsin for professional and advanced academic training. Other efforts during this period included assistance to Costa Rica, Equador, Chile, Bangladesh, and many other countries.

In the 1970s, FPL, with support from the U.S. Agency for International Development (USAID), launched a program to evaluate and demonstrate the potential for using mixed tropical hardwoods for a variety of products. This effort culminated in a major international conference in Madison, Wisconsin, in 1978. (USDA Forest Service, Forest Products Laboratory, 1978).

---

[1] The Forest Products Laboratory is maintained in cooperation with the University of Wisconsin. This article was written and prepared by U.S. Government employees on official time, and it is therefore in the public domain and not subject to copyright.

In the mid-1980s, the U.S. Congress mandated that the USDA Forest Service supplement its research efforts in tropical forestry, including forest products. FPL joined other Forest Service units in this effort, which became popularly known as the Caribbean Initiative. FPL efforts resulted in the preparation of a report entitled "Forest Products From Latin America: An Almanac of the State of the Knowledge and the State of the Art." Although the focus of the report is Latin America, it should have broad application to research efforts and information transfer in other tropical areas.

The international efforts of FPL were strengthened and institutionalized in 1988 with the establishment of the International Forest Products Research, Development, and Application Program. This paper describes how this new unit could catalyze and coordinate FPL and Forest Service efforts to promote forest products utilization internationally.

INTERNATIONAL FOREST PRODUCTS PROGRAM

The mission of the International Forest Products (IFP) Program is to "facilitate forest products research through an international program of research, development, and application between FPL and other Forest Service units, universities, and related institutions throughout the world." The IFP unit has modest resources and must rely on its parent organization and others to do the actual research. The unit's role is to help initiate and guide these efforts. In pursuit of this objective, activities are underway in the areas of (1) supporting programs in developing countries, (2) coordinating forest products research, (3) exchanging scientists, and (4) identifying applicable foreign technologies.

Supporting Programs in Developing Countries

We believe that the best, and perhaps only, way to promote the application of new technologies in developing countries is through one-on-one relationships between research institutes and between scientists in developed and developing countries. The need to support research institutes in developing countries is well recognized. We should help build upon the excellent research capability that already exists in many centers. Well-planned national research will be more effective than imported research (World Bank, Food and Agriculture Organization 1981). As discussed previously, networking or twinning arrangements between institutes in developed and developing countries are effective ways of providing support. Another is cooperative research projects or training.

Providing new or surplus equipment is another effective way of supporting institutes in developing countries. For example, FPL recently shipped two universal testing machines to the Central American Research Institute for Industry (ICAITI) in Guatemala. This nonprofit regional organization, established with support from the United Nations and now assisted by USAID, promotes regional industrial development through technical assistance, training, and applied research in support of both private and government initiatives. A third surplus universal testing machine and other surplus research equipment are now awaiting shipment to CORMADERA, a similar institute located in Quito, Equador.

Another way to support institutes in developing countries is by providing surplus library equipment, books, and periodicals. The FPL periodically ships these badly needed items to several institutes in developing countries.

These are some of the ways we are trying to provide direct support to selected institutes. Although many of the institutes represented at this meeting are engaged in similar activities, these efforts must be expanded.

Coordinating Forest Products Research

Although the IFP Program was established at FPL because of our dominant role in Forest Service forest products research efforts, the IFP Program also supports other Forest Service, university, and industry forest products research efforts. We also support the International Forestry Staff of the Forest Service in Washington, D.C., which has overall responsibility for international Forest Service activities.

One promising way of strengthening forest products internationally is through "twinning" or "networking" arrangements between organizations. For example, two organizations, most likely one in a developed country and one in a developing country, could agree to exchange staff or resources to strengthen one of the partners. Other possibilities would include a "pooling" of efforts to more effectively address problems of common interest (Burley 1987). Such networking could take place anywhere but may have more potential in the tropics where problems are often regional and resources scarce. Problems such as properties and uses of lesser known species, growth stresses, processing of difficult woods, alternative preservatives, and the need for harmonizing codes and standards would lend themselves to a unified effort.

IUFRO could play a major role in these networking or twinning possibilities. Important efforts are underway at this conference to facilitate these opportunities.

Exchanging Scientists

As discussed previously, FPL has a long history of providing research opportunities for visiting scientists. Many have been able to add to their experience through formal training at the University of Wisconsin or elsewhere. In our experience, these arrangements have been positive and beneficial to both parties, and we highly recommend scientist exchanges. The recent survey of wood technology research needs in Africa showed temporary exchange of research staff to be one of the most effective ways to strengthen the institutes surveyed (IUFRO 1989).

Recognizing the effectiveness of staff exchanges, we recently initiated the Visiting Scientist Program within the IFP Program to expand and strengthen our efforts. We are now recruiting scientists to come to FPL to work with our scientists on projects of mutual interest for 6 months or more.

We do expect visiting scientists to arrange their own financial support, but we are attempting to identify potential sources of support, particularly for prospective visitors from developing countries. We have had modest success and have had visiting scientists supported by the Food and Agriculture Organization (FAO), the USDA Cochran Middle Income Program, and soft money projects.

The IFP Program staff also provide assistance with other needs, such as housing, staff privileges, and medical insurance. We have also taken steps to provide special recognition for our visiting scientists and their contributions to the FPL research program.

We now have 24 visiting scientists at FPL, which is a typical number. Sixteen of these are from foreign institutions.

FPL and Forest Service training activities were expanded and strengthened this year with the initiation of the Forest Service Training Program on Tropical Woods. This program is supported by training funds attached to the recently passed Tropical Forestry Initiative. A portion of the funds is dedicated to forest products and is being managed by the IFP unit at FPL. The program is targeted for candidates from tropical countries who are expected to return home to jobs that are more applied in nature. Funds for round trip travel and limited support for living expenses while at the host institution are provided. Announcement and application forms have been sent, with a fall 1990 closing date. USDA Forest Service units have the lead in identifying candidates. This program will provide much needed impetus to support training at Forest Service research locations for candidates from tropical areas. The training level of the researcher was identified as the most important factor affecting research capabilities of institutes in developing countries (Bengston and Gregersen 1988).

FPL also supports the International Tropical Timber Organization (ITTO) Fellowship and Small Grants Program, which, among other things, supports short-term (1 year or less) visits to the FPL. This important program also supports FPL involvement in a project to identify all the common names of timbers.

Identifying Applicable Foreign Technologies

We are increasingly concerned in the United States about our lagging technological leadership in some areas. Many statistics can be cited to support that concern (National Science Foundation 1987, Council on Competitiveness 1988). At the same, we are increasingly aware that we should seek out foreign technology that could be applied in the United States. These trends apply in forestry and forestry research as well. Gregersen et al. (1989) conclude that U.S. gains from foreign forestry research are real and could be substantial. A role of the IFP Program is to help answer the following questions: Are new forestry-based technologies being developed in other countries that should be applied in the United States? Why have those technologies not been applied here? What research is needed to adapt them to our situation?

A common focus is the international competitiveness of countries and the role of their institutions in enhancing new technologies for their specific markets. However, we expect that advancement and application of new technologies will result from cooperative R&D on problems of common interest between countries.

Opportunities for regional approaches to solving problems would be particularly interesting in the tropics, as noted earlier. Collaborative efforts can enhance the availability of resources, distribute the risk, and facilitate the application of research results (Ronstadt and Kramer 1982).

The international forest products community has an obligation to enhance the competitiveness of wood as a material. However, its primary responsibility is to assure that forest resources are used wisely to promote good forest management. This is particularly true in the tropics. Despite the apparent opportunity to use tropical forests as a vehicle for development, they are often viewed as an unknown factor or even as an impediment. Research is needed to enhance the management of these forests for the economic benefit of the region while maintaining environmental quality.

CONCLUSION

The Forest Products Laboratory has increased its commitment to advance forest products internationally with the creation of the International Forest Products Program. This is a modest effort to be sure, but it is real and unique. Through it, FPL efforts are dedicated to the advancement of wood in the family of materials.

