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AN EVALUATION OF THE MCINTIRE STENNIS COOPERATIVE FORESTRY RESEARCH PROGRAM

By

Michael Dean Huddy

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ABSTRACT

AN EVALUATION OF THE
MCINTIRE STENNIS COOPERATIVE
FORESTRY RESEARCH PROGRAM

By

Michael Dean Huddy

This study evaluates the administrative - operative procedures of the Cooperative Forestry Research Program as authorized under the McIntire-Stennis Act of 1962. It provides the administrative agency, the Science and Education Administration/Cooperative Research (CR), information that can be used to help make the program more effective in meeting needs in forestry research.

The historical development of research programs in the United States Forest Service, universities and forestry schools, and private industry is presented to help illuminate present policy in the renewable resource community. The literature of research management techniques is reviewed to provide a source of comparison and alternative methods for management of the Cooperative Forestry Research Program.

Recommendations for change include: the development of a procedure to allocate the Federal portion of McIntire-Stennis funds to participating institutions; the development of specific goals and objectives for use in research project proposal development; the development of prioritized criteria for use in project selection; and, the determination of productivity indices taht evaluate research output and distribution in terms of its cost.

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My graduate committee including Dr. James H. Anderson, Dean, College of Agriculture and Natural Resources, Dr. Larry W. Tombaugh, Chairman, Department of Forestry; Dr. Robert S. Manthy, Professor of Forest Economics and Policy; and Dr. Lee M. James, Professor of Forest Economics and Policy; all of Michigan State University, have been helpful in shaping this topic into a researchable project. Dr. Daniel E. Chappelle, Professor of Resource Development, provided valuable criticism and assistance in the development of the project study plan. Dr. Robert S. Manthy is given special appreciation for his provision of the necessary advice and counsel throughout my doctoral program while acting as my academic advisor.

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TABLE OF CONTENTS

TABLE OF CONTENTS, (con't.).

LIST OF TABLES

INTRODUCTION

Numerous events within the past decade have dramatically changed the treatment of renewable resources in the United States. Landmark legislation, such as the National Environmental Policy Act, The Endangered and Threatened Species Act, The Federal Water Pollution Control Act, the Clean Air Act, the Forest and Rangeland Renewable Resources Act, and the National Forest Management Act, are but a few of the laws passed recently by the United States Congress that have a significant impact on renewable natural resources. These laws, and the public consciousness that gave rise to them, clearly mandate more rigorous standards of performance for renewable resource administering agencies.

Increased demand for renewable resources and the impact of recent regulating legislation has made managing renewable resources a very complex problem. A consequence of this increasing sophistication is an unprecedented demand for facts upon which to base policies, plans and practices related to these resources. Since scientific research is the means through which these facts are revealed, the adequacy of our present system of renewable resource research is being questioned. There are two viewpoints in this questioning process (Renewable Natural Resources Foundation, 1977). The first regards the content and subject matter balance of the research, e.g., "where are the gaps in the research system?", "are the users' needs being met?". The second relates to science policy and considers how renewable resource research is

organized, managed, and focused to meet the demands of policy makers, resource managers, and resource users, e.g., "is the research system fulfilling its total responsibilities by being effectively and productively managed?".

The United States Department of Agriculture is currently dealing with the content and subject balance of renewable resource research. They, in cooperation with the National Association of State Universities and Land Grant Colleges (NASULGC) are developing a national program of research for forest and associated rangelands. The stated purpose of the program is:

> To seek suggestions from a broad cross-section of the American public on program content for planning forestry research of the United States Department of Agriculture and university sector through the decade ahead. (Skok, 1977).

The Renewable Natural Resources Foundation dealt with the organization and management of renewable resource research in 1977 when it sponsored a symposium at Airlie, Virginia. At this symposium, policy aspects of forest and range related research in the United States were addressed (Renewable Natural Resources Foundation, 1977). A conclusion was:

> ...the knowledge requirements for the future management and development of forest and rangelands are enormous and cannot be met unless the research operation is improved and enlarged. Not only must the scientific effort be broadened, it needs to be better organized to produce the desired benefits...our general sentiment is that the time has come for upgrading the performance of the whole research establishment.

The Airlie House symposium did a very good job of exposing the seriousness of the renewable resource research problem. Indeed, the time has come for upgrading the performance of the entire research establishment. It is the purpose of this thesis to take a step in this direction by evaluating the administrative-management techniques and policies of

the McIntire-Stennis Cooperative Forestry Research Program and by providing recommendations for change designed to improve the program's effectiveness in meeting the ever increasing demands on renewable resource research. The scope of the study will be limited to those administrative-management techniques performed by the Cooperative Research Service, the federal agency responsible for the distribution of program funds.

Problem Identification

The McIntire-Stennis Cooperative Forestry Research Program is a federally sponsored research program designed to support forest and related research and graduate research training at state supported forestry schools and universities. The program came into existence with the signing of the McIntire-Stennis Act into law (P.L. 87-788), October 10, 1962. Appropriations to designated forestry schools began in 1964 with initial Federal appropriations of $1 million. At that time 61 institutions were certified for assistance under the program. Federal appropriations had grown to $8.2 million in 1977 with 62 participating institutions.

The program operates on a "matching funds" principle. Participating institutions may not collect Federal support in excess of what they receive in funds from state and private sources. Through the matching funds procedure, cooperation and communication between Federal, state, and private sectors is encouraged.

Currently the McIntire-Stennis Cooperative Forestry Research Program allocates its resources via a preconceived formula that does not

consider returns to investment. A basic premise of economic research program management is to consider return on investment and to allocate available resources to those alternatives shown to have the greatest return. The formula, used by CR, contains three criterion: (1) area of commercial forest land; (2) volume of timber removals from growing stock; (3) nonfederal forestry research expenditures.

This thesis maintains that the adoption of a method of resource allocation that considers the expected output of research and its value could lead to greater returns for resources invested. The Airlie House Symposium on Forest and Rangeland Research Policies in the United States indirectly supports this assertion. They suggest that in the McIntire-Stennis Cooperative Forestry Research Program..."the quality and quantity of the knowledge output in relation to the money invested should be assessed with the results influencing the funding of future research programs." (Renewable Natural Resources Foundation, 1977).

The resource allocating system in research programs, if used appropriately, is a very viable control procedure. The most appropriate use results when the allocation of resources is integrated with other management procedures such as program planning, project selection, and productivity analysis. In the ideal case research program planning provides goals and objectives to which end research and studies are directed. Proposed research alternatives are prioritized according to their relative ability to satisfy the goals and objectives specified in program plans. Highest priority research is funded first and so on down the priority list until all available resources are depleted.

Program productivity analysis procedures follow research to

determine what outputs were produced and what value these outputs have in terms of resources invested. The resource allocation system integrates program planning, project selection, and productivity analysis procedures by providing the mechanism for support of research which generates the greatest benefits in pursuit of program goals and objectives while maintaining an incentive for good productivity and results.

Cooperative Forestry Research Program Planning

National plans for forestry research have periodically been developed by the United States Department of Agriculture. These national plans provide broad goals for forestry research but fail to facilitate the use of these goals as objectives and planning criteria at levels where research is actively done. The current joint planning effort of the United States Department of Agriculture and ASCUFRO is destined to exhibit the same deficiency as these past plans.

The McIntire-Stennis Cooperative Forestry Research Program uses the research project as its basic planning unit. The mechanism through which this is accomplished is the research project proposal (Aldrich, 1977). Naitonal plans do not provide a useful function in the McIntire-Stennis program unless the goals and needs defined within them can be understood and identified with by the developers of research project proposals.

Research project proposals are generated at participating institutions by research scientists. Although national goals and objectives for forest and related research are revealed in national plans, the use of the project proposal as the basic planning mechanism for

McIntire-Stennis Cooperative Forestry Research has created a planning process that works from the "bottom-up". Without a formal process for implementing national forestry research plans as specific goals and objectives for use in the development of research project proposals, conformance to national plans and priorities in research is not guaranteed.

Researchers need help in defining those problem areas most deserving of their efforts (Marra, 1977). The research problem areas and priorities established by national plans are often difficult to relate to for an individual researcher. For this reason, it is necessary that research program administrators help direct research efforts towards priority areas by transforming national research plans into specific goals and objectives.

Project Selection

Project Selection, in the McIntire-Stennis Cooperative Forestry Research Program, is the means by which research project proposals are evaluated and subsequent research selected for support by program funds. Although numerous guidelines for research project selection in the Federal government have been developed, the way in which such guidelines are applied in the Cooperative Forestry Research Program is loosely controlled.

In the Cooperative Forestry Research Program, project proposals are evaluated and research selected at each participating institution. Final approval and Federal support are, however, dependent upon review of the project proposal by CRS personnel. They attempt to screen out duplication in research and insure compliance to the Federal interest.

The way in which project selection occurs at each institution varies greatly. Methods of project selection have purposely been left to the discretion of research administrators at the various participating institutions. Freedom in the means by which projects are selected allows for variation in needs and capabilities of the individual Cooperative Forestry Research Program working units.

It is a premise of this study that to insure the selection of high quality research, the allocation of program funds needs to be related to the project selection process. Since control over how projects are selected is satisfactorily handled by the participating institutions, it may not be wise to make the allocation of funds dependent upon the means of selection. Rather, allocation of funds should be dependent upon the output of the project selection process, i.e., based on the pertinence of the selected research to established priorities. This would guarantee a quality safeguard for both the means and the output of the project selection process.

Productivity Analysis

Productivity indices in the McIntire-Stennis Cooperative Forestry Research Program are prepared annually by the Cooperative Research Service. The indices currently developed involve the determination of how many graduate students were trained and how many publications were generated from the research projects per research scientist. The ratios, expressed in decimal form, are summed to provide a combined index. Productivity data prepared by CRS for the 1975 Cooperative Forestry Research Program year are shown in Table 1.

Table 1.--Cooperative forestry research program productivity information, 1975

State	Number of Scientists (SCI)	Number of Graduate Students (GS)	Number of Publications (PUBS)	Indexes		
				GS/SCI	Pubs/SCI	Comb.
Alabama	9	2	5	.222	.555	.777
Alaska	3	3	3	1.000	1.000	2.000
Arizona (T)	6	5	10	.833	1.666	2.500
Arizona (F)	6	7	5	1.167	.833	2.000
Arkansas	12	4	5	.333	.417	.750
California (A)	5	2	1	.400	.200	.600
California (B)	28	59	24	2.107	.857	2.964
Colorado	7	1½	0	.214	0	.214
Connecticut (NH)	6	0	4	0	.667	.667
Connecticut (S)	3	4	2	1.333	.667	2.000
Delaware	3	0	1	0	.333	.333
Florida	9	5	17	.555	1.899	2.444
Georgia	23	28	44	1.217	1.913	3.130
Hawaii	12	7	9	.583	.750	1.333
Idaho	10	14	2	1.400	.200	1.600
Illinois (U)	9	9	10	1.000	1.111	2.111
Illinois (C)	11	8	14	.727	1.273	2.000
Indiana	11	10	10	.909	.904	1.818
Iowa	8	16	4	2.000	.500	2.500
Kansas	3	1	6	.333	2.000	2.333
Kentucky	13	4	13	.308	1.000	1.308
Louisiana (BR)	12	22	14	1.833	1.167	3.000
Louisiana (R)	7	8	6	1.143	.857	2.000
Maine	21	9	27	.428	1.826	1.714
Maryland	10	5	6	.500	.600	1.100

Table 1, (cont'd.).

Massachusetts	13	8	10	.615	.769	1.384
Michigan (AA)	8	16	7	.500	.815	1.375
Michigan (EL)	12	22	18	1.833	1.500	3.333
Michigan (H)	3	3	2	1.000	.666	1.667
Minnesota	17	25	10	1.470	.588	2.058
Mississippi	22	13	10	.591	.454	1.045
Missouri	10	41	32	4.100	3.200	7.300
Montana	14	14	7	1.000	.500	1.500
Nebraska	8	1	11	.125	1.375	1.500
Nevada	5	8	1	1.600	.200	1.800
New Hampshire	8	11	5	1.375	.625	2.000
New Jersey	7	2	6	.286	.857	1.143
New Mexico	7	4	0	.571	0	.571
New York (I)	11	1	10	.091	.909	1.081
New York (S)	9	0	2	0	.222	.222
North Carolina	18	3	10	.167	.555	.722
North Dakota	3	1	0	.333	0	.333
Ohio	10	5	13	.500	1.300	1.800
Oklahoma	10	5	3	.500	.300	.800
Oregon	29	32	21	1.103	.724	1.827
Pennsylvania	27	12	23	.444	.852	1.296
Rhode Island	2	3	4	1.500	2.000	3.500
South Carolina	20	7	5	.350	.250	.600
South Dakota	4	1	2	.250	.500	.750
Tennessee	11	18	16	1.636	1.454	3.090
Texas (CS)	10	7	21	.700	2.100	2.800
Texas (N)	11	4	7	.364	.636	1.000
Utah	7	12	6	1.714	.857	2.571
Vermont	10	3	7	.300	.700	1.000
Virginia	19	38	44	2.000	2.316	4.316
Washington (P)	13	9	1	.692	.077	.769
Washington (S)	10	15	5	1.500	.500	2.000

Table 1, (cont'd.).

West Virginia	9	14	3	1.555	.333	1.888
Wisconsin	17	16	21	.941	1.235	2.176
Wyoming	3	3	0	1.000	0	1.000
Total	644	641	585			1.91

Source: CSRS, 1976.

In addition to the productivity indices prepared by CRS, the Association of State Colleges and University Forestry Research Orginizations (ASCUFRO) also publish information relating to research accomplishments in the McIntire-Stennis Cooperative Research Program. These annual reports of forestry research summarize information recorded in the Current Research Information System (CRIS) and provide a counting procedure similiar to that performed by CRS. The CRIS procedure and the "Forestry Research Progress" annual reports are discussed in greater detail in Chapter III.

The present methods of accounting for research productivity in the Cooperative Forestry Research Program do not consider the impact of research output, its value, nor to whom the benefits are distributed. These statistics are important in showing how successful a research program is in meeting national needs in forestry. They are logically the types of statistics Federal budget-makers, such as the Office of Management and Budget, are acutely interested in.

There are specific cases where the measurement of research output value, or expected value, is especially difficult. These cases occur frequently in those research areas of scientific theory or "basic" research. There are methods, however, far superior to the counting approach currently used.

Study Overview

The most formidable control procedure a research program administrator can wield is the distribution of program funds. Nothing in research can be accomplished without financial support. Those who control

the flow of resources in turn control the operation of the program.

The Cooperative Research Service currently has the power to control the flow of the Federal Government's contribution to the McIntire-Stennis Cooperative Forestry Research Program. This power is being exercised through the use of a formula procedure that is unrelated to the operation of the program. To be more effective a resource allocation system needs to actively include consideration of how the program operates and what it produces. This includes the continual integration of program planning, project selection, and program productivity analysis procedures in the determination of where program resources are allocated. Without such an integrated process it will be difficult for the Cooperative Forestry Research Program to be as effective as possible in achieving goals and objectives in renewable resource research.

It is the purpose of this study to systematically show that changes in the administrative operating procedures of the Cooperative Research Service could enhance the effectiveness of the McIntire-Stennis Cooperative Forestry Research Program in meeting the increased demands on United States forest and rangeland renewable resource research. The primary recommendation will be to develop an alternative method of allocating the Federal proportion of financial resources. Suggested changes will include: the development of specific goals and objectives for use in research project development; the development of specific priority criteria for use in research project selection; and the development of productivity indices that evaluate research output in terms of what it costs.

Procedure

The study begins with an in-dept examination of the history and development of forest and related rangeland resource research in the United States. The digression is meaningful in that it provides background information pertinent to present forest resource research policy.

Chapter II provides an introduction to research management techniques of both the public and private sector. Although the goals of public research differ from those of private sector, there exist certain fundamental principles and techniques that well serve either sector. Through the introduction of such techniques, a source of comparison and alternative management techniques for the McIntire-Stennis Cooperative Forestry Research Program are provided.

Chapter III, "An Evaluation of the Administrative Techniques of the McIntire-Stennis Cooperative Research Program", utilizes the information presented in Chapter II to analyze the operation of the McIntire-Stennis Cooperative Forestry Research Program. The administrative operating procedures and program agents are introduced, and the difficiencies in these operating procedures, as suggested by research management techniques reported in Chapter II, are explored.

The final chapter, "Conclusion and Recommendations", summarizes the material of the preceeding chapters and provides recommendations for change designed to help the McIntire-Stennis Cooperative Forestry Research Program keep pace with the accelerated demands for scientific renewable resource facts.

CHAPTER I

FOREST AND RANGELAND RESEARCH IN THE UNITED STATES

The good of forest and rangeland research is derived from the importance of the multiple resources produced on forest and rangeland. Forest and rangeland research is essentially the process through which scientific knowledge is generated and related to the management and development of forest and rangeland resources (Renewable Natural Resources Foundation, 1977, p.1).

Forest and associated rangelands comprise approximately 63 percent of the land area of the 48 adjacent states. They provide renewable resources for the perpetual production of a great variety of benefits. These benefits include the use of forest and rangelands for outdoor recreation, range grazing, timber, watershed management, and wildlife and fish habitat.

