Staff Paper Series

Staff Paper P76-22 June 1976

PUBLIC INSTITUTIONS AND AGRICULTURAL GROWTH: THE MINNESOTA EXPERIENCE

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STAFF PAPER P76-22 JUNE 1976

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This chapter examines the origins and development of the agricultural research system in Minnesota. That system encompasses the University of Minnesota's Agricultural Experiment Station; Agricultural Extension Service; and the Colleges of Agriculture, Forestry, and Home Economics. This state system is part of the U.S. federal-state research system.[1/] The research unit, the Minnesota Agricultural Experiment Station, is the central focus of this part of the study. The other units of the University's Institute of Agriculture, Forestry, and Home Economics are, though important in their own right, support or ancilliary units within the context of this study.

The organization of the chapter parallels, to some degree, that of the preceding chapter ("Minnesota Agricultural Growth, 1880-1970"). First, the origins of the federal-state system are discussed. Second, the origins and development of the Minnesota Station, and related units in the state agricultural research system, are delineated. Third, the work done, "output," at the Minnesota Station is examined. Fourth, the resources available to the Minnesota Station, the "inputs", are detailed. The fifth section deals with some creative individuals who had a major impact on the Minnesota Station and system. The final section analyzes "non-price signals" which direct research efforts.

ORIGINS OF THE FEDERAL-STATE SYSTEM

The federal-state agricultural research system is a decentralized, co-operative effort involving agencies of the federal and state governments.

On the state level, the system is based in the land grant colleges and universities. Because of its origins, the system endures the tensions created by combining the teaching, research, and extension functions. Inspite of, and perhaps because of, these diverse functions, and the decentralized structure, the system has contributed significantly to the growth and increased productivity of agriculture in the United States.[2/]

The State Level

The state agricultural research systems, like the federal system, developed in response to demands from farmers' organizations. These demands for governmental action came because of the failure of private efforts. The private efforts, by individuals, such as Peter Gideon, and by groups, e.g. the Minnesota State Horticultural Society, usually failed, primarily because of the high costs of research, limited knowledge, and the "free-rider" problem.[3/]

The innovative individual farmer or group, by trial and error experiments, made some progress in creating new implements and practices. His choice of trials was based on his knowledge of agriculture, which was, perhaps, broader than that of most farmers, but still quite limited. The expense, in time, money spent, and land and animals used for trials rather than production for sale, meant that only the wealthy normally were able to experiment. Gideon, not a wealthy man, was hampered by lack of money, and by the need to support his family as well as his research work.[4/] When the Regents of the University provided a subsidy, beginning in 1878, Gideon was able to devote his efforts to research, with considerable benefit to the state.[5/]

Experimentation conducted by private agricultural groups encountered several problems. First, the costs were high, limiting the size of the research effort. Second, innovations which increased profits represented an asset for group members. If users were charged a fee to use the research knowledge, the new technology would most likely not be used, a usual occurrence. If the innovation was made freely available to any farmer, the returns to the research sponsors was lessened quite considerably. Since it was, and is, difficult to keep implement design, new techniques, and so on, secret, or to prevent imitation, the usual result was for the innovators to enjoy a short period of comparative advantage and gain from the effort. As neighbors, farm journalists, and visitors watched the successful use of the new technology, they began imitating the innovator (i.e.adopting the innovation), reducing the innovator's comparative advantage and returns. This imitation effect is also known as the "free-rider" problem, where the benefits of change cannot be limited to the innovators.[6/]

Private efforts were first tried in the Eastern states, beginning with the formation of agricultural societies in the 1790s, and in those states, the first government efforts were sought and made in the 1840s. Following the settlement of new areas, one sign of the ending of frontier status was the start of private agricultural societies and research efforts. As the limitations upon and problems of such efforts became apparent, these newer state societies also began to call for governmental aid. By this time, the Eastern farm groups perceived the inability of state-funded efforts, and with the new, Western states, began calling for assistance from the federal government. Following passage of the Morrill Land Grant College Act and the creation of the Department of Agriculture, both in 1862, the demand for federal government assistance quited for a time.[7/]