LITERATURE CITED

Bengston, David N. and Gregersen, Hans M., 1988: What influences forestry research capacity in developed and less developed countries? *Journal of Forestry,* vol. 86, no. 2, pp. 41–43.

Burley, J., 1987: International forestry research networks: objectives, problems, and management. *Unasylva,* vol. 39, no. 3/4, pp. 67–73.

Council on Competitiveness, 1988: Signs of declining U.S. technological leadership. *Research-Technology Management,* vol. 31, no. 6, pp. 3.

Gregersen, H., Haygreen, J., Sindelar, S. and Jakes, P., 1989: U.S. gains from foreign forestry research. *Journal of Forestry,* vol. 87, no. 2, pp. 21–26.

Ingram, C. Denise, Larman, Jan G. and Contezac, Michel C., 1987: International technology transfer: the Forest Products Laboratory. *Forest Products Journal,* vol. 37, no. 7/8, pp. 15–16.

IUFRO, 1989: Research needs in wood technology: results of the African survey (1988), Abidjan, Cote d'Ivoire, 16 p.

National Science Foundation, 1987: International science and technology data update: 1987, Washington, DC, 73 p.

Rockefeller Foundation, United Nations Development Programme, World Bank, and Food and Agriculture Organization of United Nations, 1988: Report of an international task force on forestry research, 88 p.

Ronstadt, Robert and Kramer, Robert J., 1982: Getting the most out of the innovation abroad. *Harvard Business Review,* vol. 60, no. 2, pp. 94–99.

USDA Forest Service, Forest Products Laboratory, 1978: Proceedings of conference on improved utilization of tropical forests, Madison, Wisconsin, 569 p.

World Bank, Food and Agriculture Organization, 1981: Forestry research needs in developing countries: time for a reappraisal? Prepared for 17th IUFRO Congress, Kyoto, Japan, 6–17 September 1981, 56 p.

Youngs, Robert L., 1987: The Forest Products Laboratory: highlighting its advances in the international wood research community. *Journal of Forestry,* vol. 85, no. 12, pp. 33–37.

This paper was presented at the XIX IUFRO World Congress,
Montreal, Canada. August 1990.

Prepared July 1990

The Productivity of Forestry Research: Recent Experience from Five US Industries and Its Implications for the Rest of the World

Abstract

This paper examines the empirical returns to public research in four forest products industries and the southern pine timber industry of the US, reviews the characteristics of differential success and failure, and then examines implications for the future--for the US, for developed country forestry research, and for developing country forestry research.

Forest products research has great but selective promise. The public is probably underinvested in forest products research, in the US and worldwide. It promises large future gains in social efficiency, as well as additional resource gains as it provides substitutes for timber harvests from lands with competing, non-timber uses. This is an important finding when placed in the context of the world forestry role in providing for global values having to do with climate change, biodiversity, and aesthetic resource demands.

The public is overinvested in timber management research in the US. This observation is also probably accurate for Canada and the Soviet Union, and perhaps for Japan, western Europe and most developing countries. Timber management research in all countries will become a better investment as the stocks of extensively managed timber are drawn down and stumpage prices rise. For the US South, this may mean the next ten to thirty years. For developing countries, this probably means as the institutions adjust to provide more secure tenure and as policymakers revise current policies with perverse secondary impacts on the forest.

The Productivity of Forestry Research: Recent Experience from Five US Industries and Its Implications for the Rest of the World[1]

William F. Hyde, David H. Newman and Barry J. Seldon[2]

Forestry receives great attention for its role in the global environment. With this attention, forestry research should also come under greater scrutiny. Can it produce enough trees to sequester carbon--and restrict global change? Can it help protect the natural forest habitats that sustain global biodiversity? Can it produce enough trees to satisfy human demands for wood and fiber? Can it do these things efficiently?

This paper is an initial inquiry into these questions. It examines research productivity in the forestry sector of the US economy for the period 1950-80. There is a broad literature surveying the efficiency of industrial research in general and agricultural research in particular. [See Ruttan (1980) for a survey.] There is also a broad literature on the impacts of technical change. Solow (1957) and Denison (1974) observe that research--through its product, technical change--has explained between seventy and eighty percent of the increase in US non-farm

1. The original draft of this paper was prepared while we were guests of I. Vertinsky and the Forest Economics and Policy Analysis Research Unit at the University of British Columbia in January 1989. The authors did the supporting empirical work at Duke university. FEPA and the USDA Forest Service provided financial support. M. Fullerton, T. Heaps, P. Pearse and especially A. Scott raised questions or contributed insight which improved both our analysis and our exposition. D. McKenney and J. Davis, Australian Centre for International Agricultural Research; and D. Brooks, US Forest Service reviewed and improved subsequent drafts.

2. Economics Research Service, University of Georgia and University of Texas, Dallas, respectively.

production in this century. Knutson and Tweeten (1979) observe that the marginal return on agricultural research and extension expenditures in the US has been greater than 35 percent annually since 1939. These observations confirm an historic record of research activities strongly improving aggregate US economic growth. Our question in this paper is whether this broad and general research experience has also held true for the forestry sector of the US economy--and whether it is likely to be true for global forestry research.

Our general approach is through a select series of empirical cases from the US. These cases include four examples from the forest products industries and one from the timber growth and management industry. The forest products examples are the softwood plywood industry, an industry which is generally thought to be an outstanding example of research success; the sawmill and woodpulp industries, two industries which largely define the forest products sector of the US economy; and the wood preservatives industry, an industry which provides the special example of product-altering (or quality-oriented) rather than process-altering research. The timber growth and management example is the southern pine industry. The southern pine industry has supported the most successful timber management and biological improvement research in North America. It is the basis for the most advanced timber production region of the US.

A glance ahead to our results shows great gains from forest products research, gains sometimes exceeding the best observed in agriculture. The success of southern pine growth and management research, however, is altogether more doubtful. Because southern pine research is thought to be a good example, this doubt encourages greater skepticism regarding the general performance of all less promising examples of timber management research in other regions of the US. It also begs questions about the difference in performance between forest products research and timber management research and it raises the possibility that global environmental values like controlling climate change and maintaining biodiversity may be protected best by forest products research that decreases the demand for wood and fiber--rather than by direct timber growth and management research which has done a poorer job of increasing supply.

Our general inquiry was important for the US when we began in 1983 because American forestry research had not previously undergone a technical economic appraisal and because forestry was embarking on a period of unusually tight research budgets. Tight budgets beg careful justification of all expenditures. Furthermore, many developed countries shared this experience of tight budgets. Therefore, many developed country forestry institutions may also gain insight from our US observations.

Forestry has also become an exciting topic in economic development. An immense amount of money is being spent on forestry, including forestry research, in developing countries today.[3] Much of this money originates with international lending agencies which generally require repayment regardless of the eventual success of local investments. Thus, while forestry research programs intend to produce great gains for the rural poor in many developing countries, they may promise increased and

3. Mergen *et al* (1988) estimate that global forestry research expenditures approximately doubled in ten years to $1.024 billion (1980$) in 1980. Expenditures in developing countries alone increased from $79 million to $198 million. More recently, the Consultative Group of International Agriculture Research institutions agreed in December 1988 to extend their agricultural activities by introducing three new forestry research networks, one each in Asia, Africa, and Latin America.

extended national indebtedness instead if these programs are chosen with less than the greatest care and best economic insight.

An important intention of this paper is to bring these public policy concerns together. The technical assessments of research in the five specific forest industries should permit reflection on the characteristics of other, greater and lesser, American successes of the recent past and they should provide some intuition with respect to the future of forestry research in the US. They should also provide initial justifiable extrapolations for the more general forestry research situations occurring around the world--regardless of the level of local economic development.

Forest Products Research

Our prototype evaluation for the forest products industries is the softwood plywood (SWPW) industry. Our SWPW analysis begins with the dual of the production function and with research as an explicit factor of production, transforms this production function to its counterpart supply function, and simultaneously estimates supply with demand. The dual uses input prices and costs rather than quantities. It is a data intensive approach relative to most agriculture research evaluations. It has the advantage, however, of improved accuracy and it also permits eventual calculations of both marginal and average returns to research.