Multiple resource characteristics of forest and rangeland are stated in the 1960 Multiple Use-Sustained Yield Act, which states:

> "It is the policy of the Congress that the national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes."

Each year the nation's forests provide for: 624 million recreational visits, 53 percent of the feed for cattle, 125 million tons of industrial raw wood material, and 60 percent of the water for irrigation, industrial and municipal uses. The forests also serve as the

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habitat for many species of wildlife and fish including 143 that are endangered (ASCUFRO, 1976).

One third of the average American home is built of wood (USDA and NASULGC, 1977). The average American uses 618 pounds of paper and paper products annually, and that figure is expected to increase 1.8 times in the next 25 years.

In 1975 approximately $34.3 billion was spent on research and development (R&D) by all sectors of the American economy (NSF, 1975, p.1). Of this total expenditure, approximately $217 million (.6%) was expended for forestry and rangeland research (Sullivan, 1977, p.39).

The majority of forest and rangeland research in the United States is conducted by three main groups: the Federal Government; universities and forestry schools; and private industry. The development of programs of research in each of these groups is interrelated. Current research policies and priorities in research differ from research agent to research agent. These differences, to a large extent, reflect the influence of developmental interrelationships.

It is the intent of this chapter to both review the historical development of programs of forest and rangeland research in the Federal Government, universities and forestry schools, and private industry, and also to provide current data on the types of research being conducted by these groups presently. The purpose served will be to present the McIntire-Stennis Cooperative Forestry Research Program in terms of the total forestry research environment rather than as an entity in and of itself.

Federal Government Research

The Federal Government is recognized as the sponsor of the first formal forestry research program in the United States. This research dates back to 1876 when $2,000 was appropriated for a study of timber consumption, importing and exporting, and the assurance of future timber supplies (Harper, 1960, p.36). The study was instrumental in the establishment of a Division of Forestry in the U.S. Department of Agriculture in 1881 (Clepper, 1971, p.19).

Underlying the beginnings of forest and rangeland research within the Federal Government was a concern of forest resource scarcity. Exploitation of the forests by timber industry, railroads, and other citizens was creating an environment in which an impending "timber famine" was projected (Clepper, 1971, p.48).

Gifford Pinchot, Franklin Hough and Bernhard Fernow were among the first individuals calling upon the Federal Government to take an active role in establishing policy to insure the maintenance of productive forests. The Forest Reserve system was created in 1891 largely in response to prevalent exploitation concerns. The system allowed for the withdrawal of large tracts of land to unmanaged reserves. The Forest Reserves were placed under the jurisdiction of the Department of the Interior. In 1905 the Forest Reserves were transfered to the Bureau of Forestry in the Department of Agriculture and the name of the Bureau of Forestry was changed to the Forest Service. In 1907 the Forest Reserves were designated as National Forests.

The first forest experiment station was established in 1908 in the Southwest. This forest experiment station and the ones to follow, became the work places for research performed by the Forest Service. The

regional differences in forests and forest related problems were spotted early and forest experiment stations were subsequently developed in various geographic regions of the United States where regional specialization could occur (Kotok, 1948, p.69). During the early history of Forest Service research, activities were concentrated in the areas of fire prevention and control, wood utilization, silvics, and forest management. Early forestry research concerned with forest insects and diseases was conducted by the Agricultural Research Service (Harper, 1960, p.39). This function was moved to the Forest Service in 1953.

The establishment of the Forest Products Laboratory in 1910 stimulated Federal research activity in the study of forest products and wood utilization (Allen and Sharp, 1960, p.366). The establishment of the laboratory initiated another organizational mode in Federal forestry research. In contrast to the forest experiment stations, forest products research was established with a national rather than a regional orientation (Kotok, 1948, p.69).

The growing size of forest products research resulted in the establishment of a Research Branch in the Forest Service in 1915. The passage of the McSweeny-McNary Act followed in 1926. The McSweeny-McNary Act resulted in a major boost to forestry research in the Federal Government, authorizing appropriations for research and a co-ordinated forest research effort. Under the thrust of the McSweeny-McNary Act fourteen regional forest experiment stations in the continental United States were established; the forest survey was begun (in 1930); a new building for the Forest Products Laboratory was constructed; and research programs in forest economics and marketing, wildlife habitat, and soil-site-species relations were strengthened (Harper, 1960, p.39).

By fiscal 1930 the United States Forest Service accounted for approximately 93 percent of the total Federal forestry research expenditure (Committee on Forestry Research, 1962, p.864). Forestry research as performed by other Federal agencies during this period was specifically aimed at a particular aspect of forestry because of skills available and/or the agency's field of responsibility (Committee on Forestry Research, 1962, p.864).

Expenditure data for total Federal expenditures on forestry research during the fiscal year of 1959-1960 reveals that the research receiving the greatest percentage of funds was timber production at approximately 30 percent (Table 2). The next largest expenditure was made in the area of forest products and utilization with 21 percent. Forest protection, economics and marketing received 18 and 12 percent respectfully. Range management, still considered a subunit of forestry research, received 6 percent of the total 1959-1960 Federal forestry research expenditure.

The 1974 Forest and Rangeland Renewable Resources Planning Act (RPA) provided major forest policy guidelines and direction for Federal forest and rangeland research and brings this study of research program development in the United States Forest Service up to date. The RPA requires long-range program planning. It's programs are designed to be those essential to meeting present and future needs for forest and rangeland resources (USFS, 1976 p.3). In specifying long-range goals and program objectives, the RPA program identifies forest and related resource needs that research will be forced to address.

Table 2--Estimated federal agency forestry research expenditure, 1960

Fields of Work	Dollars (in thousands)	Percentage
Timber Production		
Taxonomy	$ 42	
Ecology and physiology	547	
Genetics	580	
Soils	562	
Silviculture	1,860	
Management	1,108	
Mensuration	503	
Total	5,202	30.16
Protection		
Fire	1,081	
Insects	1,068	
Diseases	965	
Animals	40	
Total	3,154	18.28
Forest Products and Utilization		
Wood preservation	483	
Packaging	315	
Timber processing	570	
Wood chemistry	484	
Physics & engineering	652	
Pulp & paper	511	
Timber growth & utilization	594	
Total	3,609	20.90
Watershed Protection & Management		
Water yield improvement	489	
Water and soil protection	257	
Watershed rehabilitation	212	
Erosional & hydrological processes	667	
Total	1,625	9.42
Range Management		
Taxonomy	39	
Ecology and physiology	307	
Range improvement practices	236	
Grazing management systems	400	
Total	982	5.69

Table 2 (cont'd.).

Fields of Work	Dollars (in thousands)	Percentage
Wildlife and Wildlife habitat		
Animal ecology	$ 278	
Management	205	
Total	483	2.77
Recreation	52	.29
Forest Economics & Marketing		
Production economics	210	
Marketing	261	
Forest survey	1,574	
Total	2,045	11.85
Forest Engineering	--	---
All Other	90	.52
Grand Total	$ 17,247	100.00

Source: Report of the Committee on Forestry Research, 1962, pg. 864

University and Forestry School Research

The first organized research in forestry at an educational institution occurred in 1899 (Westveld, 1954). Progress was slow during the next 25 years. University research did not exhibit substantial growth until after World War II.

Total budgets for forest research at educational institutions did not pass the $100,000 mark until the late 1930's (Table 3). During the 10 year period between 1940 and 1950 these institutions experienced a five fold increase in total funds allocated to forestry research.

Table 3--University Forest research budgets, fiscal 1941, 1948 and 1951

Type of Department	1940-41	1947-48	1950-51
Accredited Forestry Schools	$204,458	$502,252	$ 803,938
Other Forestry Schools	14,667	48,743	85,151
Other forestry departments	31,400	124,267	180,241
Engineering departments	6,000	79,260	130,380
Total	$256,525	$754,522	$1,199,710

Source: Westveld, 1954, p.86.

University based research prior to 1951 was directed primarily to studies of silviculture, management, and utilization (Westveld, 1954, p.87). In 1951 more than 85 percent of forest research funds were expended in these three areas (Table 4).

Table 4--Research effort in five forestry research areas by 42 of the 44 schools participating in 1951

Area	Thousands of Dollars	Percent
Silviculture	$ 273	23.2
Management	248	21.1
Utilization	480	40.8
Economics	135	11.4
Protection	42	3.5
Total	$1,178	100.0

Source: Westveld, 1954, p.87.

Although expenditures for research in forestry were increasing rapidly at education institutions, progress elsewhere in public sector state agencies was slow. Total forestry research expenditure at state

agencies other than educational institutions in 1951 was $617,462 (Westveld, 1954, p.87). Leadership in forestry research at the state level clearly was being assumed by educational institutions.

Post World War II industrial expansion and the alternative use of the forest for outdoor recreation and urban sprawl caused growing concern over physical scarcity of forest resources, particularly timber. Projections of timber demand and physical supply based on the existing levels of management and research caused the American Forestry Congress and the Mid-Century Conference on Resources for the Future to emphasize the need for expansion of forestry research (Committee of Forestry Research, 1962, p.68).

The Research Committee of the Council of Forestry School Executives had been studying ways and means of strengthening forestry research since the early 1950's (Committee of Forestry Research, 1961, p.46). In September, 1957, the Forestry School Executives brought the subject of research endorsement before the Society of American Foresters which authorized the appointment of a standing committee on forestry research. The SAF Committee on Forestry Research was charged with the responsibility to review and study research needs of concern to SAF and to make recommendations. This Committee had four main objectives: (1) to determine the current expenditures by various agencies for forestry research; (2) to study the attention being given to the most important problems in forestry; (3) to determine the areas that should be strengthened to meet present and future needs from the forest and related resources; and (4) to suggest the various ways that inadequacies in forestry research efforts might be removed (Committee of Forestry Research, 1961, p.46).

It was estimated that by 1960, 7.4 percent of the total forestry

research expenditure ($6.5 million) was attributed to forestry school activity. Funds for forestry school research in this period were obtained from a variety of sources (Table 5). State funds constituted 57 percent of the total, with the institutions themselves providing the largest amount. The federal government was the second largest doner, providing 23 percent. Grants from industry totaled 12 percent, nearly as large a portion of the total funds as did the grants from the United States Department of Agriculture.

Table 5--Sources of income for forestry research at forestry schools, 1959-1960, thousands of dollars

Sources of Funds	Total Income	
	Amount	Percent
Federal funds-USDA	$ 808	12
Federal funds-other than USDA	741	11
State funds from college budgets	2,814	43
Private funds from college budgets	296	5
Grants from other state agencies	633	10
Other state funds	226	4
Grants from industry	711	11
Grants from private foundations	135	2
Other sources	157	2
Total	$6,521	100

Source: Committee on Forestry Research, 1962, p.865.

Legislative approval for USDA appropriations to forestry research at State supported forestry schools and universities was given under the Hatch Act. Stimulus to forestry research under the Hatch Act, however, was low since its funding formula was designed to fit rural agricultural needs based on the farm crop situation, not forestry. Many felt that by creating a separate cooperative program for forestry research, the needed stimulus to forestry research at forestry schools could be attained

(Westveld, 1963, p.420). The McIntire-Stennis Act, signed into law on October 10, 1962, provided the legislation necessary to funnel Federal dollars to certified forestry schools and initiate forestry program commonly known as the McIntire-Stennis Cooperative Forestry Research Program (Sullivan and Burks, 1969).

Forestry research is specified in Section 7 of the McIntire-Stennis Act to include investigations relating to (U.S. Congress, P1.1 87-788, 1962):

"1) Reforestation and management of land for the production of crops of timber and other related products of the forest;

2) Management of forest and related watershed lands to improve conditions of waterflow and to protect resources against floods and erosion;

3) Management of forest and related rangeland for production of forage for domestic livestock and game and improvement of food and habitat for wildlife;

4) Management of forests for outdoor recreation;

5) Protection of forest lands against fire, insects, diseases, of other destructive agents;

6) Utilization of wood and other forest products;

7) Development of sound policies for the management of forest lands and the harvesting and marketing of forest products;

8) Such other studies as may be necessary to obtain the fullest and most effective use of forest resources."

Interpretation of the McIntire-Stennis Act and the environment in which it was drafted has led to the explicit recognition of two major goals of the program (Gray, 1977). They are:

1) To encourage and assist land grant and other state supported forestry schools to conduct research necessary to improve the production, protection, and utilization of forests and related rangelands.

2) To stimulate expansion in the training of scientists in forestry and forestry related specialties.

Classification of forestry research fields has not been consistent through out the existence of the program. Variations in the forestry situation in the United States have caused the administering agent of the program, Cooperative Research (CR), to change some of the original categories (Table 6). Compliance to the Oxford System of Decimal Classification for Forestry in 1969 and to the Research Problem Areas (RPA's) outlined in "A national Program of Research for Agriculture" also served to modify the classification scheme (CSRS, 1970).

Research effort and classification for 1964 (the first year of operation) and for 1975 (the latest data available) are presented in Table 6. Although the classification scheme and method of reporting (number of projects in 1964 versus scientist years in 1975) have changed, emphasis on both forest management and utilization have remained constant.

Private Sector Research

Forest products industry had a later start in developing programs of research than did the government and universities. During the 1800's the lumber industry moved from New England to the Middle Atlantic States and to the Lake States, finally branching out to the South and to the Pacific Northwest (Clepper, 1971, p.197). As the timber resource in one region was cut, the industry moved on. With an abundance of standing timber there was little incentive, economic or otherwise, for industry to perform research.

It was in the early 1900's that the public began to realize that the supplies of timber in the United States were not inexhaustable. The next decade brought much controversy over the best means to insure

Table 6--McIntire-Stennis Cooperative Forestry Research effort and classification, 1964 and 1975

1964 Research Area	# Projects	%	1975 Research Area	# Projects	%
Forest Biology	34	21.5	Inventory and Appraisal	24.2	5.0
Genetics	18	11.4	Timber Management	141.4	29.4
Silviculture	9	5.7	Forest Protection	80.7	16.8
Protection	20	12.7	Harvesting, Processing, and Marketing	124.2	25.8
Management	38	24.1	Watersheds, Soils, and Pollution	33.5	6.9
Utilization	29	18.4	Range, Wildlife and Fisheries Resources	33.0	6.9
Economics, Policy	8	5.1	Forest Recreation and Aesthetics	23.2	4.8
Marketing	2	1.3	Forest Land Use	21.3	4.4
TOTAL	158	100.0		481.5	100.0

Source: Westveld and Kaufert, 1964; and, Cooperative State Research Service, 1976.

adequate supplies of timber for future generations.

As noted earlier, research activities began in this period with the Federal Government's studies on timber supplies and timber consumption. These early studies helped to stimulate the growing concern over the ability of private industry to adequately provide for American timber needs.

The United States Chamber of Commerce sponsored a national conference on commercial forestry in 1927. The conference was attended by industrial timbermen, governmental foresters, trade associations, the press, and the general public. The profitability of private sector research and their reluctance to apply programs of research to forest management proceedures was a major topic.

D. C. Everest, President of the American Pulp and Paper Association and spokesman for the forest products industry, had these words to say concerning forestry research:

> "The perpetuation of the timber supply in the United States is the most important question confronting our people today. It involves the health, happiness, and prosperity of every person in the country. It is described as the fourth industry in the United States today, but we must remember that no industry can carry on business unless forest products are available.
>
> One reason for suggesting that government agencies carry on the work of research in forest management is the fact that the program must cover a long period. The results are not patentable and the benefits accrue to all the people. Therefore, it seems only sensible that there be one continuing agency that coordinate and carry on the work and that it be a governmental agency not dependent on voluntary organization and support." (USCC, p.20).

Early conservationists had little confidence in the willingness or ability of private industry to invest profits in the perpetuation of the resource from which they derived income (Clepper, 1971, p.202). Robert Marshall wrote:

> The only way that private forestry could be a success would be for the government to pay practically all of the expenses of starting,

> developing, and protecting the forests, leaving the owners only the harvesting of the profit. (Marshall, 1933, The Peoples Forest, Smith & Haas, NY, p. 106).

The cost of growing timber and the cost of a research program to support such a venture were not reflected in the price of stumpage (American Enterprise Association, 1950, p.21). As long as stumpage was abundant the cost of growing trees was prohibitive. With the gradual depletion of the virgin timber, the price of stumpage began to rise and make forestry and research more attractive to industrial investment.

Zebulon W. White, a long time student of private forestry, summed up the condition under which industrial forest management and research began:

> "The practice of timber growing as a business enterprise can be sucessful only within the framework of certain conditions, and most of these conditions were not present early in the 20th century. It took two more generations to develop them, and they are still being refined" ("Growth of Industrial Forestry", National Colloquim on the History of the Forest Products Industries: Proceedings, p.95).

Research in forest industry prior to 1930 was restricted to studies of lumber manufacturing and related subjects (Harper, 1960, p.30). There was little change in industrial interest or emphasis in forestry research until the shortage of forest products during and immediately following World War II which brought a new public awareness of the importance of forestry to the national economy. The improved market and price structure for forest products had a positive effect on the advance of both private and public forestry (Harper, 1960, p.15).

The greatest growth in expenditures for forestry research following World War II, particularly in the field of pulp and paper products, was in private industry. The 1950's were notable for the entry of forest industry into research in silviculture, genetics,planting, and insect and disease control (Harper, 1960, p.38). Industrial research

emphasis on wood products utilization is clearly reflected in expenditure information (Table 7).