Establishment of the land grant colleges of agricultural and mechanical arts was delayed by the Civil War.[8] By the 1870s, as the lack of material on scientific agriculture became apparent, and as the farm groups realized that the colleges of agriculture were not meeting their needs, the movement for federal and state aid resumed. The experiment station movement was based in prior European and current American experience. The state supported station at Mockern, Saxony, Germany, which was followed by the privately funded Rothamsted Experimental Station and the Edinburgh Laboratory (1842-1848), both in Britain, influenced the American developments. The Connecticut Agricultural Experiment Station, established by the State of Connecticut as an autonomous unit in 1875, was the first American Station.[9] It was followed by several state-established stations, usually attached to the land grant colleges.[10] In 1885, the Minnesota legislature authorized a station, as part of the University's College of Agriculture.

ORIGINS AND DEVELOPMENT OF THE MINNESOTA STATION

The Minnesota story parallels the national experience, and the motives behind its origin are quite similar to those behind the national and Eastern development of agricultural research and teaching institutions. Starting in the 1850s, various farmers' organizations in Minnesota attempted to find solutions to many of the problems facing Minnesota farmers. Some private efforts quickly became too expensive for individuals, and groups became active. Among the group efforts were the "Agricultural Experiment Stations" formed by the State Horticultural Society's members on their own farms. By the mid-1880s, the costs of private efforts became too great, and the Society, long a supporter of the University's College of Agriculture and Experimental Farm, began calling for a state-supported Agricultural

Experiment Station as a part of the College. Since state resources, especially because of Minnesota's frontier status, were limited and inadequate, the various farmers' groups joined with groups in states to the east in calling for federal assistance.

From the lobbying and other promotional work of the various farm groups nationally, came congressional as well as state legislation, establishing the land grant colleges and their experimental farms. Later, the state agricultural experiment stations, and later yet, the agricultural extension services were established with heavy support from farm groups. In Minnesota, the first efforts to develop a college of agriculture, in 1858 at Glencoe, were unsuccessful. In 1869, the second attempt began with the establishment of a college of agriculture in the University of Minnesota. In the early years, the college lacked stability. In addition, its experimental farm was inadequate for experimental purposes, and was poorly funded. A new campus and farm was acquired in 1882, and the Farmers' Lecture Courses, the fore-runner of the Agricultural Extension Service in Minnesota, was initiated.[11/]

Institutional Foundations

The University of Minnesota, although legally created in 1851, did not form a College of Agriculture with its own experimental farm until 1869. The University's College of Agriculture was the second attempt to provide formal agricultural training in the state. In 1858, the legislature authorized but did not fund an Agricultural College at Glencoe.[12/]

The early years of the College of Agriculture were marked by few students, a rapid turnover in faculty, distrust (at best) by the farmers, and neglect by the legislature. To the surprise of almost no one, the

first two (assistant) professors of agriculture departed after brief tenures (D. A. Robertson, 1869-70; D. P. Strange, 1872-1874). The third professor of agriculture, Charles Y. Lacy, remained for six years (1874-1880).[13/]

Under Lacy, there had been some students, but apathy and a belief that the training had little usefulness in farming worked to deprive him of them almost as fast as he recruited. His efforts were devoted largely to the comparative trials of various seeds (sent by the United States Department of Agriculture), shrubs, crops, and trees. Even though the Regents were willing to pay him to do research while he waited for students, Lacy gave up and in 1880 left the University. During the Lacy years, while the Regents "awaited a new inspiration that might breathe life into the College of Agriculture, ... [they] soothed their consciences by taking over an experiment begun by the State Horticultural Society. They assumed responsibility for the fruit farm at Lake Minnetonka and sponsored the experiments of Peter Gideon."[14/]

In January of 1881, the Regents appointed Edwin D. Porter Professor of Agriculture. Porter began with a concerted effort to meet with all of the "recognized agricultural organizations in the state," with the legislators, and with "responsible men" to determine their views on the role of the College of Agriculture in the service of the state. This public relations tour gave Porter the opportunity to discover and allay many of the fears farmers had towards "intellectuals" from the University "ivory tower." Evidence indicates that by the time Porter retired in 1889, farmers viewed the College of Agriculture, its faculty, and its new Experiment Station more favorably.[15/]