Softwood Plywood Results

Table 1 repeats the non-linear two-stage least squares (NL2SLS) estimates for the SWPW demand and supply coefficients. The general statistical tests for these equations are all satisfactory. All individual coefficients have the anticipated signs and all are significant at the ten percent level or better.

A separate statistical test rejects the hypothesis that the industry experienced other (disembodied) technical changes that are unexplained by either the public or the private R&D terms. This is not surprising. Public R&D, largely at the Forest Products Laboratory (FPL) of the US Forest Service, was extensive in the 1950-1980 period. The FPL participated in virtually all recognized SWPW technical change: new gluing techniques, experiments with little-used log species, and all new capital equipment experiments originating in the US. Private firms, in the SWPW case, concentrated on recognizing, receiving, modifying, and developing public research for the specific needs of individual plywood firms or plants.

The interesting terms for us, in table 1, are the last three terms in the production/supply equation.[4] We assume that the continuing impacts of research on output have a Koyck distribution over time. The Koyck distribution starts at a peak and deteriorates at a rate determined by the coefficient for the lag term in table 1.

---

4. The subscripts following the R&D terms refer to the number of years following a research expenditure but preceding its initial R&D impact on output. Our estimation process for specifying this lag proceeds in three steps: (1) Obtain expert opinion: FPL scientists estimated a two year research-productivity lag before the initial R&D impact. (2) Obtain two-stage least-squares estimates for an index of SWPW technology as functions of public and private R&D each lagged from one to seven years: The statistically most satisfying estimate is for two years. (3) Use these two year research-productivity lags in the NL2SLS demand and supply estimates, but retest the final demand-supply specification for alternate R&D lags: Alternate R&D lags do not improve on the SWPW demand-supply estimates in table 1.

The elasticities deriving from the coefficients in table 1 are:

supply price	0.497	initial public R&D	0.0207
demand price	-2.703	long-run public R&D	0.19
labor output	0.2057	private R&D	<0.48
capital output	0.1263		

These elasticities are not inconsistent with related previous literature (McKillop *et al* 1980, Rockel and Buongiorno 1982). All but the private R&D elasticity are significant at the ten percent level or better.[5]

The market equilibrium price and quantity and the supply price elasticity explain industry production prior to the public research investment. The public R&D elasticity, the two-year research-productivity lag, the subsequent Koyck distribution of research impacts, and the lag coefficient explaining the decline in these impacts over time, altogether determine the position of the new industry supply curve at any time after the R&D injection. The area between the original supply curve and the new supply curve, and to the left of market equilibrium, measures the gross benefit from public R&D.

The first column of table 2 shows various final measures of these gross social benefits of public SWPW research. The net present value (NPV) estimates show that primary producers and their higher level industrial processors (consumers) share almost equally in these research benefits.

5. Direct evidence of private expenditures is unavailable. Therefore, we use a proxy for private R&D expenditures and the output elasticity of private R&D must be derived as a residual. (Its upper bound is one minus the other output elasticities.)

The large producer gains cause us to inquire about the public presence in this research effort. The competitive nature of the industry, and the non-exclusive nature of many SWPW research products, suggest that the individual firm's only incentive is the payoff the firm captures before its competitors adopt the same or similar new technologies. This is probably the payoff of the first two years. The annual flows of research benefits and costs, however, indicate that the average firm conducting independent research would not have recovered its research costs in any of the first eighteen years of our analysis.[6] Thus, without a public presence, there would probably have been little research and little gain, for either producers or consumers.

The value of the marginal product (VMP) and the rate of return estimates further display the efficiency of public SWPW research. The short-run VMP is comparable to those found in agriculture and it shows that additional SWPW research investments would have returned more than their costs. The long-run VMP and the marginal internal rate of return (MIRR) are much greater than usually found in agriculture--perhaps because the initial SWPW research investments were small, or because the SWPW research-productivity lags were so short; therefore, the final research benefits are discounted less. The short-run and long-run VMPs and the MIRR all indicate that additional net social gains would have been available from even greater investments in SWPW research.[7]

---

6. There are approximately eighty firms in SIC 2436. The four largest shared approximately 38 percent of the market in 1978.

7. Sensitivity tests do not alter our confidence in these results. We examined alternative private R&D costs and discount rates. We also simulated the impact of differential Southern and Northwestern wage rates and we examined the different results that would obtain with exogenous estimates of the relevant price elasticities. The latter results show

Research in Other Forest Product Industries

The sawmill analysis furnishes most satisfactory statistical results--on the supply/production and the demand equations and on all coefficients in both equations. The supply and demand price elasticities, 0.34 and -0.60 respectively, are significant at the one and ten percent levels respectively. Both are consistent with previous literature (Robinson 1974, Adams and Haynes 1980, Lewandrowski 1989). The long-run public research output elasticity of 0.93 is significant at the five percent level. The research-implementation lag is a notable five years in the sawmill case. This longer lag is probably due to the large number, small size and diffuse nature of firms in the US sawmill industry (17,000 in 1950, 6,800 in 1980).

Average returns to public research in this industry fall in the range of 17-50 percent annually for consumers and 13-49 percent for society as a whole--depending on our estimates for the private implementation costs of new technologies. Producers are net losers. This means that, for producers, decreased production costs are largely passed on as lower consumer prices, causing producer revenue losses that cannot be offset by gains from increased outputs. It also means that sawmill managers have little incentive to invest in research and that the social gains from sawmill research would not be forthcoming if we relied on private industrial research. Marginal returns fall between five and 32 percent annually. This probably equals or exceeds the social opportunity cost of capital and it means that socially justifiable

---

that the magnitude of our SWPW results is not due to our improvements in the standard analytical approach.

sawmill research investments were at least as great as, and perhaps greater than, the historic 1950-80 investment level.[8]

The woodpulp analysis provides satisfying supply results but a problem for demand. Statistical tests on both the woodpulp supply/production equation and on its individual terms.are satisfactory. The supply price elasticity of 1.09 is significant at the one percent level and the long-run public research output elasticity of 0.32 is significant at the ten percent level. Our econometric estimation of woodpulp demand is unconvincing, however, and perhaps a constant coefficient equation form would better explain the woodpulp-consuming paper industry. Our analytical solution is to employ our supply elasticities, together with an assumption of inelastic demand. Inelastic demand is consistent with both prior woodpulp literature (Guthrie 1972, Gilless and Buongiorno 1987) and more casual observations of the high fixed cost nature of the paper industry.

Average returns to public woodpulp research are 33 percent annually for consumers and fifteen percent for society as a whole. Producer gains are negative, as they must be in an industry with perfectly inelastic demand. Marginal returns are negative, indicating overinvestment in woodpulp research.

---

8. There is an argument that Swedish sawmill research produced a substantial positive spillover to American sawmills. If this spillover were statistically significant, then it would cause large error terms in our equations and an unsatisfactory coefficient of determination. Yet the coefficient of determination is an acceptable 0.67. Furthermore, if Swedish research productivity had a regular effect over time, then it would argue for a positive-signed term for disembodied technical change. Yet preliminary supply regressions with terms for disembodied technical change were less satisfactory in general and the coefficient on disembodied technical change both had the wrong sign and was statistically insignificant. Thus, we reject the argument for Swedish, or other international, research impacts on the US sawmill industry.

It turns out, however, that some woodpulp research dealt with environmental residuals. This research is of the product-altering, rather than the cost-reducing variety. Therefore, our measures of economic return do not reflect its benefits. This means that our average and marginal returns are lower bound estimates for the true measures.

Higher government authority mandated some 1970s research on energy-saving and pollution-reducing pulping processes. Pursuit of this research was contrary to the professional judgment of FPL scientists regarding its technical and economic feasibility and this research probably would not have been conducted in the absence of political intervention. The average and marginal returns to all remaining woodpulp research for the thirty-year period would have been higher. This is a second reason why our woodpulp results are lower bound estimates for the performance of FPL scientists and managers.