Although research in forest industry was slow in starting, by 1960 industry expenditures for forestry and related research had grown to nearly 2.5 times the expenditure for forestry research in all other sectors combined (Table 8).

Recent Efforts in Research

In 1975 forest and rangeland research expenditures in the United States were estimated at $217 million (Sullivan, 1977, p.39). Private industry is credited with the majority of the 1975 expenditure at 51 percent, an approximate $111 million (Table 9). The Federal Government is reported as having expended 42 percent of the total amount, $91 million, with the remainder being credited to the States through local governments and foundations.

Actual research performed by these agents differs slightly from research fund expenditure. In 1975, for example, $1 million of federal funds was appropriated to private industry for their participation in selected forest and rangeland research studies (Sullivan, 1977, p.42). State universities and forestry schools do not register as fund sources but they perform a major role in performing forest and rangeland research. In 1977 state universities and forestry schools operating in the McIntire-Stennis Cooperative Forestry Research Program expended nearly $24 million on forest and rangeland research projects and studies (Gray, 1977, p.33). Federal appropriations to schools performing research under the cooperative program in 1977 amounted to $8.2 million. Non-Federal funds,

Table 7--Expenditures in major forestry research fields by private industry, 1959-1960

Major Forestry Research Field	Thousand Dollars
Timber production	$ 1438
Protection	189
Products utilization	59,800
Water	3
Range	35
Wildlife	18
Recreation	5
Economics and Marketing	54
Engineering	196
Other	288
Total	$62,026

Source: Committee on Forestry Research, 1962, p.867.

Table 8--Forestry research expenditures by sectors, 1959-1960

Research Group	Thousands of Dollars	Percent of Total
Federal Agencies	$17,247	19.6
Private Industry	62,026	70.6
Educational Institutions	6,521	7.4
State Agencies, Associations and Foundations	2,105	2.4
Total	$87,899	100.0

Source: Gray, 1977

Table 9--Sources of forestry research funds, United States, FY 1975

Fund Source	Amount	%
States	$15 million	7
USDA	$83 million	38
Private Industry	$111 million	51
Other Federal	$8 million	4
TOTAL	$217 million	100.0

Source: Sullivan, 1977.

from State and private sources, doubled the Federal appropriations at near $16 million (Gray, 1977).

The following sections report current forest and rangeland effort by the U.S. Forest Service, State universities and forestry schools, and private industry.

U.S. Forest Service

Of the $91 million expended by the Federal Government for forest and rangeland research in 1975, $73.3 or 81 percent, was attributed to research performed by the Forest Service (Sullivan, 1977, p.41). Of the remaining 19 percent, nearly 10 percent was funneled through the Cooperative Research Service (CRS) for State universities and forestry schools operating under the McIntire-Stennis Cooperative Forestry Research Program.

As noted earlier, forest and rangeland research in the Forest Service was initiated in part as a result of concern over adequate timber

supplies in the United States. The perpetuation of this concern was reflected in the passage of the Forest and Rangeland Renewable Resources Planning Act (RPA) in 1974. It provided Congressional direction for the Forest Service to develop a long range program assuring adequate supplies of all forest and rangeland resources in the future (USFS, 1974).

The Forest Service segragated this renewable resource program into six resource systems:

1) Outdoor Recreation and Wilderness
2) Wildlife and Fish Habitat
3) Range
4) Timber
5) Land and Water
6) Human and Community Development.

Research effort in each of these resource systems for 1975 and projected years is presented in Table 10.

Timber is clearly the major recipient of Forest Service research dollars. Research associated with the production and protection of the timber resource system involves nearly 60 percent of the total projected expenditure by the Forest Service for forest and rangeland research in 1975-2000.

Current and projected Forest Service research effort in other resource systems is substantial. An estimated $3 million was appropriated for research in recreation and wilderness in 1975 (USFS, 1974). Additionally $1.9 million was appropriated for range research and $6.0 million for wildlife and fish habitat research. The U.S. Forest Service provides for the most encompassing program of forest and rangeland research in the United States.

Table 10--U.S. Forest Service research effort by resource system, 1975, and estimated 1980, 1985, 2000

Resource System	Millions of Dollars			
	1975	1980	1985	2000
Land and Water	$16.0	$ 25.0	$ 23.0	$ 23.0
Timber	46.1	60.0	71.4	79.5
Range	1.9	4.9	6.5	6.7
Wildlife and Fish	6.0	9.1	12.2	15.3
Wilderness	.6	.8	1.0	1.2
Recreation	2.4	3.7	3.7	4.4
Human and Community Development	5.8	8.0	10.9	12.4
Totals	$78.8	$111.6	$128.7	$142.5

Source: USFS, 1974

Forest Service research is conducted in a highly decentralized organization managed by eight forest and range experiment stations, one national forest products laboratory, and one institute of tropical forestry (Buckman, 1977, p.28). Principle research performers are individual research scientists which number 900 in 1977 (Buckman, 1977, p.28).

The Forest Service publishes an assortment of statements concerning the goals and objectives of its forest and rangeland research program. These statement range from the most benevolent, such as (USFS, 1975, p.22): "the ultimate goal of (USFS) research is to protect the Nation's natural resources; gain the maximum conservation, economic and social benefits from their use; and leave the environment unspoiled", to the very pragmatic (USFS, 1967, p.9): "Prefered research programs are those that promise to enhance economic efficiency markedly - by reducing the cost of timber growing, harvesting and processing, or by increasing the amount or quality of output available from given resources".

Public relations and politics are likely influencing factors in the development of goal statements such as those indicated. Perhaps the best indication of research emphasis and interest in particular research areas is expenditure data. The data reveals that U.S. Forest Service emphasis, as reflected in research expenditure, is in the management of the Nation's forest and rangelands for the production of timber (Table 10).

State Universities and Forestry Schools

State universities and forestry schools operating under the McIntire-Stennis Cooperative Forestry Research Program expended nearly $24 million on the performance of forest and rangeland research in 1977 (Gray, 1977, p.33). Federal appropriations, through CRS, amounted to $8.2 million; the remainder was made up of state and private sources.

Research effort in 1975 has been published by the Association of State College and University Forestry Research Organizations (ASCUFRO) and is reported in Table 11. Projections of research effort by the universities and forestry schools participating in the program to 1980 and 1985 are also presented (Table 12).

In fiscal year 1975, 72 percent of the 481 scientist years devoted to forestry research by McIntire-Stennis institutions were allocated to three research programs: timber management; forest protection; timber and wood products harvesting, processing, and marketing. Projections to 1980 and 1985, shown in Table 12, assume that McIntire-Stennis appropriations will increase at a percentage twice that of U.S. Forest Service appropriations (Gray, 1977, p.35). Percentage increases are

Table 11--McIntire-Stennis Cooperative Forestry Research effort in 1975 by area*

Research Programs	# Scientist Years	Percentage of Total
Inventory and Appraisal (forest, range and remote sensing)	24.2	5.0
Timber Management (biology, culture, management, tree improvement)	141.4	29.4
Forest Protection (insects, disease, and fire)	80.7	16.8
Harvesting, Processing, and Marketing (engineering, production, product development, marketing, grades, demand and housing)	124.2	25.8
Watersheds, Soils, and Pollution (soil inventory, soil/plant/ water nutrient relations, watershed protection, water use, pollution abatement)	33.5	6.9
Range, Wildlife and Fishery Resources (habitat interactions, quality and management)	33.0	6.9
Forest Recreation and Aesthetics (demand, planning, allocation and management)	23.2	4.8
Forest Land Use (alternatives, multiple use)	21.3	4.4
Total	481.5	100.0

Source: ASCUFRO, 1976, p.32.

* The research effort reports for the McIntire-Stennis Cooperative Forestry Research Program are reviewed in scientist years rather than dollars expended. Conversion may be approximated by multiplying the scientist year figure by $52 thousand.

Table 12--State agricultural experiment stations' and forestry schools' Cooperative Forestry Research effort projected to 1980 and 1985

Research Programs	1980		Target Year 1985	
	SY's	Percent	SY's	Percent
Inventory and Appraisal	46	4.8	51	5.0
Timber Management	269	28.3	287	28.2
Forest Protection	112	11.8	117	11.5
Harvesting, Processing, and Marketing	208	21.8	222	21.8
Watersheds, Soils, and Pollution	115	12.1	123	12.1
Range, Wildlife, and Fisheries	83	8.7	89	8.7
Forest Recreation and Aesthetics	55	5.8	60	5.9
Technical Assistance	20	2.1	22	2.2

Source: Gray, 1977, p.34.

greater in scientist years devoted to research in forest recreation and aesthetics, and alternative uses of land, than for any of the remaining six research program classifications. Timber production, protection, harvesting, marketing, and processing research, however, will comprise 62 percent of all scientist years in 1980 and 60 percent in 1985.

Private Industry

Estimates can be made of what is spent on research in forest product industry through the disclosure of industrial information required by the Securities and Exchange Commission on the annual 10-K forms and the information collected by the U.S. Department of Commerce for the National Science Foundation reports. Comparatively little is known, however, about how and where private industry expends its research dollars (Business Week, 1976, p.62). Much of the research effort in industry is directed toward the objective of gaining and retaining competitive advantage so its disclosure is considered proprietary (USDA and NASULGC, 1977, p.5).

Companies are known for having two distinguishable research efforts: those associated with land and management, and those associated with new products and processes. Of the estimated $111 million in industrial research and development in forest and range, new products and processes constitute an estimated 75 to 80 percent (Sullivan, 1977, p.43).

Forest products industry accounts for 75 to 80 percent of their total forest and rangeland renewable research expenditure through internally performed research. Universities perform 10 to 15 percent of

industrial funded research (Sullivan, 1977, p.44). The balance of industrially funded forest and range research is accounted for by consultants and related industries.

CHAPTER II

RESEARCH PROGRAM MANAGEMENT

Management serves to insure performance. If performance of a desirable level could be guaranteed in the absence of management, there would be little need for its use.

Research management is a specialized field of management that deals with the application of management techniques to the process of research and research programs. The appropriateness of research management is well said in the following quotation (Marra, 1977):

> The human brain is like a muscle in that it develops and responds to exercise. But it is housed in a human body that likes to walk, rather than run, likes to stand rather than walk, likes to sit rather than stand, and likes to lie down rather than sit. The mind tends to do the same thing. Left to themselves with nondiscriminating management systems, some research people tend to choose the easier problems to work on, problems that produce no failures and can be completed in small units of effort...low-key management, may lead to research lacking in real significance.

This chapter is devoted to the exploration of research management and related techniques. It will introduce, and support with relevant literature, proven methods of research management that help increase the effectiveness of research programs. The purpose of the identification of these techniques is to introduce methods which could be helpful in improving the management of the McIntire-Stennis Cooperative Forestry Research Program.

It is necessary to note that not all research management techniques are applicable in all situations. Research program management must

consider its goals and the environment in which it operates before an appropriate portfolio of research management techniques is selected.

The techniques of public sector research management, for example, differ from those reported in the private sector. This situation exists largely because the goals underlying research in the private sector are different than those underlying research in the public sector. Industrial research is part of an overall business strategy whose purpose is to achieve specific business objectives (Reeves, 1967). It differs from public sector research which lacks clearly defined business objectives such as profit, and relies on less definable targets such as the "public interest" (Fleischer, 1974).

There are certain "universal" principles and techniques that could serve any research program. It is the objective of this chapter to review the research management techniques of both the public and the private sectors and to identify those techniques and principles of mutual benefit.

Fundamentals of Research Management

Reeves (1967) has suggested that successfully managed research programs contain the following elements: (1) a plan of action based upon company objectives; (2) creation of the technology required by the plan; (3) a method for getting the technology to "pay off" in terms of the resources invested. Although research program management does not participate in the creation of technology, it is the function of management to insure that these elements are present in research programs. Research managers facilitate their function through the use of research

management techniques.

A complete description of research management techniques would require nothing less than a very large text. This study is limited to a discussion of the research management techniques of priority establishment, project selection, and benefit measurement. Since agency goals in both the public and private sectors are generally established by agency rather than by research administrators, program planning within the department of research consists of determining how to most effectively attain defined agency goals. This type of program planning is best accomplished through the use of prioritization and project selection techniqes. Appendix III provides greater detail on the various techniques and how they are used.

Research Priorities

Research priorities serve essentially two functions: they define areas within which individual research projects and studies are selected, and, they indicate which studies and projects should be performed first. The first step in the development of research priorities is the selection of relevant criteria (Babcock, 1977). What are considered relevant criteria is dependent upon what is considered important in a particular situation.

Fleischer (1977) has developed a list of criteria useful in establishing research priorities (Table 13). Fleischer's list includes objective economic criteria, such as benefit-cost ratio, and also subjective criteria, such as the "public's interest". In any given situation those criteria may or may not be relevent. It could be that a research situation would require total reliance upon economic criteria.

Table 13--Criteria useful in establishing research priorities

1. Benefit-cost ratio
2. Likelihood of success on schedule
3. Need for immediate action
4. Feasibility of plan for success
5. Likelihood of adoption of results
6. Contribution to knowledge base
7. Fit within existing research capability
8. What is being done elsewhere
9. Is it in the public's interest

Source: Fleischer, 1977, p.50.

Another situation may be such that economic returns are either immeasureable or inappropriate for total reliance.

The point to be stressed here is that in the development of research priorities, a list of criteria, regardless of their nature, needs to be developed. The responsibility for this process is with the research manager. Once the criteria list is established, the second step in the development of research priorities is to rank the criteria in terms of their relative importance. Ranking of priority criteria is also the responsibility of the research manager, and, in most cases, ranking may be done simultaneously with the selection of the criteria list.

Since research in the private sector is supportive of an overall business strategy, the establishment and ranking of relevant criteria is often merely a statement of those specific business objectives sought. In the private sector, the use of economic criteria is very appropriate.

The establishment of research priorities in the public sector is made more difficult because of a goal structure more complex than business objectives and because of the highly diffuse decision-making process that is generally present. Decision-making in governmental research performing agencies is a hierarchial process (Shumway, et. al. 1975).

Broad areas of priority are identified at the top of the hierarchy and become the framework within which more specific priorities evolve at corresponding lower levels.

The priority process in such a system is sequential in nature. Priority guidance, often in the form of recommended budget levels, is issued from each superordinate level to its immediate subordinate level, based in turn on the guidance it has received and its decision on how priorities should be further appointed (Baker, et. al., 1976).

Priorities in research are important in those cases where there are too many research projects to do given time and other resource constraints. The establishment and ranking of criteria is not the endpoint of the priority process. In fact, these priority criteria have value only when they are used in the selection of research projects from the host of alternatives.

Project selection is essentially a continuation of priority establishment. The difference is that priorities establish ranked needs in research, and project selection chooses those projects best suited to fulfill those needs. Techniques of project selection are in general better developed than techniques of priority establishment. A study by Kaldor (1966) is a good example of how far methodology in the establishment of research priorities has come. He discusses conceptual considerations involved with the establishment of research priorities but, unfortunately, does not specify how to involve these conceptualizations into a decision-making framework. Hildreth (1966) presents another interesting study on the establishment of research priorities, but, as in many other studies, does not provide a statement of a systematic procedure to establish them.

Relative importance of priority criteria is a subjective decision. The absence of systematic procedures for the establishment of priorities is largely because of the subjectivity of the decisions necessary to establish them. What is considered important at one time and place may not be considered important in another time and place. Once the decision on priorities has been made, the criteria resulting are readily applied to the analytical and well developed methods of project selection. The problem changes from the determination of what to do, to how to economically optimize what has been planned.

Project Selection

Once research priorities are established, project selection techniques are utilized to determine which particular research project provides the attainment of the research priorities. In general, project selection involves an ex ante evaluation of proposed research. The techniques succeed in providing an ordinal ranking of the proposed research projects in terms of their expected contribution to satisfying the research priorities.

In cases where research is an ongoing process, project selection is a decision by which an intermittent stream of changes are made to lists of currently active and proposed projects (Baker, 1974). A detailed process flow model of project selection has been constructed. In general, the process consists of six main stages:

1) Generating and changing the inventory of project proposals.
2) Reviewing the status of current and proposed projects for the purpose of deciding when to make a change.

3) Identifying the projects and proposals to be evaluated and compared with respect to change and the criteria, variables, and constraints to be used in the evaluation.

4) Evaluating the designated projects and proposals.

5) Comparing the alternatives and choosing among them.

6) Recycling to gather additional information, to reformulate criteria variables, and constraints, and to define entirely new alternatives.

(Brandenberg, 1966, p.21).

There are a myriad to techniques available to the research manager for use in the project selection process. Peer review is commonly used largely because of its simplicity in use. Peer review involves the use of associated scientist (peer) evaluations of proposed research. In the most formal sense, selected scientists are provided with copies of research proposals and are requested to give personal evaluations of the worth of the research and the probability of success. The resulting evaluations are made available to a decision maker on which projects to select.

The National Science Foundation utilizes peer review as a major method of research proposal evaluation. Many journals and periodicals utilize a form of peer review to "referee" works submitted for publication. Michigan State University makes use of a peer review panel to select research proposals submitted under the Hatch and McIntire-Stennis Programs. Peer review finds the least use in the private sector where peer approval is often less important than economic criteria. Peer review, however, provides an excellent means through which to insure scrutiny of publically performed research (Bowers, 1972).