Porter made two contributions to the future growth and prestige of the College and (later) the Experiment Station: first, he systematized the distribution of knowledge through the practice of visiting and lecturing to farmers' clubs and a formal "Farmers' Lecture Course"; and second, he convinced the Regents to acquire land more suitable for a farm, in St. Anthony Park (then northwest of St. Paul). The Farmers' Lecture Courses developed into the Farmers' Institutes and (in 1910) into the Agricultural Extension Division, which became the Agricultural Extension Service in 1914. Over two hundred people attended the first series of lectures in 1882--about seven times the number Porter had hoped for. His selection of the new farm was equally well received by the leading farm organizations, especially by the State Horticultural Society and the Grange.[17/]

Institutional Development

In 1885, the state legislature directed the Board of Regents to establish an agricultural experiment station. The Regents immediately designated the University Farm as the new experiment station and the College of Agriculture faculty its staff. The station was to conduct original research or verify other work done on the physiology and diseases of plants and animals, to determine remedies for various problems, to determine the chemical composition and stages of growth of plants, to analyze the soils and waters of the state, to develop plants, trees, and shrubs adapted to the soil and climate of the state, and to conduct other related research.[18/]

The objectives of the University Farm were three: first, to provide a laboratory (school) for training future farmers in practical agricultural techniques; second, to provide employment to aid students in financing their educations; and third, to provide a place to conduct the research work

proper to an experiment station. While the practical training furnished in the preparatory School and the College of Agriculture could have been detrimental to the research orientation necessitated by the work of the Experiment Station (since the educational faculties comprised the research staff), the results of this union of functions in the same people was turned to advantage over time. The School and the College became the transmission agents for the experiment station as the students acted as private extension agents to their parents and neighbors. This personal contact helped promote acceptance of the work done at the University Farm. While these functions and roles have been modified with the passage of time, they still adequately state the mission, functions, and role of the campus, College, Station, and, to a lesser extent, the students of the Institute of Agriculture, Forestry, and Home Economics in the service of the people.[19/]

The fact that Minnesota established an Experiment Station two years before the Hatch Act of 1887, which provided federal funding, was an indication of the strength of state support for agricultural improvement. Farmers as individuals or as members of agricultural organizations supported the School and the College of Agriculture and the Experiment Station, and influenced the course of their development. In fact, these wealthier, organized farmers in large measure determined what problems the institutions would examine.

Individual farmers, for example, initiated some flax wilt research in 1889 by appealing to Governor Merriam for assistance in solving a pressing problem. At the request of the Governor, the Regents appointed

Otto Lugger, the Station Entomologist, to investigate the causes of flax wilt--thought to be a soil deficiency of some kind. Dr. Lugger was already well known to the farmers of Minnesota for his expertise in combating crop-destroying insects. Lugger reached the wrong conclusions about the causes of the wilt, but in creating an interest in the flax-wilt problem, he made a considerable contribution to the ultimate solution. Other examples of farmers and farm organizations influencing activities of the Station abound.[20/] Again, farmers, farmers' organizations, and other "consumers' of the Station's research product still influence the work of the Station and the Institute.

Organizational structure

Under the Porter organization, necessitated to meet the requirements of the newly passed Hatch Act, the older College of Agriculture was joined by the new Experiment Station. To coordinate these two units, a Department of Agriculture (similar to an Institute) was created. In the early years, the Dean of the Department was also Dean of the College and Director of the Experiment Station. Later (1895-1900), the position of Dean of the College of Agriculture was separated from the position of Dean of the Department. Under the Department was the School of Agriculture (established in 1886-1887), headed by a Principal.