The wood preservatives analysis is also problematic. Our demand specification is statistically significant but the supply/production equation is less reliable. The demand price elasticity of -1.62 is significant at the one percent level. The supply price elasticity of 0.47 is insignificant. (There is no comparable econometric wood preservatives literature.) The R&D coefficients have the correct signs but only the private R&D coefficient is significant. The insignificant public coefficient may be due to the large investment in FPL research designed to reduce the petroleum-based environmental residuals associated with wood preservatives. Public research cost data include this investment but our output measure does not reflect their research products. The resulting partial cost-output mismatch may explain the statistical insignificance.

Nevertheless, we proceed on the confidence of the correct sign on the public coefficient (as is common in the research evaluation literature where statistical insignificance is the norm). The long-run public research output elasticity is 0.274. The average social return on public wood preservatives research may be as great as 293 percent annually. (Rates of return to consumers and producers are indeterminate because their time streams change signs several times.) Marginal social returns are negative, indicating either overinvestment or significant benefits in unmeasured product-altering wood preservatives research. Removing the costs of product-altering and environmental research would raise the marginal returns, perhaps to the positive range where they would also remove the question of overinvestment.

Comparative Results

Table 2 summarizes the similarities and differences in research production across the four forest products industries. The first summary observation is that public research investment was socially justifiable at some level in all four industries. That is, there were substantial net social gains from public research in all four. Yet:

- The benefits of research would be spread too thinly among eighty establishments to sustain much *private* research investment in SWPW. Research benefits would be spread even more thinly among 6,800 or more sawmill firms. Indeed, the sawmill industry conducts virtually no private research of its own.
- Inelastic demands in sawmills and woodpulp indicate that these industries pass most of their research gains to consumers. One reason why concentrated industries, like the woodpulp-consuming

paper industry, might vertically integrate is to absorb those consumer benefits.

- The producers of wood preservatives and woodpulp cannot capture the benefits of those research improvements that decrease the non-market environmental residuals occurring in the production process.

In sum, all four industries can justify public research at some level on the basis of the resulting consumer and net social benefits. The minimal (often even negative) and intermittent producer benefits, the inability to establish lasting proprietary rights to these benefits, and the unlikelihood of sharing research costs across firms make large private producer investments in research unlikely in these industries. (These conclusions are all insensitive to reasonable adjustments in either private research implementation costs or the social discount rate.)

The generalized determinants of research performance are unclear. The results from these four industries suggest that neither firm size nor market power are correlated with public forest products research success. Average returns are greatest in SWPW and wood preservatives, which are the middle industries with respect to firm size and market power. The small size of the research programs in SWPW and woodpulp, the long research-implementation lag in the diffuse sawmill industry, the absence of unaccounted product-quality benefits in our benefit measures for wood preservatives and perhaps woodpulp, and ill-conceived political encouragement of some woodpulp research all appear to be more important explanatory factors of research performance than either firm size or market power.

In conclusion, public research performance in these four industries for the period 1950-1980 ranged from adequate to superior. It brought social gains that were often greater than those usually anticipated for marginal private investments, comparable to (if more variable than) the 35-110 percent average returns in Ruttan's (1980) survey of public agricultural research investments, and substantially in excess of either (negative returns for) public investments for non-industrial private forest incentives (Boyd and Hyde 1989 ch. 3) or (small positive returns for) public forest timber management (Repetto 1988, Boyd and Hyde 1989 ch. 8). These comparative observations are implicit compliments for the forest products research managers of the 1950-80 period of our analyses and they should encourage the research managers of today to sustain their best judgments.

Timber Growth and Management Research

Evaluating timber growth and management research poses new problems unfamiliar in either agriculture or forest products research. First, forest landowners, unlike SWPW millowners for example, are not a homogeneous group, all with similar production functions. Rather, the classes of public, industrial, and non-industrial private (NIPF) landowners may each have different management objectives and only industrial landowners may have strict timber production objectives. This restricts our confidence in the profit maximization assumption underlying any specification of an aggregate production function.

Furthermore, there are two new difficulties for direct estimates of stumpage research shifters: (1) The long and uncertain lags between initial research and eventual productivity surely obscure statistical reliability. (2) Less frequent data (Forest inventories are generally collected in ten year cycles.) and data that cannot segregate growing stock from final output put timber management research evaluation at additional disadvantages relative to either agriculture or forest products research evaluation.

This causes us to reflect further about the dynamics of timber production research. Our southern pine production relationship explains standing inventory as a function of various capital and labor inputs and a time shifter. The time shifter is a proxy for disembodied technical change. It includes research-induced inventory shifts and it may include some regular increases in productivity due to unspecified causes other than research.

Stumpage supply is a second function of the various inputs to supply, including inventory. The time shifter in the previous production function becomes a supply shifter. Supply is more complex, however, because southern pine production is a joint input for two supply functions, solidwood and pulpwood. Therefore, southern pine research has an impact on two products and we must simultaneously estimate supply and demand for both products, each with a standing forest inventory term.

Limited data restrict the empirical analysis of inventory production. There are twelve state and four periodic inventory observations between 1948 and 1984. The inventory observations, n, first must be corrected to reflect (a) inventory plus removals in the years between successive observations and (b) constant measures of inventory quality for all four periodic observations. There are no observations of the standard capital and labor inputs to production, but there are observations on ownership type Ok and management intensity m which coincide with each state inventory observation. These act as proxies for capital and labor intensity. For example, plantations on industrial lands are more input intensive than mixed oak-pine stands on NIPF lands. Finally, biological and site quality observations B_i, collected as part of the periodic observations on forest inventories, control for exogenous effects like regeneration preferences, weather and improvements in soil quality. The aggregate production analysis also adjusts over time for changes in the land area of the southern pine forest.

The general functional form is

$$V = a \, c_{i}^{3} \, c_{n}^{3} \, B_i^{a} \exp(g_n \, n) \; (d_{k}^{3} \, d_{m}^{3} \, `_{km} O_{km}) \; n$$

where the a_i, g_n, and $`_{km}$ are unknown parameters, and n is the error term.

The statistical estimations are satisfying. The signs on all coefficients in the basic equation support intuition and fourteen of seventeen coefficients are statistically significant. An R^2 of 0.99 indicates that the independent variables explain virtually the entire variation in the dependent variable. Most important for our analysis, the technical change shifters are all significant at the five percent level or better (for the basic equation and for various specialized equations reflecting specific management-ownership combinations).

In sum, we have confidence in the ability of the time coefficients to explain shifts in production. They explain approximately seven, fourteen, and six percent shifts in successive (approximately decennial) inventory periods from 1948 to 1984. The total increase is 27 percent for the full period, or about 0.7 percent annually, compounded.[9] This

9. Conversations with university forestry researchers and forest industry research administrators suggest that they look for volume

may be a generous estimate of research-induced productivity shifts because it includes both 1) non-research-induced shifts and 2) movements along as well as shifts in the production function. It also may be conservative, however, because our approach controls for shifts in management type that may be partially research induced. Sensitivity tests for variation in the estimated production shift protect against these biases affecting our general conclusions.

Table 3 repeats the results of our three-stage least-squares (3SLS) demand and supply estimates. (There is no previous econometric evidence of the joint solidwood-pulpwood market for southern pine stumpage.) The general statistical tests for the four equations are satisfactory.[10] The inventory coefficients imply solidwood and pulpwood elasticities of 0.391 and 1.201, respectively.

Our measure of gross research benefits follows a derivation by Hertford and Schmitz (1977) that relies on our estimate of research-induced inventory shifts and the various demand and supply elasticities. Table 4 shows the *undiscounted gross* research benefits accruing to consumers, producers, and all society in both the pulpwood and solidwood markets for the range of research-induced inventory shifts between 0.5 and 1.0 percent annually. Total social benefit estimates are sensitive to this inventory shift but they are insensitive to large variations in the demand and supply elasticities.

---

increases of twenty percent over a southern pine timber rotation of 25-40 years. Their expectations are consistent with our observations.

10. The interesting observation that pulpwood is a substitute in solidwood supply, yet solidwood is a complement in pulpwood supply, supports an earlier observation for Sweden by Johansson and Lofgren (1985).