In individual participant comparative methods a single judge compares the overall subjective worth of one item to another or to a group of items (Shumway, 1975). Several techniques are found within this

category: Q-sort; paired comparisons; successive ratings; successive comparisons; and the dollar metric approach.

The Q-sort technique divides proposed projects into hierarchical categories on the basis of their expected benefits (Helin and Souder, 1974; Maclay, 1974). The Q-sort technique often involves the sorting of cards, which contain essential information about a particular project, into preconceived categories (Shumway, 1973).

No quantitative values are assigned to any category, but each may be divided into additional categories until no significant difference in anticipated benefits are discernable among its constituents. Ordinal ranking is obtained between categories on the basis of anticipated benefits. The Q-sort technique also appears in the literature as a method of classifying a set of items according to the individual opinions of a group of people (Bell and Souder, 1974).

With paired comparisons a complete ordering of projects is obtained and verified (Shumway, 1973). All possible pairs are compared and the one with the highest expected benefit is identified. No quantitative value is assigned to any project - only ordinal ranking.

An arbitary base number is assigned in the successive rating methodology. The base number is assigned to the highest ranked project. Numbers are then given to each subsequent project in accordance with its anticipated benefits relative to the top ranked project.

With successive comparisons initially assigned values are refined be comparing the value of one high-benefit project to portfolios of lower benefit ones. The number of projects in the portfolio is successively reduced until the single high-benefit project is preferred to the portfolio.

The final individual comparative approach, the dollar metric methodology, uses paired comparisons to identify the preferred project from each possible pair. From an estimate of the expected cost of each project the participant specifies how much the cost of the preferred project could increase before the other is chosen. This process is repeated for all pairs. Next, the participant determines how much the cost of the least preferred project could increase (or decrease) before a decision would be made to fund no project within the entire research area. The base figure which results permits the specification of anticipated benefit in dollar terms.

Group determined methodologies include: the round table approach; the chain of command approach; and the Delphi method. In the group determined methodologies, individual reviewers evaluate the research proposals using any of the available ranking techniques. Individual evaluations are then grouped for a final ranking. The individual evaluations are collected and analysed via a group determined methodology.

In the round table approach an attempt is made to reach group consensus over a particular evaluation. The chain of command approach, on the other hand, does not group the individual reviewers evaluations. The individual evaluations originate at the bottom of a hierarchical chain of command and are passed from subordinate to an immediate superior. Modifications are made at each step in the chain of command until the evaluation reaches the top where a final ranking is issued.

The Delphi method of group ranking provides for feedback and reconsideration by individual reviewers before a final submittal to the decision-making unit (Harman and Press, 1975). Each reviewer submits his evaluation to other reviewers. The other reviewers evaluate the

evaluation and anonymously return it to the originator for any desired corrections. Corrected evaluations are in turn submitted to the decision-making unit.

Scoring models comprise the major source of multi-dimensional ranking methodologies (Moore and Baker, 1969a, 1969b; Shumway and McCracken, 1975). Scoring models involve the selection of a discrete set of criteria under which all of the projects can be evaluated. Each project is rated by a numerical scale in each of the selected criteria. An overall project score is calculated by summing the product of criteria weight and the projects criteria scores.

A number of comprehensive reviews of techniques available to the research program manager for project selection and evaluation are reported in the literature. Among them are: Baker and Pound (1964); Cetron, Martino and Roepeke (1967); Baker and Freeland (1975); and Clarke (1974). Each author presents a unique system of classifying these techniques. An example of such a classification system is that reported by Moore and Baker (1969):

1) Scoring models which compute an overall project score based on ratings of the project against preselected criteria considered critical to the project's success.

2) Economic models which employ calculations such as net present value, internal rate of return or economic equations.

3) Constrained optimization models which attempt to optimize an economic objective function subject to specified resource constraints.

4) Risk analysis models which are based on a simulation analysis of input data in distribution form and provide output in the form of distributions of benefit factors, as for example rate of return or market share.

The various classification systems are interesting, but they are all different ways of reporting the same techniques. Clarke (1974)

postulates that none of the classification systems reported are "fail-safe".

Regardless of how they are classified, there are many methods of project selection available for use by the research manager. What is considered a useful method in one situation may be useless in another situation. It is the function of the research manager to select a method most appropriate to his own situation. The purpose of the above is to introduce a few of the available techniques and to provide the research manager a means through which relevant literature may be discovered.

Benefit measurement

Benefit measurement techniques are distinguished from project selection techniques in the fact that they involve an ex post, cardinal determination of research value. Although the project selection techniques discussed also involve a sort of benefit measurement, the distinction between ex post and ex ante analysis is important.

Ex post benefit measurement analysis is used by governmental, industrial and university research agencies when the evaluation of completed research, or research in progress, is necessary. Such analysis is beneficial in justifying past dollars invested in research and in vying for continuation of funding. Ex ante evaluation is used more as an allocation device for resources related to research programs (USFS, 1967).

Benefit measurement techniques are important in productivity accounting procedures. They provide the types of information that indicate to the research manager what was purchased for resources invested and to

whom these benefits were distributed.

It is not considered sufficient in research to allow the creation of technology to be the end point of the research process. Benefit measurement techniques enable the research manager to follow through on the creation of technology. It helps to insure that every effort is made to either apply output to an existing problem or, in the case of basic research, to identify those areas of potential future benefit and to make the output accessible for such future applications.

The goals underlying research in the private sector have made the use of ex post benefit measurement to research quite common. The research undertaken in private industry generally has an existing application. Output is easily gauged. Industrial evaluation of research has been done in relation to company profits (Bachman, 1972), to company sales (Taymour, 1972), and in its ability to generate profitable business opportunities (Gee, 1972).

Most of the pioneer work in research benefit measurement in the public sector has been done within the realm of agricultural research. Research in benefit measurement analysis is viewed as a production process in which research inputs are used to devise a specific output, e.g., more or better food at least cost. The value of the research input into a production process is gauged by the increase in productivity.

Griliches (1958) computed the annual return on investments in research and development of hybrid corn to be near 700 percent. The total increase in productivity in corn during the period of study was attributed to investments in research and development. The value of the increased productivity was then placed in respect to hybrid corn research and development.

Peterson (1967) computed returns to poultry research by developing a supply function for poultry both before and after the implementation of a program of poultry research. In measuring the downward shift in the supply function over the period of analysis, he computed a savings of resources due to poultry research. Ayer and Schuh (1972) and Akino and Hayami (1975) have followed a study procedure similiar to the one used by Peterson for cotton and rice research respectfully.

Mansfield (1965) analyzed the contribution of national research and development to the nation's economic growth between 1927 and 1960. By totaling R&D expenditures in real dollars and comparing the resulting figure with a constant dollar figure for national output over the same time period, Mansfield computed a marginal rate of return to investment in research and development.

Collier and Gee (1973) suggest that research be evaluated ex post in terms of pre-defined goals and objectives. The first step in the evaluation process they recommend is the evaluation of the technical staff associated with the research program. Staff evaluation is done to determine whether or not they have accomplished the pre-defined goals and objectives established by them and the research agency and clientele. The next step is determination of the potential value of what the staff has produced. The value determination is made by those departments within the agency, or other clients, who are to make use of the research output.

CHAPTER III

THE MCINTIRE STENNIS COOPERATIVE FORESTRY RESEARCH PROGRAM

The purpose of this chapter is to evaluate the administration and operation of the Cooperative Forestry Research Program as authorized by the McIntire Stennis Act, P.L. 87-788, adopted in 1962. A historical prospectus of the events leading up to the passage of the Act is provided in Chapter I. This chapter reviews the roles of the various agents involved with the administration or operation of the program and discusses these procedures in terms of the research management techniques provided in Chapter II.

Program Agents

There are numerous agents associated with the operation and administration of the McIntire-Stennis Cooperative Forestry Research Program. Those agents having direct association with the program include: The Science and Education Administration/Cooperative Research (formerly the Cooperative State Research Service); the Association of State College and University Forestry Research Organizations (ASCUFRO); the administrative-technical representatives (ATR); the Cooperative Forestry Research Advisory Committee and the Advisory Board; and research project principal investigators.

Cooperative Research

Cooperative Research (CR) is the federal agency through which the McIntire-Stennis Cooperative Forestry Research Program is administered. CR administers formula and special grant programs of the Department of Agriculture in support of research programs at State institutions (U.S. Congress, 1976, p.29). Among the programs administered by CR is the Hatch program which provides for formula funds to agriculture and related research at State institutions.

The role that CR plays in the administration of the McIntire-Stennis Cooperative Forestry Research Program is to provide assistance to the research administrators in coordinating research among the State institutions, and between them and other agencies in the Department of Agriculture (U.S. Congress, 1976, p.29). This assistance includes participation in long range program development at each institution in the various regions and nationwide.

Cooperative Research personnel do not conduct research. They review proposed projects and studies to insure they meet requirements specified in the McIntire-Stennis Act. Cooperative Research provides national coordination for the program. Each year CR computes and makes available annual productivity information concerned with each participating institution and accomplished research.

Association of State College and University Forestry Research Organizations

The McIntire-Stennis program owes much of its early history and later growth to the Association of State College and Forestry Research Organization (ASCUFRO) (Sullivan, 1969, p.2). ASCUFRO and the McIntire-Stennis program are closely associated since institutional membership in ASCUFRO is based on certification of eligibility for Cooperative Forestry Research Program support under the McIntire-Stennis Act.

Membership in ASCUFRO is open to either the administrative head or the Forestry Representative at any college or university certified to receive McIntire-Stennis funds. Members are grouped into six geographical divisions headed by an elected chairman who is also then a member of the Executive Committee of ASCUFRO. Each Regional Committee meets at least once a year for the primary purpose of encouraging regional cooperation in the conduct of forestry research. In addition, matters of policy and procedure that concern members are formulated for action by the association which meets once a year.

The Executive Committee functions in: developing information on existing research programs and on the needs for future research in the individual institutions; pointing out Federal policies and procedures that will implement support for member research programs; and developing justification statements in support of appropriation requests and in supporting these programs to CRS, the U.S. Office of Management and Budget, and to the Appropriations Subcommittee for Agriculture in the U.S. House of Representatives and the U.S. Senate (Sullivan, 1969, p.3.).

ASCURFO serves as a vehicle for members to exchange information,

form policies, and cooperate in developing and conducting forest and rangeland research in the United States (ASCUFRO, 1976, p.3). Each year ASCUFRO compiles and reports the past year's accomplishments under the Cooperative Forestry Research Program. Their findings are compiled and comprise the majority of the report prepared by CRS and printed at the U.S. Government Printing Office.

Administrative-Technical Representitive

The administrative-technical representative (ATR) is the principle coordinator of the Cooperative Forestry Research Program at each of the participating institutions. The individual is designated by the Governor of the particular State in which the institution is located. The ATR is often the director of the state agricultural experiment station associated with the institution. If the participating institution does not have an associated agricultural experiment station, the ATR selected may be associated with the administration of the School of Forestry at the institution.

As the principle coordinator of the Cooperative Forestry Research Program within the participating institutions, it is the ATR's function to select projects to be funded and to direct the appropriate and correct amount of resources to particular projects. At Michigan State University project review is done by a panel of scientists using a peer review method of analysis. The establishment of peer review panels at all institutions participating in the McIntire-Stennis and Hatch programs has been requested by CR administrative personnel (Aldrich, 1977).

Specific guidelines have been developed and suggested for use by

ATRs in their evaluation of project proposals (Cooperative Forestry Advisory Board, 1963, p.2). The criterion suggested for project evaluation by the ATR are designed to ascertain:

1) the relative importance of the proposed project within the areas of research defined in the McIntire-Stennis Act

2) potential in terms of productive results

3) clarity of stated objectives

4) technical adequacy of research procedures

5) whether adequate facilities and a competent investigator are available to supervise the proposed research

6) whether adequate coordination with other forestry research in the area is being achieved (Cooperative Forestry Research Advisory Committee, 1963).

Once approval is made by the ATR, or associated peer panel, final review by CR personnel is designed to assure national coordination and insure that broad policy guidelines are being met.

Cooperative Forestry Research Advisory Committee

The establishment of an advisory committee for the McIntire-Stennis Cooperative Forestry Research Program is authorized and directed in the McIntire-Stennis Act. The Cooperative Forestry Research Advisory Committee is established to provide council and advice to the administrators of the program to help..."prescribe rules and regulations as may be necessary to carry out the provisions of the Act" (U.S. Congress, P.L. 87-788, 1964).

The advisory committee is constituted to give equal representation to Federal-State agencies concerned with developing and utilizing the Nation's forest resources and to forest products industries. Half of

the 14-man committee are representatives of the country's forest industries and half are representatives of Federal and State agencies concerned with developing and utilizing the Nations forest resources. The Chairman of the Committee is the Assistant Secretary of Agriculture for Conservation, Research and Education, and the Assistant Chairman of the Committee is the Administrator of the Cooperative State Research Service.

By representing industry and Federal-State agencies other than CR and by being chaired by the Assistant Secretary of Agriculture, the Committee serves the cooperative nature of the program in its policy forming function. Forestry schools participating in the program are not represented on the Committee. The participating forestry schools, however, provide a different type of advisory group called the Cooperative Forestry Research Advisory Board.

Cooperative Forestry Research Advisory Board

The establishment of a Cooperative Forestry Research Board is mandated in the McIntire-Stennis Act. Although the Advisory Board councils and advises the formulation of policy and regulations, as does the Advisory Committee, the Advisory Board's major function is to determine the apportionment of Federal funds among the participating institutions.

The Act mandates that the Board will consist of no less than seven officials chosen by majority vote from representatives of the participating forestry schools. The Act also mandates that the Board consider, in their apportionment function, pertinent factors including, but not limited to, areas of non-Federal commercial forest land and volume of

timber cut annually from growing stock within individual participating States.

The apparent success of formula funding under the existing Hatch Act program and the mandate to consider particular factors in apportionment suggested the use of a formula funding apportionment procedure for the McIntire-Stennis Program. The Cooperative Forestry Research Advisory Board developed and adopted such a formula at their first official meeting in 1963 (Cooperative Forestry Research Advisory Board, 1963). The formula ranks participating institutions on the basis of three criterion: 1) area of commercial forest land in the state (40%); 2) volume of timber removals from state; and 3) non-Federal forestry research expenditures. A more complete description of the formula funding process is presented in the "Program Operation" section of this chapter.

With the specification of such an apportionment mechanism the function of the Advisory Board was essentially eliminated. The Advisory Board continues to meet annually, however, in conjunction with the Advisory Committee. At the onset of the annual meeting, the Advisory Board and the Advisory Committee meet jointly in order that the Advisory Board has the opportunity to make recommendations to the Advisory Committee. The concerns of the program participants and research performers are therefore brought before the Advisory Committee through the membership of the Advisory Board before policy is made.

Principal Investigators

The principal investigator is the individual responsible for the administration and performance of research at the project level. The

principal investigator is generally the individual who generates the research project. He may or may not have other research scientists or graduate students working with him on a project. Numbers of personnel and time spent on the research project depend upon the nature and importance of the research.

It is the responsibility of the research project's principle investigator to prepare the initial research project proposal and the subsequent annual progress reports. This administrative procedure is accomplished through the use of the Cooperative Research Information System forms (CRIS). CRIS forms used include AD 416, Research Resume; AD 417, Classification of Research; AD 419, Funds and Manpower; and AD 421, Progress Report. These forms are provided in the Appendix of this report.

Forms AD 416 and 417, Research Resume and Classification of Research, serve for approval of proposed research projects and for the extension or revision of projects existing. These two forms are the official record of approval of the project and they remain as the master record of each project until the project is revised, discontinued, or terminated.

Form AD 419, Funds and Manpower, supplies the information necessary for the accounting of all funds and personnel associated with McIntire-Stennis research projects active during a calendar year. Form AD 419 is due September 15 of each year a project is active.

Form AD 421, Progress Report, has a dual purpose. Not only does it provide a means through which progress and accomplishments are reported, it also serves as a termination report form when the project is closed. Progress reports on active projects are due each January 15. Project termination reports are submitted at the time of termination.

Program Operation

In chapter II, the allocation of resources among competitive alternatives is shown to be the most viable administrative operating procedure in managing research programs. Allocation of resources is most beneficial when it is integrated with the management operation of priority establishment, project selection, and productivity analysis.

A critical evaluation of how the Federal proportion of financial resources are allocated in the McIntire-Stennis Cooperative Forestry Research Program is presented in the following section. The evaluation includes a discussion of the current formula procedure for apportionment of funds and how this procedure differs from models described in related literature. Also included in this section is a critical evaluation of the process of priority establishment, project selection, and productivity analysis as they exist in the Cooperative Forestry Research Program.

Formula Funding

The process for apportioning Federal funds among Cooperative Forestry Research Programs participating institutions involves the use of a pre-determined formula developed in 1963 by the Cooperative Forestry Research Advisory Board (Cooperative Forestry Research Advisory Board, 1963). The formula process allocates funds to states and territories containing forestry schools and universities participating in the research program. In those cases where there is more than one participating institution in the state, it is the responsibility of the State's governor to allocate the funds among these institutions.

The formula funding process in the Cooperative Forestry Research Program has two main steps: the ranking of the states, or participating U.S. territories, involved in the program; and the determination of what amount of the Federal appropriation goes to each state.