Total benefits are small, $40-80 million for the full thirty-year period from 1950 to 1980. Consumers (loggers, millowners, and final product consumers) gain more than stumpage producers. This distributive result is similar to the experience of agriculture, sawmills, and woodpulp where research benefits quickly pass to higher level producers and final consumers in the form of lower prices. The emphasis on consumer gains encourages a public role in southern pine research. Solidwood producers gain only minimally and pulpwood producers are gross losers as they pass more than their full gains on to consumers. This conclusion anticipates the more general observations that industrial landowners seem to be reducing their research budgets and relying relatively more heavily on NIPF producers to supply their mills. (NIPF lands provide approximately seventy percent of annual southern pine harvests.) It also anticipates that even those NIPF landowners with clear timber management objectives have little private incentive to encourage research in new timber management technologies.

The Efficiency Benefits of Southern Pine Research

Measures of efficiency gains also require knowledge of the R&D expenditures on timber growth and management research. Historic budget data are unavailable for many of the institutions involved in southern pine research. Therefore, we began with known US Forest Service budgets for the Southern and Southeastern Forest Experiment Stations--reduced by those research expenditure categories not clearly and fully associated with southern pine growth and management (*e.g.*, forest recreation). We can extrapolate expenditure series for the other research participants--for state and university research, industry research, and forestry extension--from occasional direct evidence over the years, and from periodic references to the size of these expenditure categories relative to Forest Service expenditures. We disregard all research expenditures prior to 1935, the uncertain level of expenditures by university/industry cooperatives, and the uncertain contribution of general forestry education to improving southern pine yields--all in the name of conservative total cost estimates. Conservative cost estimates, together with generous benefit estimates, will provide a confident upper bound for observations on the efficiency of timber management research.

The research-productivity lag poses an insurmountable estimation problem for timber growth and management. Our alternative is to examine a full range of hypothetical lags. We consider lags from zero to twenty years in five year increments and compare costs and benefits in all five cases. We begin with cost cohorts representing accumulations of the annual expenditures that induce our measured 1950-1980 southern pine research benefits. The first cost cohort is 1935-1960, the second is 1935-1965, etc. The first cohort is the smallest research cost accumulation but it implies a maximum twenty-year lag before its last research expenditures (1960) begin to affect harvests (1980).

Table 5 shows the results. Net benefits are negative for all but the single most extreme case. Even then they remain small at an accumulated $29 million for the entire thirty-year period of research impacts--or an average of only $80,000 per state per year. The second part of table 5 provides an additional check for the robustness of these results by comparing only the Forest Service share of all southern pine research costs with our total benefit estimates. Net benefits remain negative for the most reasonable cases of positive social discount rates and moderate research-productivity lags.

In conclusion, annual *physical* research gains of 0.7 percent may satisfy industrial researchers but the social efficiency of these gains is uninspiring at best for southern pine growth and management. This conclusion holds for the sum of a broad collection of research activities. These results do not preclude the possibility that select and more specific research activities, perhaps various nursery-oriented research activities or weed control research, may display more satisfying results.[11] Nevertheless, because southern pine is generally considered the best example of timber management research success, it is probably unnecessary to examine other broad regional cases or forest types. We anticipate similar, or poorer, results for them.[12]

Reflections on Timber Growth and Management Research

Can we believe this empirical observation of generally poor economic performance for southern pine management research? What explains it: perhaps low long-run timber production costs? Low production costs would

---

11. Consider the economic literature on gains from nursery management and improved seed stock (Davis 1967, Porterfield 1974, Westgate 1986, Williams and deSteiguer 1990). Much of it anticipates that microeconomic speculations can transmit into aggregate, sector-wide gains, particularly in the southern pine region. This transmission may not hold without sharply declining stumpage price effects and resulting negative net revenues. The potential of herbaceous weed control research is better documented (Huang and Teeter 1990, Warren 1990). In sum, the literature raises the spectre of possible economic gains from some timber growth and management research.

12. We followed this examination of economic efficiency with an inquiry into the redistributive merit of southern pine research. We used the US Forest Service's input-output model (IMPLAN, Alward and Lofting 1990) to examine wage and employment impacts in the forestry sector and in the full economy for three important forestry regions within the South. The important policy shifter in these analyses is a research-induced timber productivity increase of three percent (approximately 0.7% annually) for a normal 2-5 year cycle of business expansion. The resulting wage and employment shifts are never large and they are always unimportant for the lowest wage industries.

leave few opportunities for cost-saving production gains, therefore little inducement for research and few final opportunities for introducing technological improvements.

Most timber production research has been of the land-saving or capital-(investment time)-saving variety. This is a reasonable outgrowth of what are often natural transfers from agriculture research. It is also reasonable because land and capital, not labor, are the predominant physical inputs. Land and capital have not been economically scarce inputs in forestry, however, and they will not become scarce inputs so long as there are stands of old growth timber, abandoned old fields reverting to timber, and remaining timber harvest opportunities on less accessible sites.

These observations are consistent with the frontier hypothesis for development of the forestry sector of the US economy. Even among southern industrial forests, less than forty percent are actively managed plantations (USDA Forest Service 1988). Therefore, it should not be a surprising observation that current stumpage prices do not cover the costs of active silvicultural investments for all the acres from which timber is harvested. Removing the bounty of naturally occurring timber, however, must eventually cause stumpage supplies to decrease.

The available empirical evidence suggests that this transition from frontier to developed forest economy has been going on for some time. Relative roundwood prices probably have been rising for over a century (Ruttan and Callaham 1962, Barnett and Morse 1963, Manthy 1978).[13] We might reasonably anticipate that they will continue to rise gradually

13. This experience of rising relative prices for such a long period of time is unique for lumber, and perhaps timber, among all primary resources (Barnett and Morse 1963, Manthy 1978).

until they finally equal the full long-run (timber rotation) costs of active silvicultural management on most forestlands. [There will always be some marginal lands contributing some share of all harvests from unmanaged, naturally occurring, low opportunity cost timber (Sedjo and Lyon 1990).]

Nevertheless, relative prices cannot continue increasing indefinitely and there is some expectation that the long-run upward price trend will deteriorate within the next ten to thirty years (Berck 1978, Libecap and Johnson 1978, Lyon 1981). It may have tapered off already in the South (Dutrow *et al* 1982, Cubbage and Davis 1986). Prices will eventually attain the level of full active silvicultural production costs on more acres before they cease to increase any further (in the absence of unanticipated shifts in demand). This means that the future may be more promising for southern pine research investments. In sum, the prior poor performance of southern pine research in the aggregate surely urges the utmost care in choosing which timber growth and management research budgets to continue supporting. Furthermore, it encourages greater care and greater reluctance for support of timber growth and management research for the other species and other forest types which probably have an even less distinguished history of research productivity than southern pine.

Final Reflections and Broader Policy Implications

This final section reflects on the meaning of our empirical results for the future of forestry research in the US and draws implications from this American experience for both the developed and the developing countries of the rest of the world. We speculate that available forest inventories and final consumer markets are critical indicators of world research policy implications different from those for the US.

Policy Implications for American Forestry Research

Our analyses support the public policy advice to concentrate forestry research on forest products and to fund timber growth and management research only most lightly and most carefully. Concerns for equity; including laborers, small landowners, and rural development; do not alter this recommendation.

Forest products research has an entirely more satisfying past than timber management research but a past that still encourages cautious decisions regarding both justifiable public roles and future budget allocations. Our analyses justify a public role in research for each forest products industry we examined. Careful review, however, shows that the specific justification varies from industry to industry and that there is no reason to anticipate that the general justification for a public role is universal across all forest products industries. Future investments in these and other forest products industries require prior inquiry into the nature of each industry's production costs, its research-productivity lag, the likelihood of research adoption, and the industry's market concentration, in order to determine the independent justification for a public research role in that industry.

Furthermore, successful research performance in the past is not a necessary indicator of outstanding future performance. For example, SWPW research was a great success between 1950 and 1980 but the SWPW industry has been partially replaced by the newer products of the structural particleboard industry. The growing market share of the latter industry (and declining share of the former) suggests a greater future potential for particleboard research.

Experience also recommends caution in adjusting research budgets to short-term political perceptions rather than longer-term market signals. For example, higher level government directives responding to both energy and environmental concerns in the 1970s failed to produce new cost-reducing technologies for the woodpulp industry. These directives did, however, divert Forest Products Laboratory research resources that had a previous history of more socially efficient production.

Nevertheless, our summary statement for forest products research is that previous research, on the whole, has been socially rewarding. We anticipate the same for the future, both in narrow and measurable economic efficiency terms and in broader social welfare terms. For example, we anticipate successful product-altering research, like some research in the woodpulp and wood preservatives industries which improves environmental quality. The benefits of product-altering environmental research, of course, fail to appear in those economic accounts of research and technical change that can only measure process innovation.

We also anticipate that forest products research and new technologies save on wood utilization and, therefore, save standing timber and forestland for other, often non-market, land uses. US Forest Service calculations, for example, suggest that the truss frame construction technology may save a volume of wood greater than annual programmed harvests on all lands proposed for wilderness withdrawal.[14]

14. Specifically, the 28.6 million acres proposed for wilderness withdrawal in RARE II. (US Forest Service calculations provided by H.G. Wahlgren, February 15, 1989.)

Indeed, the truss framing example nicely addresses another important question for forest policy. Forest land use, with competing industrial, recreational and environmental demands, is one of the most important natural resource issues of our time. Apparently, forest products research is a more elastic substitute for forest land than timber management research. Forest products research is also a better public investment than public timber management itself. Therefore, investing in forest products research may be one of the better ways to reduce the land use conflict and to save forests for competing non-timber uses.

This observation gains significance as we reflect on its implications for the important global issues of climate change and biological diversity. Forests provide the habitat for many endangered species and trees sequester the carbon that controls climate change. Apparently, forest products research, by decreasing the demand for wood and wood fiber, contributes more than timber management research to protecting the forest and these global values. We anticipate that biological forestry research may be better advised to concentrate on identifying critical species and habitat and improving their management.

Various other researchers find approximately two percent annual rates of technical change across the forest product industries. They also observe a labor-saving bias in technical change (Kendrick 1961, Stier, 1980, Greber and White 1982, Buongiorno and Lu 1989). Therefore, the rates of land- and capital-saving change are somewhat less. Even land- and capital-saving rates of 1.5 percent, however, are more than double the 0.7 percent average annual rate we observe for southern pine. This means that, for a constant output of forest products, the uses of roundwood and capital facilities as inputs decline at the rate of 1.5

percent annually. It also means that, in 48 years, research and technical change will permit the forest product industries to consume just one-half their current level of all roundwood inputs while producing the same volume of final product. In contrast, it takes timber-management research 103 years to double the volume of southern pine harvests. It takes even longer for timber management research in other US species and it would take longer for southern pine if southern pine research investments were reduced to a lower, more socially efficient level.

Implications for Forestry Research in the Rest of the World

These US experiences are only partially transferable. We must examine the specific market situations and policy incentives in other countries, for both forest products and timber growth and management, and contrast them with US markets and incentives before we can determine which conclusions transfer from the US forestry research experience to the rest of the world. We might anticipate that our general encouragement of forest products research does transfer, with emphasis on products with large markets. General conclusions for timber management research are more difficult. There may be four classes of cases, two in developed countries and two in developing countries, depending on local market and incentive conditions for timber and forestland in each country.

Developed countries: Forest products research opportunities for developed countries are comparable to those for the US. The products are similar and the markets are generally well-developed. Price-induced research and technical change may generally payoff at a high rate of social return, much as it does in the US.

The timber inventory and forest land situations may distinguish two developed country alternatives for timber management research. Canada and the Soviet Union are countries like the US, countries with large extensive margins of timberland. Indeed, Canadian and Soviet forest inventories are subject to a lower average level of active silvicultural management than US forest inventories. This extensive resource holds down stumpage values in Canada and the Soviet Union. Therefore, we expect that land and timber are relatively less scarce factors of production than labor and capital facilities, that the economy-wide incentives inducing labor- and capital-saving research are greater than the incentives inducing land- and timber-saving research, and that technical change can proceed only at a slow rate in the timber management industry. Forestland development follows the frontier hypothesis of economic growth. Like the US, there may be select and scattered timber management research opportunities in Canada and the Soviet Union, but general timber management research probably is not a highly productive activity in these countries.

This conclusion is consistent with Sedjo and Lyon's (1990) finding that, in an integrated world market, intensive forestry would be practiced on only the very best sites. Sedjo and Lyon find that, in the US South, only modest levels of investment in regeneration are optimal. In much of Canada, optimal management levels are low cost and very extensive.

Japan and the developed countries of western Europe *may* suggest a different case for timber management research. These countries arguably possess no substantial extensive land margin supporting a natural bounty of timber and there are few old fields freely reverting to forests. In this case, the impact of wood and wood fiber imports from North America, the Soviet Union and tropical countries with a forest frontier will determine the viability of Japanese and western European timber management research.

The impact of imports will be *important* for timber management research if imports are large enough to have an impact on domestic stumpage prices. This means that imports will have kept Japanese and western European stumpage from achieving a level of scarcity comparable to the relative scarcity of substitute resources. Therefore, the extensive timber frontier in other parts of the world is also an economically important frontier for Japan and western Europe. In this case, timber management research is not a socially attractive investment, even in Japan and western Europe. It will become more attractive as it becomes a better investment in the exporting countries.

Alternatively, the impact of wood and wood fiber imports will be *unimportant* for timber management research if relative Japanese and European stumpage prices are changing at a rate comparable with the rate for substitute resources in these economies. In this latter case, timber management would be a developed industry in Japan and western Europe and the price incentives for timber management research and technical change would be fully operative and comparable with those for the rest of the economy. Timber management research would be fully as attractive as forest products research in this case.[15]

15. Japan's log imports from North America, the Soviet Union and the tropics were 62 percent of total domestic consumption in 1987. Japan's imports of roundwood equivalents from the same regions were 71 percent of total domestic consumption in 1987. The comparable western European

Determination of the correct alternative explanation for developed countries like Japan and those in western Europe must wait for (a) inference from assessments of regional relative stumpage price trends or (b) direct evidence from individual timber management research appraisals comparable to our assessment of southern pine research in the US.

<u>Developing countries</u>: There is less processing and the markets for processed wood and fiber products are less extensive in the developing countries than in the US. Therefore, the scope for forest products research in general is smaller in most developing countries than it is in the US. The result may be fewer forest product research opportunities, but those research opportunities that do exist probably offer the same high social rewards that forest products research offers in the US and other developed countries.

The logging industry may be a particularly good candidate for developing country forest products research. Our southern pine results and our extrapolations from them to other species and forest types and other parts of the world say nothing about logging research investments. Standing timber priced on the stump (stumpage) is our physical market measure in the southern pine case. Logging is the next higher step in the production process. Logging technologies are more labor- and capital equipment-intensive and less land- and resource-intensive than timber

---

import proportion from the same regions was, perhaps, one-third as great (J. Vincent, Michigan State University, personal communication, March 29, 1990). These data suggest the hypothesis that Japan may fall in the first category where imports from regions with forest frontiers are deterrents to price-induced technical change and economically viable timber management research. They also suggest the hypothesis that western Europe falls in the second category, and timber management research may be economically viable. We emphasize, however, that these data are weak evidence and that the Japan and western European cases beg further inquiry.

growing and management. Therefore, they are similar to forest products technologies as likely candidates for productive research investments.