State rank is determined through the summation of the following weighted factors: 1) area of commercial forest land (40%); 2) volume of timber removals from growing stock (40%); 3) non-Federal research expenditures (20%). These weighted criterion are summed and the state with the smallest sum is given the rank of 1. The state with the greatest sum is given the highest rank.

Once rank is determined for the participating institutions it is inserted into the following formula:

$$\text{State-Territory Appropriation} = \text{base amount} + [\text{Total Federal Appropriation} - (\text{base amount})(\#\ \text{participating institutions})] \times \frac{\text{rank}}{\text{sum of ranks}}$$

A total Federal appropriation of $8.2 million, a base fund of $12,500 per participating state, and 51 participating states-territories, such as existed in 1977, would yield a Federal allocation of $282,022.96 for the state with rank of 51. The determination is made as follows:

$$\text{State-Territory Appropriation} = \$12{,}500 + [\$8.2\ \text{million} - (\$12{,}500)(51)] \times \frac{51}{1431} = \$282{,}022.96$$

If the rank of the state had been 1 instead of 62 the total Federal allocation would have been $17,784.68.

The formula funding procedure, adopted by the Cooperative Forestry Research Program in 1963, reflects the environment and needs of forestry research in 1963. The only change came in 1974 when the first item was changed from non-Federal commercial forest land to total commercial

forest land. Orginally the intent was to funnel dollars to areas of commercial forest value where other Federal research, such as that conducted by the Forest Service, was not already being performed. The criteria selected were chosen to funnel Federal forestry research dollars to states where there was relatively greater amounts of commercial forest land, larger annual cuts from this land, and private sector involvement in the forestry research process (Westveld, 1963).

The formula adopted is essentially static. There is no consideration of the dynamics of forestry and the forestry research process. Since the good of forestry research is derived from relative gains made in the resources produced on forest land, it is necessary that the allocation of finances in the research process take note of the changing importance of forest resources. Good research management in part involves allocating available funds to areas which have the highest expected value of output. Pre-defined criteria, developed in 1963, can not be expected to provide the analysis necessary to funnel McIntire-Stennis Cooperative Forestry Research dollars to the most pertinent research problems, nor to those places where the highest quality of research output can be expected.

Recent governmental publications have suggested the development of competitive grant procedures in the allocation of agriculture and forestry research dollars (National Research Council - National Academy of Sciences, 1972; National Academy of Sciences, 1975). In competitive grant procedures research dollars are made available for particular high priority problem areas. Research proposals address these specified problem areas and available funds are apportioned to those research projects deemed most suitable. Suitability is determined through

critical examination of the project proposal.

There are arguments against over-emphasis on competitive grants. These arguments are based on the premise that sound programs of research can not be developed and maintained on a tenuous budget. Additionally, under certain operations, basic research projects may have less chance in securing competitive grant funds if they do not apply to specified priority problem areas.

The controversy over competitive grants verses formula funding was summarized this way by the Committee on Science and Technology, U.S. House of Representatives (1976, p.72):

> "Research programs cannot be turned on and off at will like water from a spigot. It takes time to build facilities and establish productive teams of scientists...on the other hand, continuing unquestioned support can lead to complacency and lack of productiveness."

In order to maintain stability in research programs, it is not recommended that appropriations come exclusively from competitive grants. How much base level appropriation is needed to provide a stable program of research is a difficult decision, but should by based upon the particular research capabilities of the various participating institutions. The allocation of funds to various institutions needs to be more aligned with the pertinence of proposed research and past performance than with the criterion currently in use.

Research Priorities

The priorities for research in the McIntire-Stennis Cooperative Forestry Research Program are derived from the goals for forestry research developed in national plans and programs for forestry research. There have been a number of cooperative national forestry research plans in

the recent past. The Forest Service developed a program in 1964. In 1967 a joint task force of USDA and the National Association of State Universities and Land Grant Colleges (NASULGC) prepared a national plan for forestry. As mentioned earlier in this report, USDA and ASCUFRO are currently preparing a national research plan for forests and associated rangelands based on the requirements specified in the 1974 Forest and Rangeland Renewable Resources Planning Act (RPA).

The current effort places planning activities within the framework of the Regional and National Agricultural Research Planning System. Planning is headed by a national committee that coordinates the activities of four planning regions: Northeastern, North Central, Southern, and Western (USDA and NASULGC, 1977). The system will operate continuously with a five year planning cycle integrated each year.

During the summer of 1977, Regional Working Conferences within each of the four regions met, proposed and rated forest and associated rangeland research problem areas. Representatives at these working conferences formed a broad cross-section of public and private interests. The purpose was to receive suggestions from all interests associated with the use of forest and rangeland resources. Department of Agriculture and university administrators will utilize the results of the regional working conferences to develop a national plan of forestry research. The plan will reflect both regional and national issues and priorities of forestry research conduct and content.

Although these national planning efforts for forestry research provide a broad framework for national research priorities, specific priorities for the development of project proposals where research is actually performed are not available. Principle research investigators are given

a large degree of freedom in determining areas most deserving of their efforts.

In Chapter II it is pointed out that researchers need help in defining those problem areas most deserving of their efforts. The research problem areas and goals established by national plans are simply too vague and broad for most researchers to relate to on their own accord. Given the freedom to do so they will pursue those topics of most interest to them.

Research priorities are essentially a ranked list of criterion considered pertinent to current needs in research. Priorities in research vary in time and among differing geographic areas. Simple reliance on goals provided in national plans is not sufficient. For research planning to be effective it is necessary that it is implemented in research project development. This is accomplished through the establishment of research priorities for use by research workers in the development of research project proposals.

Research priorities serve essentially two functions: they define areas within which individual research projects and studies are selected; and, they indicate which studies and projects should be performed first. The current informal process of establishing research priorities in the Cooperative Forestry Research Program fulfills neither of these functions. It is the responsibility of research administrators to develop a list of ranked criteria for use by researchers in the development of project proposals. The same criteria are then used to evaluate proposed research projects.

Project Selection

Project selection is essentially a continuation of priority establishment. The difference is that priorities establish rank needs in research and project selection chooses those projects best suited to fulfill those needs. There is great flexibility in the process of selecting research projects at the various institutions participating in the Cooperative Forestry Research Program.

An indication of the flexibility in where the Federal share of funds may be used is made in the following quotation (Wylie, 1974, p.56):

> Choice in the use to which funds may be part is a most important element of planning, and degrees of freedom within the university to choose research in which to engage vary with fund source, from great latitude with state appropriated money to rigid application to areas agreed upon in advance in Federal grants and in most industry-supported projects. In between, the McIntire-Stennis funds can be applied to any area important to the state or nation that falls within the definition of forestry as stated in the act. Overall, considerable freedom and flexibility is often slight over a short time span and during nongrowth periods in the universities.

Michigan State University utilizes a panel of scientists chaired by the director of the Agricultural Experiment Station in a peer review process. The peer review process, essentially as reported in Chapter III has gained favorable attention among CRS administrators.

In a recent letter to the Directors of State Agricultural Experiment Stations and ATR's of the McIntire-Stennis Cooperative Forestry Research Program, CR administrator, R. J. Aldrich, formally requests that each institution develop a peer review system of project selection (Aldrich, 1977). Guidelines for the peer review process are given in the letter. These guidelines include:

1) Insure completion of project outline.

2) Evaluate relevance of proposed research.

3) Evaluate quality and scientific value of the proposed research.

4) Consider opportunities for cooperation with other individuals or units.

5) Provide opportunity for the project leader to interact with reviewers and make appropriate adjustments.

6) Provide CSRS (sic) with an indicator, project by project, that the process was followed.

This request for the development of peer review panels is designed to insure similiarity in the development of formal procedures of project selection at each institution.

The use of peer review systems of analysis and evaluation is well defended (Bowers, 1972). Peer review, however, need not be considered the best alternative in all situations. Souder (1973) tested the value and managerial acceptability of three expected value project selection models. He concluded that high model value does not necessarily indicate high managerial acceptability. A project selection model must not only have a high value in use, it must also be understood and accepted by research program managers.

Peer review systems may be modified to be made more responsive to particular situations. Use of scoring model designs and checklists have been used in conjunction with peer review systems with considerable success (Shumway, 1973). The development and effectiveness of a particular type of peer review system, or any project selection system, is highly dependent upon the environment in which it will be used.

Each participating institution in the Cooperative Forestry Research Program has been granted the authority to develop their own particular peer review process of project selection (Aldrich, 1977). There was no formal recognition of the myriad of formal techniques of project selection

available for use. Many of these techniques are summarized in Chapter II.

Benefit Measurement

Productivity indicies are prepared annually by CR administrators. Preparation of these indicies involves the determination of the number of graduate students and publications per scientist associated with the Cooperative Forestry Research Program. The indicies are tabulated and made available to interested parties at the annual ASCUFRO meetings, the annual Cooperative Forestry Research Advisory Board and Committee meeting, and to others upon request from CRS headquarters in Washington, D.C. The indicies have nothing to do with appropriation procedures but serve a well used means of comparison of success between the participating institutions.

Cooperative Research administrators also perform "special research reviews" of research programs at participating institutions. Cooperative Research policy requires a research review of cooperative forestry research universities at least every four years. The routine approach includes a review, project by project, followed by a written report and recommendations.

The special reviews are performed by teams of qualified individuals from other university research programs, private industry and the U.S. Forest Service (Wylie, 1974). The participation of a cross-section of interested parties helps provide for cooperation and coordination in forest research between the existing research performers.

Increased emphasis on accountability is one of the most significant developments in public finance in the 1970's (Eddleman, 1978). Executive and legislative budgeting systems are requiring specific documentation

of research program impacts for funds to be made available.

The increased accountability requirements imply less freedom for public research managers in planning and conducting programs. Fundamentally, if accounting requirements are not met, financial support for research programs will not be available.

The present accounting system used in the Cooperative Forestry Research Program says little of the impact resulting from research output. Productivity indicies based upon quantities of publications, number of graduate students, and number of research scientist years (counting procedures) are not sufficient to satisfy Federal accounting requirements such as those requested by the Office of Management and Budget in annual budget requests.

Counting procedures are often used in measuring research and research program productivity. Proponents of this counting procedure are large in number, but their reasoning most closely aligns the ease of computation (Shockley, 1957; and Hodge, 1963). The counting approach is more a measure of an institution's emphasis on publications than it is a measure of research effectiveness (Sandretto, 1968). The number of research publications should not be considered as important as the content of research publications.

Research productivity is most accurately gauged by the relative attainment of preconceived goals and objectives (Collier and Gee, 1973; Bowman, 1977). Research program goals and objectives are best developed in the program planning process and subsequently become very useful in productivity analysis.

Along with better measures of research productivity, it is also important to determine what research productivity and output means in

terms of social benefits. Thurou (1978) states:

> While real dollar support for civilian R & D has more than tripled since W. W. II, our real standard of living measured, for example, as gross national product per capita or as output per man hour, is rising no faster than when we were making a much smaller R & D effort.

There has been no linear, iron-clad relationship developed between improvements in the quality of life, or other social welfare indicators, and sizable increases in funding for R & D. It is clear that we need to seriously consider how to relate R & D to the outputs we expect for our investment. The same holds true for investments in the McIntire-Stennis Cooperative Forestry Research Program.

There have been isolated attempts to show cost effectiveness in the Cooperative Forestry Research Program. The University of Florida, for example, reported a benefit/cost ratio of 65 to 1 on a research project associated with fertilization of slash pine. Direct costs of the research was computed to be approximately $3.5 million. To compute benefits, the total physical yield gained in the application of fertilizers to slash pine subsequent to the research were valued and compared to research and application costs.

This type of economic analysis is dangerous in that it does not consider other factors contributing to increases in physical yield. It is important, however, to attempt to develop relationships between the inputs and outputs of McIntire-Stennis research. Economic information, such as that supplied by the University of Florida, is at least a step in this direction.

SUMMARY AND CONCLUSIONS

The results of the McIntire-Stennis Cooperative Forestry Research Program have been substantial. In providing the legislation necessary to funnel Federal dollars to certified forestry school institutions, the program has prompted an increase in the level of forestry research and contributes financial support necessary for growth and development of participating institutions. Since passage of the Act, more than a thousand graduate students have graduated while working on an associated project, and more than five thousand research documents have been published (Gray, 1977).

In the late 1950's and the early 1960's, educational institutions were seen as excellent means through which forestry research could be fostered. According to early Cooperative Forestry Research Program proponents, Federal support for forestry research at these institutions could accomplish at least three things simultaneously: 1) open a new avenue to strengthen and stimulate forestry research at state universities and land grant colleges; 2) bring the skills of additional university scientists to bear on pressing forestry problems; 3) stimulate the training of graduate forestry researchers needed by private and public research institutions and agencies (Westveld, 1962).

The program has served well the originally specified goals of producing forestry research output and the training of graduate forestry researchers. The environment in which the McIntire-Stennis Cooperative

Forestry Research Program operates today, however, is different than the environment in which the legislation was originally developed. Changes have occured not only in the needs of forestry research and research workers, but also in the ways of organizing and managing research programs.

Recent legislation pertaining to the renewable natural resources have established new dimensions and added both new requirements and a new urgency to the management and development of the forest rangelands in the United States (RNRF, 1977). With the management of renewable resources becoming increasingly sophisticated, mounting information needs have placed a serious strain on the present system of renewable resource research in the United States. Reliance upon past performance and process will not adequately provide for the increased demands for researched scientific facts and technology. The time has come for upgrading the performance of the whole research establishment.

The underlying purpose of upgrading programs of research is to effectively generate more research output for resources invested. Upgrading may be facilitated either through reorganization or policy changes. Recently the President's Reorganization Project in the Office of Management and Budget concluded that..."many - perhaps most - of our current major natural resource challenges require policy changes, not reorganization" (Tombaugh, 1979).

Reorganization is costly and time consuming. Followers of recent attempts to reorganize the Society of American Foresters and to create a new Department of Natural Resources in the Federal Government will certainly bear witness to the costs of reorganization. Drastic changes are not needed to bring the McIntire-Stennis Cooperative Forestry

Research Program in line with the increasing demands being placed on it. This study has attempted to show that policy changes could markedly enhance the economy of the program, without reorganization.

In this study, the problem of economizing on the Federal share of the McIntire-Stennis funds is addressed from the administrative level, the Cooperative Research Service. Chapter I reviews the content of forest and rangeland research in the United States. It states that renewable resource needs in research are provided through the efforts of three main agents: the U.S. Forest Service; universities and forestry schools participating in the McIntire-Stennis Cooperative Forestry Research Program; and private industry. Current policies in each of these agents reflect developmental interdependencies and their particular goals and orientation towards research.

Private industry performs research basically to gain and support competitive advantage in their pursuit of traditional business objectives. The United States Forest Service program of research is shown to be one designed to insure the fulfillment of timber needs for today and for the future. Goals underlying research in the McIntire-Stennis Cooperative Forestry Research program are:

1) to encourage and assist land-grant and other state supported forestry schools to conduct research necessary to improve the protection, production, and utilization of forests and related rangelands.

2) to stimulate expansion in the training of scientists in forestry and forestry related specialities needed by the Forest Service and forest industry research programs (Gray, 1977).

Recommended policy changes bear in mind the goals underlying research in these sectors and do not intend to change the orientation of research in the Cooperative Forestry Research Program. The objective is to

stimulate change necessary to help the program be more effective in what it does.

The problem addressed in this study is not with the research that has or is being done, but with how it is organized and focused to address pertinent issues in renewable resources. This is a problem in research management.

Chapter II, "Research Program Management", discusses the research management techniques most essential in the administration of the Cooperative Forestry Research Program; priority establishment, project selection, and productivity analysis. The techniques presented are derived from research management literature of both the public and private sector. Chapter II provides a foundation from which the operating techniques of the Cooperative Forestry Research Program are compared.

A critical analysis of the program is provided in Chapter III, "The McIntire-Stennis Cooperative Forestry Research Program". Current methods of priority establishment, project selection, productivity analysis, and resource allocation are discussed in terms of the techniques reported in Chapter II.

Economic research program management involves allocating available funds to areas which have the highest expected value of output. Current McIntire-Stennis procedures to allocate the Federal share of funds involve the use of a pre-conceived formula that does not consider returns to investment. A process for allocating resources among the participants of the McIntire-Stennis program that integrates priority establishment, project selection, and productivity measurement is identified in Chapter III.

Research priorities serve essentially two functions: they define

areas within which individual research projects and studies are selected; and, they indicate which studies should be performed first. Project selection is essentially a continuation of priority establishment. The difference is that priorities establish ranked needs in research, and project selection chooses those projects best suited to fulfill those needs.

Project selection methodologies reported in Chapter II involve the use of well defined priority criteria. Priorities in the Cooperative Forestry Research Program are those specified in national plans for forestry research and are difficult to relate to for project selection and research project development.

Productivity analysis is currently accomplished through the use of a counting procedure. The counting procedure involves the determination of how many graduate students and publications result per research scientist associated with Cooperative Forestry Research projects. Research productivity, however, is most accurately guaged by the relative attainment of pre-conceived goals and objectives (Collier and Gee, 1973; Bowman, 1977).