Most modern logging technologies were developed in economically advanced countries where labor is scarcer relative to capital equipment. This relative difference in factor endowments may suggest opportunities in many developing countries for modern, yet relatively more labor-intensive, logging technologies. The absence of good roads and the range of topographic conditions across all developing country harvesting situations suggests further opportunity for either capital specialization or greater reliance on labor's versatility. In any case, logging technologies specially adapted to developing country conditions may be a rewarding forest products research opportunity.[16]

The market for wood as a domestic fuel for heating and cooking is an additional large market, therefore an additional forest products research opportunity, that is not so important in most developed countries. This market provides incentives for additional wood processing technologies that may be less important in developed countries. The obvious examples are charcoal research and research on improved stoves. The latter is a well-known recent success in many developing countries. Research to improve the efficiency of fuelwood consumption may have additional appeal from an equity perspective. The poorest households spend the largest household budget shares and have the highest income elasticities for fuelwood and its substitutes (Hyde 1991).

Timber management research, as always, is more problematic. Many developing countries possess extensive stands of mature forest. The depths of the Amazon and Congo watersheds and the northeast of Thailand

16. J. Douglas of the World Bank alerted us to this point. Laarman (1978) provides analysis and empirical evidence for the Philippines.

are examples. These forests compare with the US, Canadian and Soviet case. A large extensive margin of forestland holds timber production costs low. Timber is not scarce relative to other factors of production and there is little economic incentive for timber management research. Timber management research in this case will have little social payoff.

Other developing countries may have less extensive forest resources but insecure tenurial rights for their remaining timber resources. The arid lands of India, the nationalized forests of Nepal and the uplands of the Philippines are examples (Hyde 1991). Insecure tenure encourages immediate local resource-consuming self-interests and removes any incentive for long-term resource management. Therefore, it dissipates all economic incentives associated with the basic timber and forestland resources and causes resource depletion. In this case, there can be no price incentive for timber management research and timber management research is a misuse of public funds.

Finally, there are numerous cases of unintended but perverse policy spillovers to the forest resource. Binswanger (1989), for example, identifies a long list of macroeconomic policies and policies directed at rewarding other sectors; *e.g.*, agriculture, livestock, mining; that encourage Amazonia's conversion to non-forest uses. Boyd *et al* (1991) measure the impacts of a similar list for the Philippines. These policy spillovers come to rest on the forest resource because forests are generally a residual land use often without a specialized market-oriented constituency. These policies are equivalent to downward relative timber price shifts. They act as further disincentives for timber management research.

These three; a large margin of extensive timber management, insecure resource tenure, and perverse policy spillovers; are important cases in very many developing countries. They are dissimilar with agriculture and they cause dissimilarity with the successful agriculture research experiences which are well-known for many developing countries. Therefore, direct comparisons with agriculture research in these countries, or with timber management research in developed countries, only conceal the important production relationships and the real policy issues. Unreasoned arguments to the contrary are distressing.

It seems to us that the altogether different issues of insecure resource tenure and perverse policy spillovers are the *necessary* first issues of policy inquiry in these cases. The products of timber management research, whether the timber is for domestic or for market consumption, cannot be introduced successfully until these issues are dealt with better. Tenure and perverse policy spillovers from non-forestry sectors are the better initial target for public research investments.

This said, we must also recognize another, more satisfying, timber management research case in many developing countries. Tenure is secure on most agricultural land and we observe many farmers who recognize the personal benefits of tree crops. We also observe some successful commercial forest plantations. Economic incentives are fully operative for the subset of these tree crops and these commercial plantation species for which the natural forests on the extensive margin of land with insecure tenure are unsatisfactory substitutes. This is a small but increasing share of developing country timber resources. Acacia in Bangladesh may be an example (Byron 198). The economic incentive exists, but the small overall size of these farm forests and commercial plantations suggests generally small returns to timber management research. This recommends timber management research concentrating on those few species with large and widespread markets, as well as minimum competition from species growing naturally on the extensive margin.

This recommendation is consistent with the more biological research orientations of Buckman (1988) and Davis *et al* (1988). Buckman also encourages forestry extension in these cases. Successful extension improves research benefits by decreasing the communication time between successful research and its implementation by the many small forest farmers.

As the natural forests are depleted, as institutions adjust to ensure secure tenure, and as policymakers reconsider perverse policy spillovers, then we can anticipate that this final case will become more characteristic of developing country timber management. Farm forestry and commercial plantation forestry will become more prominent and the economic and social incentives for timber management research will increase. This may, however, take some time in most developing countries. Our evidence argues that the time has not yet arrived in the southern pine region of the US. It probably has not yet arrived elsewhere in the US, in Canada or in the Soviet Union. Therefore, we must urge the greatest care in choosing timber management research activities, particularly as a widespread use of public funds in developing countries.

Literature Cited

Adams, D.M., and R.W. Haynes. 1980. The 1980 softwood timber assessment market model: Structure, projections, and policy simulations. Forest Science Monograph 22. Supplement to Forest Science 26(3).

Alward, G.S., and E.M. Lofting. 1990. IMPLAN version 2.0. USDA Forest Service Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-GTR-

Barnett, H., and C. Morse. 1963. Scarcity and Growth. Baltimore: Johns Hopkins University Press for Resources for the Future.

Berck, P. 1978. The economics of timber: A renewable resource in the long run. Bell Journal of Economics 9(3):447-62.

Binswanger, H. 1989. Fiscal and legal incentives with environmental effects on the Brazilian Amazon. Washington: World Bank discussion paper 69.

Boyd, R.G., W. Cruz, and W.F. Hyde. 1991. Unintended public policy spillovers on upland resources and the environment. American Economic Review 81(2):

Boyd, R.G., and W.F. Hyde. 1989. Forestry sector intervention: the impacts of public regulation on social welfare. Ames: Iowa State University Press.

Buckman, R.E. 1988. As summarized in Buckman on tropical forestry research. ISTF News 9(4):3.

Buongiorno, J., and H-C. Lu. 1989. Effects of costs, demand and lumber productivity on the prices of forest products in the United States, 1958-84. Forest Science 25(2):349-63.

Byron, N.

Cubbage, F.W., and J.W. Davis. 1986. Historical and regional stumpage price trends. Forest Products Journal 36(9):33-9.

Davis, J., D. McKenney and J. Turnbull. 1988. Potential gains from forestry research and a comparison with agricultural commodities. Draft manuscript. Canberra: Australian Centre for International Agricultural Research ACIAR/ISNAR project paper 15.

Davis, L.S. 1967. Investments in loblolly pine clonal seed orchards. Journal of Forestry 65(6):882-87.

Denison, E. 1974. Accounting for United States economic growth, 1929-1969. Washington, DC: Brookings Institution pp. 131-37.

Dutrow, G., J.M. Vasievich and M. Conklin. 1982. Economic opportunities for increasing timber supplies. In USDA Forest Service, An Assessment of the Timber Situation in the United States, 1952-2030. Forest Resource Report No 23 pp. 246-254.

Gilless, J.K., and J. Buongiorno. 1987. PAPYRUS: A model of the North American pulp and paper industry. Forest Science Monograph 28. Supplement to Forest Science 33(1).

Greber, B. J., and D. E. White. 1982. Technical change and productivity growth in the lumber and wood products industry. Forest Science 28(1):135-147.

Guthrie, J.A. 1972. An economic analysis of the pulp and paper industry. Pullman, Wa.: Washington State University Press.

Hertford, R., and A. Schmitz. 1977. Measuring economic returns to agricultural research. In T. M. Arndt, D. G. Dalrymple and V. W. Ruttan, eds. Resource allocation and productivity in national and international research. Minneapolis: University of Minnesota Press pp. 148-167.

Huang, Y.S., and L. Teeter. 1990. An economic evaluation of research on herbaceous weed control in southern pine plantations. Forest Science 36(2):313-29.

Hyde, W.F., ed. 1991. Forestry and rural community development: An empirical examination from South and Southeast Asia. London: Oxford University Press.

Johansson, P. O., and K. G. Lofgren. 1985. The economics of forestry and natural resources. Oxford: Basil Blackwell.

Kendrick, J.W. 1961. Productivity trends in the United States. Princeton: Princeton University Press.

Knutson, M., and L.G. Tweeten. 1979. Toward an optimal rate of growth in agricultural production research and extension. American Journal of Agricultural Economics 61(1):70-76.

Laarman, J. 1978.