Recommendations

Cooperative Research currently has the power to control the flow of Federal dollars to the McIntire-Stennis Cooperative Forestry Research Program. This power is being exercised through the use of a formula procedure that is unrelated to the operation of the program. The principal recommendation of this study follows:

(1) Cooperative Research, in conjunction with the Cooperative

Forestry Research Advisory Board, needs to develop and implement an alternative method of distributing the Federal portion of program funds.

The development of such a system, as illustrated in Chapter II, will involve the integration of other research management procedures such as program planning, project selection, and productivity analysis. The allocation system should provide the mechanism for support of goals while maintaining an incentive for good productivity. The adoption of a method of resource allocation that considers the expected output of research and its value will lead to greater returns for resources invested.

Legislative mandate (P.L. 87-788) has specified that the mechanism for resource distribution be chosen by the Cooperative Forestry Research Advisory Board. For this reason, it is necessary that recommendation (1) be proposed to the Advisory Board. Since the Advisory Board is made up of Association of State College and University Forestry Research Organization members, the needs and desires of the research "work-place" will be represented.

Cooperative Research participation, at least in an advisory capacity, is an important component of this development process. Increased emphasis on accountability is one of the most significant developments of the 1970's. Executive and legislative budgeting systems are requiring specific documentation of research program impacts for funds to be made available. Cooperative Research administration should be able to provide the types of input necessary to make the proposed allocation system responsibe to executive and legislative mandates. Without this critical component, sustained Federal support is doubtful.

The proposed allocation system integrates program planning, project selection, and productivity analysis. In order for this to be possible,

it is also suggested that policy changes occur in these areas. It is recommended that:

(2) Specific goals and objectives need to be developed for use in project planning.

National plans for forestry research have periodically been developed by the United States Department of Agriculture. These national plans provide broad goals for forestry research but fail to facilitate the use of these goals as objectives and planning criterion at levels where research is actively done. The current joint planning effort of the United States Department of Agriculture and ASCUFRO is destined to exhibit the same deficiency as these past plans.

The McIntire-Stennis Cooperative Forestry Research Program uses the research project as its basic planning unit. The mechanism through which this is accomplished is the research project proposal. National plans do not provide a useful function in the McIntire-Stennis program unless the goals and needs defined within them can be understood and identified with by the developers of research project proposals.

Research project proposals are generated at participating institutions by research scientists. Although national goals and objectives for forest and related research are revealed in national plans, the use of the project proposal as the basic planning mechanism for McIntire-Stennis Cooperative Forestry Research has created a planning process that works from the "bottom-up". There is no formal process for linking national forestry research goals and objectives to local research project proposals.

The development of specific goals and objectives for project planning could be accomplished through the use of techniques similar to those reported by Shumway, et. al., in 1975, which are reviewed in Chapter II

and in Appendix III. The techniques involve a hierarchical environment such as that found in the Cooperative Forestry Research Program. The technique enables broad goals to be filtered down to subordinate levels where they become increasingly specific and operational.

Once goals and objectives are developed, it is necessary that the projects best suited to accommodate them are selected for funding. The project selection techniques reviewed in Chapter II and Appendix III generally require a specification of prioritized criteria for decision making. To better deal with the project selection problem, while not relinquishing the function from the participating institutions, the following recommendation is made:

(3) Prioritized criteria for use in project selection need to be developed periodically be program administration.

Many techniques have been reported in the literature pertaining to the establishment of priorities and the selection of criteria for decision-making. A sample list of potential criteria was presented earlier (page 42). The over-riding issue is the fact that what is relevant is ever changing. In all cases, priority setting and criteria selection is a subjective decision. Subjective techniques are presented in Chapter II. Some, such as the Delphi method, appear to have more better potential than others. However, it appears that how the decision of priority and criteria establishment is made, is less important than insuring that the process occurs. Prioritized criteria must be available for utilization of systematic project selection techniques such as those reviewed in Chapter II.

The final step in the research management chain-of-events is evaluation of research results. The evaluation procedures currently used in

the Cooperative Forestry Research Program (see pages 7-10) is neither an appropriate nor an accurate means of evaluating research output. It is therefore recommended that:

(4) Productivity indices need to be developed that evaluate the value of research output, and its distribution, in terms of its cost.

Following Collier and Gee (1973), it is suggested that forestry research be evaluated in terms of the relative attainment of specified research program goals and objectives. From a program management standpoint, the success and value of research must be determined by the relative attainment of specified goals and objectives.

Effective research management requires the interaction of planning, project selection, productivity analysis, and control. Recommendations for change in any one of these areas implies an examination and possible modification of all others. The four recommendations developed as a result of this study recognize these interrelationships. Their adoption will require major changes in McIntire-Stennis Cooperative Forestry Research Program administration, but should result in a more efficient and effective program.

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APPENDIX I

THE MCINTIRE-STENNIS ACT

Calendar No. 1974

87TH CONGRESS
2D SESSION

H. R. 12688

[Report No. 2013]

IN THE SENATE OF THE UNITED STATES

AUGUST 7, 1962

Read twice and referred to the Committee on Agriculture and Forestry

SEPTEMBER 7, 1962

Reported by Mr. EASTLAND, with amendments

[Omit the part struck through and insert the part printed in italic]

AN ACT

To authorize the Secretary of Agriculture to encourage and assist the several States in carrying on a program of forestry research, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it is hereby recognized that research in forestry is the driving force behind progress in developing and utilizing the resources of the Nation's forest and related rangelands. The production, protection, and utilization of the forest resources depend on strong technological advances and continuing development of the knowledge necessary to increase the efficiency of forestry practices and to extend the benefits that flow from forest and related rangelands. It is recognized

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that the total forestry research efforts of the several ~~State~~ colleges and universities and of the Federal Government are more fully effective if there is close coordination between such programs, and it is further recognized that forestry schools are especially vital in the training of research workers in forestry.

SEC. 2. In order to promote research in forestry, the Secretary of Agriculture is hereby authorized to cooperate with *colleges and universities in* the several States for the purpose of encouraging and assisting them in carrying out programs of forestry research.

Such assistance shall be in accordance with plans to be agreed upon in advance by the Secretary and (a) land-grant colleges or agricultural experiment stations established under the Morrill Act of July 2, 1862 (12 Stat. 503), as amended, and the Hatch Act of March 2, 1887 (24 Stat. 440), as amended, and (b) other ~~State-supported~~ colleges and universities offering graduate training in the sciences basic to forestry and having a forestry school; however, an appropriate State representative designated by the State's Governor shall, in any agreement drawn up with the Secretary of Agriculture for the purposes of this Act, certify those eligible institutions ~~of~~ *in* the State which will qualify for assistance and shall determine the proportionate amounts of assistance to be extended these certified institutions.

SEC. 3. To enable the Secretary to carry out the provisions of this Act there are hereby authorized to be appropriated such sums as the Congress may from time to time determine to be necessary but not exceeding in any one fiscal year one-half the amount appropriated for Federal forestry research conducted directly by the Department of Agriculture for the fiscal year preceding the year in which the budget is presented for such appropriation. Funds appropriated and made available ~~to the States~~ under this Act shall be in addition to allotments or grants that may be made under other authorizations.

SEC. 4. The amount paid by the Federal Government to any State-certified institutions eligible for assistance under this Act shall not exceed during any fiscal year the amount available to and budgeted for expenditure by such college or university during the same fiscal year for forestry research from non-Federal sources. The Secretary is authorized to make such expenditures on the certificate of the appropriate official of the college or university having charge of the forestry research for which the expenditures as herein provided are to be made. If any or all of the colleges or universities certified for receipt of funds under this Act fails to make available and budget for expenditure for forestry research in any fiscal year sums at least as much as the amount for which it would be eligible for such year under this Act, the

difference between the Federal funds available and the funds made available and budgeted for expenditure by the college or university shall be reapportioned by the Secretary to other eligible colleges or universities of the same State if there be any which qualify therefor and, if there be none, the Secretary shall reapportion such differences to the qualifying colleges and universities of other States participating in the forestry research program.

SEC. 5. Apportionments among participating States and administrative expenses in connection with the program shall be determined by the Secretary after consultation with a national advisory board of not less than seven officials of the ~~forestry schools of the~~ State-certified eligible colleges and universities chosen by a majority of such ~~schools~~ *colleges and universities*. In making such apportionments consideration shall be given to pertinent factors including, but not limited to, areas of non-Federal commercial forest land and volume of timber cut annually from growing stock.

SEC. 6. The Secretary is authorized and directed to prescribe such rules and regulations as may be necessary to carry out the provisions of this Act and to furnish such advice and assistance through a cooperative State forestry research unit in the Department of Agriculture as will best promote the purposes of this Act. The Secretary is further authorized and directed to appoint an advisory committee

which shall be constituted to give equal representation to Federal-State agencies concerned with developing and utilizing the Nation's forest resources and to the forest industries. The Secretary and the national advisory board shall seek at least once each year the counsel and advice of the advisory committee to accomplish effectively the purposes of this Act.

SEC. 7. The term "forestry research" as used in this Act shall include investigations relating to: (1) Reforestation and management of land for the production of crops of timber and other related products of the forest; (2) management of forest and related watershed lands to improve conditions of waterflow and to protect resources against floods and erosion; (3) management of forest and related rangeland for production of forage for domestic livestock and game and improvement of food and habitat for wildlife; (4) management of forest lands for outdoor recreation; (5) protection of forest land and resources against fire, insects, diseases, or other destructive agents; (6) utilization of wood and other forest products; (7) development of sound policies for the management of forest lands and the harvesting and marketing of forest products; and (8) such other studies as may be necessary to obtain the fullest and most effective use of forest resources.

SEC. 8. The term "State" as used in this Act shall include Puerto Rico.

APPENDIX II

CRIS FORMS AND RELEVENT INFORMATION

INTRODUCTION[1]

These instructions supersede the revision of October 1969. They are for the specific use of the State Agricultural Experiment Stations, Schools of Forestry and Land-Grant Colleges of 1890 and Tuskegee Institute. The Current Research Information System (CRIS) input form consists of four pages or parts characterized as:

	CRIS FORM NUMBER
Research Resume	AD 416
Classification of Research	AD 417
Funds and Manpower	AD 419
Progress Report	AD 421

The Research Resume (AD 416) and Classification of Research (AD 417) are filled out and submitted at the time a project (Work Unit) is initiated or revised. These forms serve as the official record of approval of the project and remain as the master record on each project unless the project is revised, discontinued or terminated.

Funds and Manpower (AD 419) is submitted annually, September 15.

Progress Report (AD 421) is submitted annually, January 15. It also serves as a Termination Report when a project is closed.

Because of the complexity of the forms and the many fields, it is essential that these instructions be followed exactly. Each field or data item on the form is identified by a number. All funds should be assigned to specific research projects. The usage of Administrative projects should be held to a minimum and limited to administrative activities. Any expenditures on projects designed for providing Centralized services should be prorated to appropriate research projects. Manpower (SMY) should not be reported on the CRIS Form AD 419 for Administrative projects.

SPECIAL NOTE TO DIRECTORS OR ATR(s) - When submitting new projects or project revisions for Hatch or McIntire-Stennis, please indicate in your transmittal letter the amount of funds being assigned to the project and the source of the funds: (1) from Director's reserve or (2) by transfer from other projects.

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[1] The suggestions for improving the functionality of this Manual that were made by Director B. E. Day and Paul Casamajor, Assistant to the Director, of the California Agricultural Experiment Station are acknowledged and appreciated.

U. S. DEPARTMENT OF AGRICULTURE

RESEARCH WORK UNIT/PROJECT DESCRIPTION - RESEARCH RESUME

U. S. DEPT. OF AGRICULTURE, STATE AGRICULTURAL EXPERIMENT STATIONS AND OTHER INSTITUTIONS

DATE (Day, Month, Year): Date of preparation of Form

1 ACCESSION NO.	AGENCY IDENTIFICATION NO. 2	3	4	5 WORK UNIT/PROJECT NO.	6 STATUS (x appropriate box)
Assigned	by CRIS			As assigned by State Agency reporting	NEW ☐A EXTENDED ☐B REVISED ☐C DISCONTINUED ☐D TERMINATED ☐E PENDING ☐F

7 TITLE

Maximum 100 characters and 80 if possible (includes letters, symbols and spaces). Don't use "research on", "investigation of", etc.

8 PERFORMING ORGANIZATION	CITY	STATE/COUNTRY	ZIP CODE	CONG. DISTRICT
Department-(Agronomy, Animal Science, Agricultural Economics, etc.)				Blank

13 RESPONSIBLE ORGANIZATION	CITY	14 STATE	ZIP CODE
Hatch - SAES McIntire-Stennis - State Institution responsible Special Grants - CSRS			

12 INVESTIGATOR NAME(S) (Last name first)	SOC. SEC. NUMBER(S)	15 RESPONSIBLE INDIVIDUAL (Last name first)
Project leaders (not more than 3 names)	For each person listed	Head of organization listed in Field 13

16 RESEARCH LOCATION ON CAMPUS: YES ☐A NO ☐B

PROJECT TYPE

17 FOR USDA USE: Blank

CONTRACT ☐A GRANT ☐B COOP. AGMT. ☐C IN-HOUSE ☐D

18-1 FOR STATE USE: x appropriate box — McINTIRE-STENNIS HATCH ☐H M ☐M S ☐S STATE

CONTRACTS, GRANTS AND COOPERATIVE AGREEMENTS

18-2 GRANT AUTHORITY	18-3 DISP. OF EQUIP.	18-4 CONTR/GR/AGMT. NO.	19 FACE AMOUNT	20 FY	95 TOTAL SMY
Blank PL 89-106 ☐A PL 89-934 ☐B	Blank NONE PURCHASED ☐1 REVERTS TO GOV'T ☐2 RETAINED ☐3	Blank PL 480 FUNDS ☐A ☐K	BLANK		

21 FACILITIES: Check appropriate box as to work location
FEDERALLY OWNED ☐A FEDERALLY LEASED ☐B COMBINED ☐C STATE ☐D OTHER ☐E

22-23 REGIONAL PROJECT NO.: Leave blank unless contributing to regional project

24 OBJECTIVES 25 APPROACH (Use space needed for "24 OBJECTIVES", then indicate "25 APPROACH")

Total of 2400 characters available Fields 24, Objectives; 25, Approach; and 85, Progress Report (AD 421).

Try to keep Fields 24 and 25 within 800 spaces (about 10 typewritten 80-space lines) leaving balance for Field 85, Progress Reporting.

In Field 25, aim for succinct description of methods with emphasis on unique aspects, avoiding details of standard methods.

27 KEYWORDS

Ten or less preferred. Agricultural/Biological Vocabulary, Volumes 1 and 2, USDA 1967, is helpful reference.

RECOMMENDED			APPROVED — Check applicable one — CONCURRED		
SIGNATURE	TITLE	DATE	SIGNATURE	TITLE	DATE
Project Leader					
Department Head	Signing procedure in these two blocks should be according to internal requirements of the experiment station or other institution.				
Etc.					
Etc.					

SIGNATURE TITLE DATE

CONCURRED (RPDES) ☐ / APPROVED (CSRS) ☐ Leave Blank

28 AWARD DATE (Day, Mo., Yr.)	29 START DATE (Day, Mo., Yr.)	30 TERMINATION (Day, Mo., Yr.)	DURATION (Mos.)
Contracts or Grants	When research to begin	Completion, extension or revision date	

U. S. DEPARTMENT OF AGRICULTURE

RESEARCH WORK UNIT/PROJECT DESCRIPTION - CLASSIFICATION OF RESEARCH

U. S. DEPT. OF AGRICULTURE, STATE AGRICULTURAL EXPERIMENT STATIONS AND OTHER INSTITUTIONS

DATE (Day, Month, Year): Date of preparation

1 ACCESSION NO.	AGENCY IDENTIFICATION NO. 2 3 4	5 WORK UNIT/PROJECT NO.	31 HATCH MARKETING
Leave Blank	Leave Blank	Same as Field 5, AD 416	Leave Blank YES ☐ A NO ☐ B

32 BASIC RESEARCH	33 APPLIED RESEARCH	34 DEVELOPMENT EFFORT
Enter estimated percent in each. Sum of 32, 33 and 34 = 100%		

CLASSIFICATION BY ACTIVITY, COMMODITY, SCIENCE, PROBLEM AREA AND PPBS CODES

	ACTIVITY		COMMODITY		SCIENCE		PROBLEM AREA	PPBS	PRODUCT OF (2) X (4) X (6)
	(1) CODE	(2) %	(3) CODE	(4) %	(5) CODE	(6) %	(7) CODE	(8) CODE	(9) %
41									
42									
43									
44									
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Use Manual of Classification of Agricultural and Forestry Research. Revision II (January 1973) for proper coding.

For each project classify Activity (1), Commodity (3) and Field of Science (5).

Sum of Activity percentages MUST equal 100% Commodity percentages should aggregate to 100% for each Activity listed. Likewise, Field of Science percentages aggregate to 100% for each Commodity listed. Enter only code numbers that appear in the Manual.

Must total 100%

SPECIAL CLASSIFICATION

SPECIAL CATEGORY	%	SPECIAL COMMODITY	%	PESTICIDE CODE	%	WATER RESOURCES CODE	%
55 Pollution related		62		68 Target I		73	
56 Health and medical related		63		69 Target II		74	
57 Tobacco-health related		64		70 Target III		75	
58 Weather related		65		71 Target IV		76	
59 Nuclear radiation related		66		72 Target V			
60 Poverty area related		67					
61 Natural beauty related							

See definitions in CSRS-OD-1258.