Lewandrowski, J.K. 1989. A regional model of the US softwood lumber industry. Draft manuscript. Agricultural Economics Department, North Carolina State University.

Libecap, G.D., and R.N. Johnson. 1978. Property rights, nineteenth-century federal timber policy and the conservation movements. Journal of Economic History 39(1):129-42.

Lyon, K.S. 1981. Mining of the forest and the time path of the price of timber. Journal of Environmental Economics and Management 8(4):330-45.

Manthy, R.S. 1978. Natural resource commodities - a century of statistics. Baltimore: Johns Hopkins University Press for Resources for the Future.

McKillop, W., T.W. Stuart, and P.J. Geissler. 1980. Competition between wood products and substitute structural products: an econometric analysis. Forest Science 26(1):134-148.

Mergen, F., R.E. Evenson, M.A. Judd and J. Putnam. 1988. Forestry research: a provisional global inventory. Economic Development and Cultural Change 36(1):149-71.

Porterfield, R.L. 1974. Predicted and potential gains from tree improvement programs: A goal programming analysis of program efficiency. Technical report #52. Raleigh: North Carolina State University School of Forest Resources.

Repetto, R. 1988. Subsidized timber sales from national forests in the United States. In R. Repetto and M. Gillis, eds., Public policies and the misuse of forest resources. Cambridge: Cambridge University Press. pp. 353-84.

Robinson, V.L. 1974. An econometric model of softwood lumber and stumpage markets, 1947-67. Forest Science 20(2):171-80.

----- 1975. An estimate of technological progress in the lumber and wood products industry. Forest Science 21(2):149-154.

Rockel, M.L., and J. Buongiorno. 1982. Derived demand for wood and other inputs in residential construction: a cost function approach. Forest Science 28(2):207-19.

Ruttan, V.W. 1980. Bureaucratic productivity: the case of agricultural research. Public Choice 35(3):529-47.

Ruttan, V.W., and J.C. Callahan. 1962. Resource input and output growth: Comparisons between agriculture and forestry. Forest Science 8(1):68-82.

Sedjo, R., and K. Lyon. 1990. The long-term adequacy of world timber supply. Washington: Resources for the Future.

Solow, R.M. 1957. Technical change and the aggregate production function. Review of Economics and Statistics 39(3):312-20.

Stier, J.C. 1980. Estimating the production technology in the US forest products industries. Forest Science 26(4):471-482.

USDA Forest Service. 1988. The South's fourth forest: Alternatives for the future. Washington: Forest Resource Report no. 24.

Warren, W.G. 1990. Some novel statistical analyses relevant to the reported growth decline in pine species in the southeast. Forest Science 36(2):448-63.

Westgate, R.A. 1986. Benefits and costs of containerized forest tree seedling research in the United States. In D. Burns (ed.) Evaluation and planning of forestry research. USDA Forest Service Northeastern Forest Experiment Station. General Technical Report NE-GTR-111.

Williams, C.G., and J.E. deSteiguer. 1990. Value of production orchards based on two cycles of breeding and testing. Forest Science 36(1):156-68.

Table 1: NL2SLS Estimates of SWPW Demand and Supply Coefficients

demand		production/supply	
intercept	8.8088** (3.8696)	labor	.2057** (.1125)
own price	-2.7034* (-.4901)	capital	.1263** (.0604)
construction wage	-0.6076*** (-.4205)	$(\text{private R\&D})_{t-2}$	.0660* (.0218)
cost of capital	.1263** (.0597)	$(\text{public R\&D})_{t-2}$	.0247** (.0131)
substitute (lumber) price	3.0603* (.4265)	lag	.8694* (.0378)
final product price	2.3583*** (1.5586)		
R^2	.8869		.9839
D-W	1.46		---
Durbin's h	---		.0270
degrees of freedom	22		22

Numbers in parenthesis are standard errors.
Asterisks refer to statistical significance in one-tailed tests:
* = 1%, ** = 5%, *** = 10%
All coefficients implicitly refer to year t except where otherwise indicated.

Table 2: Returns to Public Research Investments (1950-80) in Selected Forest Products Industries

	softwood plywood	sawmills	woodpulp	wood preservatives
NPV (consumers' surplus)[c]	$1.32	38.97	$.018	$61.90
(producers's surplus)[c]	$1.50	-17.56	-$.022	-$68.29
(net economic benefit)[c]	$2.84	25.96	$.004	$251.86
IRR on NPV (consumers' surplus)	326%	34%	33%	multiple solutions
(net economic benefit)	499%	28%	15%	293%
VMP (short run)[a]	$12.49	----	----	----
VMP (long run)[b]	$58.17	$2.62	$.44	$ .34
MIRR	299%	16%	<0	<0

a. In 1967$
b. In 1967$ discounted at 7%
c. In billions of 1967$ discounted at 7%. Consumers' and producers' surpluses are <u>each</u> net of total research costs. Therefore, net economic benefit = net consumers' plus net producers' surpluses <u>plus</u> total research costs.

Table 3: 3SLS Estimates for Southern Pine Pulpwood and Solidwood Markets

pulpwood demand		pulpwood supply		solidwood demand		solidwood supply	
intercept	731,700 (570,600)	intercept	-776,000* (-181,100)	intercept	-1,645,000* (-501,900)	intercept	888,900* (168,800)
own price	-9,092** (-5,127)	own price	4,921** (19.53)	own price	-3,162** (-1,423)	own price	3,072* (374.1)
final good price	1,800 (6,387)	inventory	0.02246* (0.001260)	final good price	21,730* (6,943)	inventory	0.00648* (0.00167)
labor	304,300* (97,570)	solidwood price	491.1** (239.8)	labor	114,900** (50,730)	pulp/paper price	-11,280* (-1,694)
capital	-2,341,000* (-764,900)			capital	1,025,000** (731,400)		
lagged production	0.2265** (0.1004)			lagged production	0.7860* (0.1299)		
R^2	.869		.952		.938		.934
D-W	1.116		1.034				1.475
Durbins' h					0.821		
F	31.84*		171.89*		72.62*		122.65*
degrees of freedom	24		26		24		26

Numbers in parenthesis are standard errors
Asterisks refer to statistical significance: *=1%, **= 5%, ***= 10%

Research Management for the Future

PROCEEDINGS OF A MEETING OF

IUFRO SUBJECT GROUPS S6.06/6.08, MANAGEMENT OF FORESTRY RESEARCH
IN CONJUNCTION WITH THE XIX CONGRESS OF THE
INTERNATIONAL UNION OF FOREST RESEARCH ORGANIZATIONS

AUGUST 7-9, 1990
MONTREAL, CANADA

Contents

Table 4: Gross Benefits, 1950-80, from Southern Pine Research (millions of 1967$, undiscounted)

	annual research-induced production shift					
	0.5%			1.0%		
benefitting group	consumers	producers	total	consumers	producers	total
market						
solidwood	18.54	2.10	20.64	36.86	5.04	41.90
pulpwood	31.58	-11.53	20.05	63.03	-22.74	40.29

Table 5: Net Benefits, 1950-80, from Southern Pine Research (millions of 1967$)

present net value, with full estimated costs

social discount rate	0%		4%		7%	
research-induced production shift	0.5%	1.0%	0.5%	1.0%	0.5%	1.0%
cost cohort						
1935-1960	-15	29	-89	-13	-243	-121
1935-1965	-81	-38	-217	-141	-450	-328
1935-1970	-178	-135	-372	-292	-667	-546
1935-1975	-320	-276	-558	-482	-894	-773
1935-1980	-527	-483	-780	-705	-1,130	-1,008

present net value, with US Forest Service Southern and Southeastern Forest Experiment Stations' research expenditures only

social discount rate	0%		4%		7%	
research-induced production shift	0.5%	1.0%	0.5%	1.0%	0.5%	1.0%
cost cohort						
1935-1960	16	60	-13	63	-96	26
1935-1965	-5	39	-53	23	-162	-40
1935-1970	-35	9	-101	-25	-229	-107
1935-1975	-67	-24	-144	-68	-281	-160
1935-1980	-102	-58	-181	-106	-321	-200