Total not to exceed 100%

Classification will be done by CSRS staff.

79 COOPERATORS
Check one or more as appropriate
USDA ☐ A OTHER FEDERAL AGENCIES ☐ B INDUSTRY AND OTHER ☐ C STATE ☐ D

83 REPORTING DEPARTMENT WITHIN STATE PERFORMING INSTITUTION
Name of department listed in Field 8, AD 416.

COOPERATING DEPARTMENTS WITHIN STATE PERFORMING INSTITUTION (List)

80 Major active cooperators (3 maximum) at your institution not shown in Field 8
81 that make substantial formal contribution. Do not include other States on RRF projects.
82

FORM AD 417 (2/68)

AD 419

U. S. DEPARTMENT OF AGRICULTURE

RESEARCH WORK UNIT/PROJECT DESCRIPTION - RESEARCH FUNDS AND MANPOWER

FOR STATE AND OTHER NON FEDERAL INSTITUTION USE

DATE (Day, Mo., Yr.): Date of Submission

1 ACCESSION NO.	AGENCY IDENTIFICATION NO. (2 3 4)	5 WORK UNIT/PROJECT NO.	22-23 REGIONAL PROJECT NO.
Fields	1 through 7 will be preprinted by computer.	If not	see instructions

7 TITLE

for these Fields for Form AD 416.

ALLOCATION OF RESEARCH FUNDS TO WORK UNIT/PROJECT AT LOCATION	FIELD NUMBER	Net amount available to Project FY ACTUAL $	FY ESTIMATED $ 1/
FEDERAL RESEARCH FUNDS CSRS ADMINISTERED			
HATCH FUNDS	(201)	To	To
REGIONAL RESEARCH FUNDS	(202)	nearest $	nearest $
McINTIRE STENNIS FUNDS (TOTAL INCLUDING CARRYOVER)	(203)		
McINTIRE STENNIS FUNDS (NEW OBLIGATION AUTHORITY), *Washington office use only* (Leave Blank)	(206)		
SPECIAL GRANTS FOR RESEARCH (PL 89-106)	(204)	Past fiscal	Present
OTHER FUNDS (IDENTIFY)	(205)	year	fiscal year
TOTAL (Excluding 206)	(231)		
OTHER FEDERAL RESEARCH FUNDS			
USDA CONTRACTS GRANTS COOP AGMTS (IDENTIFY AGENCY)	(219)		
NATIONAL SCIENCE FOUNDATION	(209)		
ATOMIC ENERGY COMMISSION	(310)		
AGENCY FOR INTERNATIONAL DEVELOPMENT	(308)		
DEPARTMENT OF DEFENSE	(311)		
NATIONAL INSTITUTES OF HEALTH	(316)		
PUBLIC HEALTH SERVICE	(312)		
HEALTH EDUCATION AND WELFARE (OTHER)	(313)		
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	(314)		
TENNESSEE VALLEY AUTHORITY	(315)		
OTHER (IDENTIFY)	(318)		
TOTAL	(332)		
NON-FEDERAL RESEARCH FUNDS			
STATE APPROPRIATIONS	(220)		
SALE OF PRODUCTS	(221)		
INDUSTRY GRANTS AND AGMTS	(222)		
OTHER NON FEDERAL FUNDS	(223)		
TOTAL	(233)		
TOTAL ALL RESEARCH FUNDS AT LOCATION (Excluding 206)	(234)		

MANPOWER		MAN YEARS ACTUAL	MAN YEARS ESTIMATED
NON FEDERALLY EMPLOYED MANPOWER (REPORT NEAREST 0.1)			
SCIENTISTS (ASST. PROF. AND ABOVE)	(241)		
PROFESSIONAL SUPPORT	(242)		
TECHNICAL SUPPORT	(243)		
CLERICAL, LABOR AND OTHER	(244)		
TOTAL MANYEARS	(350)		

SUBMITTED BY (Signature) | TITLE

Director, A-TR or person authorized by Director or A-TR, or Research Coordinator

1/ Estimated column may be used if the institution wishes to report their estimated Federal-grant program on this form.

FORM AD 419 2/68

FORM AD 421 12-68 ..S. DEPARTMENT OF AGRICU...

RESEARCH WORK UNIT/PROJECT DESCRIPTION - PROGRESS REPORT

U.S. DEPT. OF AGRICULTURE, STATE AGRICULTURAL EXPERIMENT STATIONS AND OTHER INSTITUTIONS

DATE (Day, Mo., Yr.) Preparation Date

1. ACCESSION NO.	AGENCY IDENTIFICATION NO. 2 3 4	5 WORK UNIT/PROJECT NO.	22-23 REG'L PRO.. NO.	6 STATUS (Mark only if applicable) DISCONTINUED ☐ D TERMINATED ☐ E
Fields 1 through 12 (except 6) will usually be preprinted by				

7 TITLE

computer. If not, see instructions for same Fields on Guide for AD 416.

8 PERFORMING ORGANIZATION	12 INVESTIGATOR NAME(S) SOCIAL SECURITY NUMBER(S)
See above.	See above.
	84 PERIOD COVERED BY THIS REPORT (YR) (MO) (YR) (MO)
	Covers period since last report.

85 PROGRESS REPORT

Total of 1600 characters available providing Fields 24 and 25 (AD 416) do not exceed 800. If they exceed 800 the space available will be 2400 minus the number in both Fields 24 and 25.

Report significant accomplishments with brief expression as to why the results are significant scientifically or practically. Statements should be good enough to appear without change in a published abstract.

If too soon to report accomplishment, indicate status or stage of development of work.

McIntire-Stennis projects - indicate number of graduate students associated with project.

If termination enter the follow...g:

Actual Termination Date: _____
Month Day Year

87 PUBLICATIONS

88 TOTAL OTHER PUBLICATIONS THIS PERIOD (NUMBER) In excess of 5.

List up to 5 publications since last report. Include only those actually published. Do not include manuscripts. It is suggested that listings be in accordance with the University of Chicago Style Manual. For journal articles or publications of a series, the order is:

Author(s) in caps
Title
Name of Journal (or series with name of issuing agency)
Volume number, with date of issue in parentheses
Page Numbers

KEYWORD BANK (Add, delete, or change as required)

Keywords listed in Field 27, AD 416, will usually be preprinted by computer here. Add, delete or change as needed.

90 MAJOR ACHIEVEMENT ANTICIPATED IN MONTHS: (1-3) ☐ A (4-6) ☐ B (7-9) ☐ C (10-12) ☐ D (13-15) ☐ E (16-18) ☐ F OTHER ☐ G

From time of report. Check appropriate box to indicate expected newsworthy results

APPROVED: Signed by Station Dir., A-TR or person authorized by

SIGNATURE Dir. or A-TR TITLE

USAGE AND ROUTING OF CRIS FORMS

Form Number	Purpose	Where Submitted	When Submitted	Number of Copies
AD 416 and 417	Hatch - Approval of proposed research project. McIntire-Stennis - Approval of proposed research project. Special Grant - To provide CSRS with information on leader, objectives, plan of work, keywords, classifications and cooperators. State - Notification of an approved State funded project. Project Revisions - Applies to each of the above. Project Extensions - Applies to each of the above.	Administrator, CSRS	Anytime throughout year.	Original and 2 copies
AD 419	Annual Funds and Manpower Report for each project active during a fiscal year (State and Federal) at a State institution.	Deputy Assistant Administrator, PESR, CSRS.	September 15	Original and 2 copies
AD 421	A. Annual Progress Report for each project active during a calendar year.	Deputy Assistant Administrator, PESR, CSRS.	January 15	Original and 2 copies
	B. Final Report of Progress for discontinued or terminated projects.	Deputy Assistant Administrator, PESR, CSRS.	Whenever a project is terminated.	Original and 2 copies

APPENDIX III

RESEARCH PLANNING AND CONTROL

INTRODUCTION

The purpose served by this appendix is to provide background information for the design of an efficient resource allocation model for forestry research. The intention is to document the current state-of-the-arts in research planning and control. To this end, the review provides information concerning various methods and techniques available for economic valuation used in research management decisions. It documents situations where efficient allocation systems have been developed and successfully employed and identifies personnel and institutions involved in similar studies.

The report is divided into two major sections. First, an overview of research planning is provided. Particular attention is given to techniques available for establishing research priorities, selecting individual research projects and measuring research benefits. The second major section is the source of the overview material and the annotated bibliography.

The reviewed management techniques indicate that procedures normally used by government and universities for establishing research priorities and evaluating research performance are not as effective as those used in industry. This does not automatically imply that industrial procedures should be adopted by public agencies. Industrial research tends to be aimed at well defined goals and objectives against which research progress can be tightly measured. The goals of much publically funded research are not as clear as those in problem oriented industrial research. Consequently, selection of research priorities and evaluation of research programs in the public sector is more difficult than in more highly controlled industrial situations.

OVERVIEW

This section covers concepts of research planning. Emphasis is given to techniques available for establishing research priorities, selecting individual research projects and measuring research benefits.

Research Priorities

The development of research priorities defines areas within which individual research projects are selected. Subsequent decisions involve the selection of particular projects recognized as those of highest relative benefit within the framework of the established priorities.

There is not a great deal of literature dealing with the process through which research priorities are developed. Much has been written about what various priorities are, but there is a lack of literature concerned with formal procedures and systems designed to objectively determine these priorities.

In the industrial sector, priorities for research are problem oriented. Research utilizing operations research and management science techniques apply in making the production process more efficient. Often, specified percentages of the company's total sales are funneled back into a research and development department to be used specifically in the development of new and improved products. This research is justified by management's desire to remain competitive in the market place. Priorities are a ranking of goals. In government and universities, this goal framework is highly complex as it involves many complementary and/or competing considerations. The development of research priorities in the

public sector, therefore, lacks the objectivity found in the private sector.

Shumway, et. al., (1975) has identified the complex hierarchical structure associated with government agencies and the subsequent decision-making process involved within this structure. Broad areas of priority are generally identified at the top of the hierarchical structure through political decisions. These broad areas of priority then serve as a framework within which more specific priorities are developed at corresponding levels in the government structure. Priorities become increasingly specific but remain within the framework of priority established in the higher levels of authority at lower levels in the hierarchy. After priorities have been established individual projects are identified through the use of project selection and benefit measurement techniques.

Thirteen reports prepared for the Northeastern Regional Planning Committee in Upper Darby, Pennsylvania are listed in the annotated bibliography. These are examples of the types of reports found in the government sector dealing with the establishment of research priorities. In these studies, subcommittees comprised of scientists in particular research areas were established and charged with the responsibility of determining research priorities, in their respective fields, for the northeastern United States. The resulting research priorities are listed, but the selection procedures employed are not documented. Apparantly they were subjectively determined.

Kaldor (1966) discusses many conceptual considerations that must be involved with the establishment of research priorities. He fails, however, to elaborate specifically on how to involve these conceptual considerations into a decision-making framework. Hildreth (1966) made

another attempt at attacking the establishment of research priorities, but does not provide a procedure for systematic establishment of priorities.

The literature reviewed suggests that the establishment of research priorities in industry is more efficient than the selection of priority in government and universities. Efficiency elludes to the attainment of pre-conceived goals and objectives. Research goals and objectives are not clearly identified by government, public agencies and universities in the selection of research priorities. Industry, on the other hand, tends to direct its research to clearly defined goals and objectives. Its efficiency then can be guaged quite readily in the measurement of the attainment of these pre-conceived goals and objectives.

Historical data provide some indication of past priorities in research. Past expenditure patterns indicate historical priorities. Articles listed in the "Establishing Research Priorities" section of the annotated bibliography authored by the National Science Foundation and the USDA Forest Service provide this type of data.

Project Selection

Project selection techniques involve the selection of particular research projects from a set of proposed projects. Project selection involves an ex ante evaluation of research proposals. It provides an ordinal ranking of proposed research projects for funding.

In contrast, the benefit measurement, discussed in the next section of this appendix, deals with an ex post, cardinal measure of value. It comprises techniques to determine the rate of return to particular

research once initiated. However, some benefit measurement techniques, such as that reported by the U.S. Forest Service (1967), involve an ex ante determination of suspected value.

In project selection, a presumedly constrained budget is allocated to a portfolio of research projects chosen from a host of research proposals. The selection of a particular portfolio is done within the framework of pre-conceived research priorities. These priority areas are defined through a political or an historical decision-making process and are discussed in the "Priority Establishment" section of this report.

Shumway (1973) has written an excellent and comprehensive review of the project selection methodology associated with research. Before utilizing Shumway's article as an outline in our discussion, we will examine peer review, a method of project selection that Shumway does not explicitly cover.

Peer review involves the evaluation of research and research proposals by scientists associated with specific research areas being considered. Selected scientists are provided with copies of the research proposals and requested to give ex ante, subjective evaluations about the relative worth of the research and probability of success. The specific evaluations are given to the decision-maker who forms his decision on the basis of the evaluations. Often specific criteria are specified to the reviewers and are used as guidelines to the evaluations.

Peer review is a widely used technique of project selection, both in a formal and informal sense. In a formal sense peer review is used as the prime tool in research decisions. The National Science Foundation, for example, utilizes peer review as a major method of research proposal evaluation. Informally, peer review is found in many decision-making

processes in the form of informal discussions and suggestions from colleagues.

Shumway (1973) categorized project selection techniques into 3 distinct classes: individual participant comparative methods; group determined methods; and multi-dimensional ranking methods.

In the individual participant comparative methods, a common characteristic of a single judge comparing the overall subjective worth of one item to another or a group of items is shared. Several techniques can be used by the individual evaluators and will be discussed below. These methodologies categorized as individual participant comparative methods include: Q-sort; paired comparisons; successive ratings; successive comparisons; and the dollar metric approach.

The Q-sort technique divides proposed projects into hierarchical categories on the basis of their expected benefits. The Q-sort technique involves sorting of cards, each of which contains essential information about a particular project, into pre-conceived categories. No quantitative values are assigned to any category, but each may be divided into additional categories until no significant differences in anticipated benefits are discernable among its projects. Ordinal ranking is obtained between categories on the basis of anticipated benefits. This Q-sort technique also appears in the literature as a method of classifying a set of items according to the individual opinions of a group of persons (Helin and Souder, in Belland Souder, 1974).

With paired comparisons, a complete ordering of projects is obtained and verified. All possible pairs are compared and the one with the higher expected benefit identified. Again, no quantitative value is assigned to any project - only an ordinal ranking.

An arbitrary base number is assigned in the successive rating methodology. The base number is assigned to the highest ranked project. Numbers are given to each subsequent project in accordance with its anticipated benefits relative to the top one.

With successive comparisons initially assigned values are refined by comparing the value of one high-benefit project to portfolios of lower benefit ones. The number of projects in the portfolio is successively reduced until the single high-benefit project is preferred to the portfolio.

The final individual comparative approach to be discussed is the dollar metric methodology. In this methodology, paired comparisons are used first to identify the preferred project from each possible pair. From an estimate of the expected cost of each project the participant specifies how much the cost of the preferred project could increase before the other is chosen. This is repeated for all pairs. Next, he determines how much the cost of the least preferred project could increase (or decrease) before a decision would be made to fund no project in this research area. This base figure permits the specification of anticipated benefit in dollar terms.

In the group determined methodologies, the individual reviewers evaluate the research proposals using any of the mentioned ranking techniques separately. The individual evaluations are then grouped for a consensus and final ranking. The individual evaluations can be collected and analyzed in any of the following manners: the round table approach; the chain of command approach; or the Delphi Method.

In the round table approach, the group meets together, over

differences of opinion and then concludes with a group consensus. The chain of command approach, however, does not group the individual reviewers. The individual evaluations originate at the bottom of the chain and are passed from subordinate to immediate superior. Modifications are made at each step in the chain of command until the evaluation reaches the top where a final ranking is issued.

The Delphi method of group ranking (Harman and Press, 1975) provides for feedback and reconsideration by the individual reviewers before final submittal. Each reviewer submits his evaluation to other reviewers. The other reviewers evaluate the evaluation and anonymously return it to the originator for any desired corrections. These corrected evaluations are submitted to the decision-maker.

Scoring models comprise the major source of multi-dimensional ranking methodologies (Moore and Baker, 1969a; 1969b; Shumway and McCracken, 1975). Scoring models involve the selection of a discrete set of criteria under which all of the projects can be evaluated. Each project is rated by a numerical scale in each of the selected criteria. An overall project score is calculated by summing the product of criteria weighing and scores overall criteria.

Many of the articles reviewed did not take a specific focus on particular techniques as did those articles discussed above. These articles took a wider view of research as a part of an entire decision-making system. Those references that did not specifically deal with particular techniques of selection or benefit measurement, but dealt with some aspect of placing research into an agency-wide decision-making process are reported below.

A most interesting study completed recently in this systems

approach area was concerned with a large hierarchical R&D organization of the government (Baker, et. al., 1976). In this report the highly diffuse decision-making structure within government agencies is discussed. A similar study involved the development of a resource allocation system for such a technology based public organization (Shumway and Huang, 1975).

In the studies it was found that decision-making in hierarchical organizations is a diffuse process. A number of conjectures supporting this premise were made, in another study, and supported with empirical evidence (Shumway, et. al., 1975). A few of the more interesting conjectures reported and supported through empirical evidence were: 1) changes in project funding will occur in all phases of the budget cycle; 2) changes in project funding will also occur at all organizational levels; and 3) changes made by an entity cannot be predicted from prior project funding information by a simple proportional or linear relationship. These conjectures were postulated for systems defined to be large and hierarchical. A hierarchical environment was defined to exist if:

1) Several individuals are involved in the making of a decision.
2) These individuals are in different organizational levels, organizational units (at the same hierarchical level) and/or geographic locations.
3) The decision is partitioned into several activities.
4) Considerable time elapses between initiation and termination of the activity resulting in the decision.
5) A final decision results but is not ridged at any point in time.

It is postulated that such a hierarchical environment is common to

many public and private agencies. This work completed on such a system could prove to be very valuable for any future work due on such an organization and should be considered.

Benefit Measurement

Evaluation of research ex post, after it has been initiated, is often used to justify past research investments and to demonstrate the need for continuation of funding for research in process.

The measurement of potential benefit is a tool that can be used as an ex ante allocation device (USDA Forest Service, 1967). These methodologies, however, were discussed in more detail in the "Project Selection" section of this overview. This ex ante evaluation technique is actually the essence of many project selection methodologies used in industry. This ex ante approach is likely to become more commonplace with stronger budget control procedures in the public sector.

Most of the pioneer work in research benefit measurement was done within the realm of agricultural research. Research was viewed as a production process in which inputs were used to devise a specific output, presumably new technology. The value of this research output was guaged by the increase in productivity generated as a result of the research output.

Griliches (1958) computed an annual return of 700 percent to research and development of hybrid corn. Peterson (1967), while concerned with the return to poultry research, measured the downward shift in the supply function of poultry and measured the value of poultry research in terms of this downward shift and the subsequent savings of

resources that was obtained. Ayer and Schuh (1972) and Akino and Hayami (1975) have completed similar studies recently in cotton research and rice research, respectfully.

Mansfield (1965) in analyzing research and development contributions to the nation's economic growth, utilized a very similar approach to that used by the researchers in the agricultural sector. He determined a marginal rate of return to company investments in R&D for a time period between 1927-60. Simply by totaling R&D expenditures in real dollars and comparing this with the constant dollar value of the company's output over that time period, he computed the marginal rate of return to investments on R&D. It seems somewhat crude at this point in time to consider cost of R&D inputs as the only factor in the value of the company output (other factors, including demand, should be taken into consideration), but back in 1965 this study served a major purpose in getting interest in the evaluation of research moving.

Since these early studies, many engineers with specific companies in mind have created numerous ex post evaluation techniques. Industrial evaluation of research has been done in relation to company profits (Bachman, 1972); to company sales (Taymour, 1972); and in its ability to generate profitable business opportunities (Gee, 1972).

All of the techniques located, however, are inadequate in that they fail to consider the many other factors that are influential in determining the value of industrial output besides investments in research and development. Perhaps Coller and Gee (1973) in their simple approach to post evaluation of research have a better idea. They propose that research be evaluated in terms of pre-defined goals. The first step in the evaluation process is an evaluation of the technical

staff to determine if they accomplished their agreed upon goals and objectives. The second step in the evaluation process is in the determination of the potential value or worth of what the staff has produced. This value is determined by those departments and personnel within the company who are to make use of the research output.

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Fishel, W. L. 1970. A Disjointed Incrementalist's Approach to Measuring Research Benefits and Costs. Paper read to a meeting of the Committee on Economics of Natural Resources Development, 26 October 1970, at the University of California Extension Center, San Francisco, California.

With regards to benefit-cost analysis, a framework for classification of components for any allocative process is presented.

Fishel, W. L. 1970. Uncertaintly in public research administration and scientists subjective probability estimates about changing the state of knowledge. Ph.D. dissertation, North Carolina State University at Raleigh.

An introduction of subjective probability estimate to benefit cost analysis is made.

Fishel, W. L. editory, 1971. Resource Allocation in Agricultural Research. Minneapolis: University of Minnesota Press.

This book presents the views and findings of a number of experts concerned with the problems, issues and procedures involved in the allocation of resources for agricultural research.

Harman, A. J., and Press, S. J. 1975. Collecting and analyzing expert group judgment data. Rand Corporation P-5467.

Three methods of multivariate analysis are described for quantifying and analyzing group judgment data collected from a parcel of experts.

Heenan, D. A. and Addleman, R. B. 1976. Quantitative techniques for today's decision makers. Harvard Business Review:32-53.

Several different methods of multivariate analysis, a quantitative technique to determine comparative advantage between choices, are discussed.

Jones, M. V. 1973. A comparative state-of-the-art review of selected U. S. technology assessment studies. MITRE Operations, Washington, D. C.

A comprehensive review of technology assessment in the United States. Provides an introduction to literature available.

Kahalas, H. 1975. Planning for research and development - The impact on society. Long Range Planning 8:37-42.

Future trends in R&D and its potential effect upon society is examined.

King, W. R. and Cleland, D. I. 1975. The design of management information systems: An information analysis approach. Mgt. Sci. 22:286-297.

Deals with the use of managers in developing management information systems; a methodology of providing management with relevant information.

Kotok, E. I. 1948. Organization of research in the U. S. Forest Service. Unasylva 2:69-76.

Describes the organizational setup of research in the Forest Service as it existed in 1948 and prior.

Lake Tahoe Area Research Coordination Board. 1975. Research coordination and utilization of the Tahoe Basin, South Lake Tahoe, California.

A look at how research is conducted at the Tahoe Basin. It details the structure of the Research Coordination Unit and the progress being made towards meeting its objectives.

McGaughey, S. E., and Thorbecke, E. 1972. Project selection and macroeconomic objectives: A methodology applied to Peruvian irrigation projects. Am. Jo. of Ag. Econ. 54:32-40.

A ranking function is developed and used as a method of obtaining investment priorities. This methodology is then applied to 11 Peruvian irrigation projects.

Moore, J. R. and Baker, N. R. 1969a. An analytical approach to scoring model design application to research and development project selection. IEEE Trans. Eng. Mgt. EM-16:90-98.

Limitations of standard scoring models are identified and an analytical scoring model, which takes both quantitative and qualitative criteria developed.

Moore, J. R. and Baker, N. R. 1969b. Computational analysis of scoring models for R&D project selection. Mgt. Sci. 16:212-232.

A comparison and analysis of several scoring models. The additive type index is shown to have important advantages over the multiplicative index.

Paulsen, A. and Kaldor, D. R., 1969. Evaluation and planning of research in the experiment station. J. of Farm Econ. 51:1149-1161.

Explanation of a procedure for planning at the Iowa Agriculture and Home Economics Experiment Station, Iowa State University, that involves the use of first and second level panels of scientists.

Radosevich, R. and Hayes, R. L. 1973. Toward the implementation of R&D resource allocation models. IEEE Trans. Eng. Mgt. EM-20:32-33.

A listing of attributes deemed necessary for the selection of a resource allocation model for research is made.

Rensi, G., and Claxton, H. D. 1972. A data collection and processing procedure for evaluating a research program. USDA Forest Service research paper PSW-81.

This report describes a set of computer programs and subroutines used to process information required for an analytical procedure to assist the allocation of research resources in a government research organization, as was developed by the Forest Service.

Rouse, W. B., and Sheridan, T. B. 1975. Computer-aided decision-making: Theory and practice. Technological Forecasting and Social Change 7:113-126.

Discusses the application of computer technology to the decision-making process. Specific programs are referenced along with the presentation of a realistic decision-making structure for application.

Russel, D. G. Resource allocation in agricultural research using social-economic evaluation and mathematical models. Can. J. Ag. Econ. 23:29-52.

Goals in agricultural research were identified in three categories having a total of nine dimensions. A resource allocation system is developed to provide criteria and assessment information to generate decision-making information.

Shea, K. R. and Bayley, N. D. 1976. A new approach for planning or coordination of a large project. Presented October 16 IVFRO World Congress, June 1976, at Oslo, Norway.

Describes the Adapted Convergence Technique for Agricultural Research (ACTAR). This is a technique used by some Federal agencies to plan and organize research and development activities.

Shumway, C. R. 1973. Allocation of scarce resources to agricultural research: Review of methodology. Am J. Ag. Econ. 55:557-566.

Project selection tools such as project ranking and resource allocation optimizing methods are reported.

Shumway, C. R. and Hwang, J. D. 1975. Application of a resource allocation system in a technology-based public organization. R&D Mgt. 6:31-37.

A resource allocation system developed in earlier articles is applied to governmental laboratory by the author and reported here.

Shumway, C. R. and McCracken, R. J. 1975. Use of scoring models in evaluating research programs. Am J. Ag. Econ. 57:714-718.

The article reports how scoring models are used at the North Carolina Agricultural Experiment Station to rank recommended resource reallocations.

Shumway, C. R., Maher, P. M., Baker, N. R., Souder, W. E., Rubenstein, A. H., and Gallant, A. R. 1975. Diffuse decision-making in hierarchical organizations: an empirical examination. Mgt. Sci. 21:697-707.

Several a priori conjectures are presented concerning how the decision to fund research projects might be made in a hierarchically and spatially diffused organization.

Souder, W. E. 1973. Analytical effectiveness of mathematical models for R&D project selection. Mgt. Sci. 19:907-923.

The author tests the effectiveness of four mathematical programming models used as decision aids in project selection and funding of research and development.

Souder, W. E. 1973. Utility and perceived acceptability of R&D project selection models. Mgt. Sci. 19:1384-1394.

The value of and managerial acceptability of three expected valve maximizing project selection models was assessed within five different R&D organizations. Generally high value did not necessarily indicate high acceptability.

Souder, W. E. 1975. Achieving organization consensus with respect to R&D project selection criteria. Mgt. Sci. 21:669-681.

In this study at four different organizations a strong leader was found to be necessary if an impact method for achieving organizational consensus was used.

Stack, R. 1975. R&D coordination in industry and university. Res. Policy 3:360-371.

Describes a policy used at German universities concerned with coordinating research programs.

Stottenberg, C. H., Ware, K. D., Marty, R. J., Wray, R. D., Wellons, J. D. 1970. Planning research for resource decisions. Ames: Iowa State University Press.

The book defines a systematic approach to research on forest resource problems. A model is defined for understanding the relationship between resource management and research.

Talon, S. 1969. What is a decision? Mgt. Sci. 16:172-189.

Decision-making is described as a series of sequential steps and information gathering.

Tauss, K. H. 1975. A pragmatic approach to evaluating R&D programs. Research Mgt. 18:13-19.

Research projects are ranked through paired comparison techniques using only simple arithmetic. Projects are selected corresponding to their relative rank.

Tharp, M. M. 1974. Natural Resource Economics in USDA - Organization and research emphasis. USDA, Washingotn, D. C.

A historical prospectus of research organization in USDA. USDA, Agricultural Research Service. 1976. Management and planning system. Washington, D. C.: U. S. Government Press.

USDA Forest Service. 1964. A national forestry research program. Forest Service miscellaneous publication 965.

A national program of research for forestry is provided.

USDA Forest Service. 1967. A P-P-B Special Study of timber research opportunities. Washington, D.C.

This document outlines current research projects in USDA and addresses opportunities for additional needed research in timber production.

Wallenius, J. 1975. Comparative evaluation of some interactive approaches to multicriterion optimization. Mgt. Sci. 21:1387-1396.

A report of an experiment on a decision maker's response to the performance of the interactive methods for multicriterion optimization.

Benefit Measurement

Akino, M. and Hayani, Y. 1975. Efficiency and equity in public research: Rice breeding in Japan's economic development. Am. Jo. Ag. Econ. 57:1-10.

A comparison of the return on investment in rice research to the return on investment in other public expenditure areas is made. A conclusion that there is an under investment in rice research relative to other areas is made.

Albala, A. 1975. Stage approach for the evaluation and selection of R&D projects. IEEE Trans. Eng. Mgt. Em-22:153-164.

It is here proposed that the evaluation of a research project should utilize different models appropriate to the particular stage the research project is in. Specific models are suggested.

Allen, D. H. 1967. Two new tools for project evaluation. Chemical Eng. July 3:75-78.

From a simple cash flow diagram a methodology is given to determine equivalent maximum investment period and the interest recovery period. It is useful only in those areas where a cash flow over-time exists.

Andarawea, A. B. 1969. Evaluation of public research programs in agriculture. Can. J. Ag. Econ. 17:157-169.

A brief presentation of the evaluation techniques of research in agriculture is made and a system of resource allocation involving ex-ante education is suggested.

Augood, P. R. 1973. A review of R&D evaluation methods. IEEE Trans. Eng. Mgt. Em-20:114-120.

A listing of various existing R&D evaluation methodologies is reported here. Combinations of certain methodologies is suggested as being useful in certain circumstances.

Ayer, H. W., and Schuh, G. E. 1972. Social rates of return and other aspects of agricultural research: The case of cotton research in Sao Paulo, Brazil.

The internal rate of return to Brazilian society from cotton research is estimated here to be 90 percent. Methodology and distribution of benefit is also presented.

Bachman, P. W. 1972. The value of R&D in relation to company profits. Res. Mgt. 15:58-63.

Relates R&D evaluation as a direct relation between R&D costs and company profits.

Baker, N. R., and Freeland, J. 1975. Recent advances in R&D benefit measurement and project selection methods. Mgt. Sci. 21:1164-1175.

A review of the literature addressed to quantitative models of the R&D benefit measurement and resource allocation decision. Literature reviewed has been divided into 2 sections: 1) benefit measurement, and 2) project selection/resource allocation methods.

Bowers, R. 1975. The peer review system on trial. Am. Sci. 63:624-626.

The peer review system is described here as being indispensable.

Clarke, T. E. 1974. Decision-making in technologically based organizations: A literature survey of present practice. IEEE Trans. Eng. Mgt. EM-21:9-23.

A comprehensive review of the literature dealing with idea generation, transmission and evaluation; market group involvement in the innovation decision process; project selection and evaluation; and possible impact of formal project selection models or techniques on the bench scientist or engineer since 1967 is made.

Cochran, M. R., Pyle, E. B., Greene, L. C., Clymer, H. A., and Bender, A. D. 1971. Investment model for R&D project evaluation and eslection IEEE Trans. Eng. Mgt. EM-18:89-100.

A mathematical model utilizing discounted cash flow for project evaluation and a linear programming algorithm for project selection is developed.

Collier, D. W., and Gee, R. E. 1973. A simple approach to post-evaluation of research. Research Mgt. 16:12-17.

Post evaluation of research should measure 1) whether or not stated objectives were met, and 2) if the objectives were met did it result in any significant value to the instituting organization.

Fishel, W. L., editor. 1971. Resource allocation in agricultural research. Minneapolis: University of Minnesota Press.

This book presents the views and findings of a number of experts concerned with the problems, issues and procedures involved in the allocation of resources for agricultural research.

Gee, R. E. 1972. The opportunity criterion - A new approach to the evaluation of R&D. Res. Mgt. 15:64-71.

Griliches, Zvi. 1958. Research costs and social returns: Hybrid corn and related innovations. J. Pol. Econ. 66:419-431.

Return to investment on hybrid corn is determined by subtracting the cost of development of hybrid seed from the resulting value of the increase in corn production. An annual return of 700 percent is determined.

Harman, A. J., and Press, S. J. 1975. Collecting and analyzing expert group judgment data. Rand Corporation P-5467.

Three methods of multivariate analysis are described for quantifying and analyzing group judgment data collected from a panel of experts.

Horowitz, I. 1963. Evaluation of the results of Research and Development: where we stand. IEEE Trans. Eng. Mgt. EM-10:42-51.

The state-of-the-art concerning the evaluation of research and development in 1963 is examined. A broad macroeconomic as well as a firm and project level outlook is taken.

Mansfield, E. 1965. Rates of return from industrial research and development. Am. Econ. Review :310-322.

Productivity change was found to be statistically correlated to the rate of growth of cumulated R&D expenditures in ten large chemical and petroleum firms and ten manufacturing industires in the post-war period.

Mansfield, E. 1972. R&D's contribution to the economic growth of the nation. Res. Mgt. 15:31-46

A summary of the work that has been performed to develop and apply measurements of R&D's impact at the macro level.

Office of Management and Budget. 1976. Problems in evaluation: A background paper. Washington, D. C.

Outlines problems and deficiencies often found in evaluation programs.

Pearson, A. W., and Allen, J. M. 1969. Assessing research and development. Science J.: 79-83.

A variety of methods for assessing industrial research and development are presented and stated to be in use in British industry.

Peterson, W. L. 1967. Return to poultry research in the United States. J. Farm Econ. 49:656-669.

A production function and an index-number approach are used to estimate shifts in the supply function of poultry products. Consumer surplus estimates are made to give insight as to return on investment.

Tauss, K. H. 1975. A pragmatic approach to evaluating R&D programs. Research Mgt. 18:13-15.

Research projects are evaluated using only simple arithmetic through paired comparison methodology.

Taymour, M. E. 1972. The value of R&D in relation to net sales. Res. Mgt. 15:47-57.

A methodology for relating the contribution of R&D to a company's total sales is reported.

USDA Forest Service. 1967. A P-P-B special study of timber research opportunities. Washington, D. C.

Outlines current research projects in USDA and addresses opportunities for additional research for timber production and timber use.