Within the College and Experiment Station, there were various divisions (elsewhere known as departments). The first divisions were (1888): Agriculture, Agricultural Chemistry, Entomology and Botany, Horticulture, and Veterinary [Medicine]. Dairy Husbandry (1891) and Animal Husbandry (1892) were created out of the Division of Agriculture, which was renamed the Division of Agronomy and Farm Management (1896). In 1908, the Division of Entomology and Botany was renamed Botany and Plant Pathology; and the Division of

Agricultural Engineering was created. In 1909, the College of Forestry was created out of the Division of Horticulture and Forestry. In 1911, the Bureau of Research in Agricultural Economics was authorized, and was established in 1912 as the Division of Agricultural Economics. In the 1920s, the Division of Home Economics and the "Division" (really, a branch of the Minneapolis campus's department) of Rural Sociology were established. The Farmers' Lecture Courses (1882) had become the Farmers' Institutes in 1885-1886, and in 1910, the Division of Agricultural Extension. In 1914, following the Smith-Lever Act, the Agricultural Extension Service was created as a separate unit in the Department, co-equal with the College and Station. Most of the organizations and new divisions reflected changes within the Experiment Station, and to a lesser extent, the College of Agriculture induced by changes in the agricultural sector.

The 1887-1888 structural reorganization of the Department to meet the requirements of the Hatch Act also was an attempt to fit the Station to meet its newly expanded role. With the approval of the Regents, authority was vested in the Director of the Station (who was also the Dean of the Department of Agriculture). The Board of Regents Agricultural Committee (which included the Director, ex officio) was to exercise general supervision. Under the Director came the Corps of Experimentation, composed of the Division Heads. The staff of the Station and the faculty of the College of Agriculture were identical.[21/]

Resigning in 1889, Porter was succeeded by Nelson W. McLain, who soon found the staff challenging his authority as he interpreted his duty and powers. Professor David N. Harper traveled to the Red River Valley to investigate wheat raising without McLain's approval. The Director, at the next staff meeting, made clear his opinion that he was the one responsible for all lines of work and was the one to authorize research

selection and travel. Harper objected to this method of determining what work was to be done, and in explicit reference to the Regents' rules of 26 April 1888, stated that such authority was properly that of the Station Corps of Experimentation. The resulting loss of authority of the Director, and the decline of respect shown him by the staff led to McLain's departure before the end of his second year. His successor, Clinton D. Smith, served almost eighteen months before he too departed, in large measure because of conflicts with the staff.[22/]

Between 1889 and 1893, decision making and authority rested not in the legally responsible Director, but in the staff as a group. Regent William Liggett was appointed Chairman of the Experiment Station Staff in December 1893. Because of his unquestioned authority (as Regent-Chairman) and because of his diplomatic skills which the staff continually tested, Liggett was able to reestablish the authority and dignity of the Office of Director by December 1896, when he was made Director of the Station. The staff voiced no unhappiness at the return to the directorship method of administration. Serving through July 1907, Liggett made possible the maintenance of a central authority in the Station. Combining the position of Director with that of the Dean of the Department and the College of Agriculture reinforced the power and prestige of the office. This joining of the positions with a Vice or Assistant Director to administer the Station under the Dean and Director's supervision continued for over fifty years until Dean Harold Macy's appointment, when H. J. Sloan was appointed Director of the Agricultural Experiment Station (1954).[23/]

The Department of Agriculture expanded in the 1890s, into the second decade of the Twentieth Century. The first branch station was

opened in Lyon County, on Orren C. Gregg's "Coteau Farm," in 1893. In 1896, branches at Crookston and at Grand Rapids were founded, followed by the Cloquet Forest Experiment Station (1907), and the Fruit Breeding Farm at Zumbra Heights on Lake Minnetonka (also in 1907). Stations were established at Morris (1910), Duluth and Waseca (1912), and a School of Agriculture, similar to the one opened at the University Farm main campus in 1887, was established at Morris. In the 1920s, an Experimental Creamery was operated at Albert Lea. A potato experiment was conducted by the Duluth Station at Castle Danger until the 1950s. In 1946, the Rosemount Station was opened on the shrapnel-littered lands of a World War II arsenal, and in 1957, the Lamberton Station was created.[24/] Superintendents headed these branch stations, with varying degrees of control exercised by the central station.

At Crookston and Grand Rapids, and later at Waseca, schools of agriculture were opened. These schools, like the Morris and central schools, functioned during the six winter months, and conducted "home projects" in the summer months which brought the teaching staff into contact with the farming parents of students. The teaching staffs, also formed the bulk of the research staffs at the various stations, and usually worked with the central station staff on research projects. Most research was adaptive in nature, though some original research was initiated and/or conducted at the branch stations. In the late 1950s, the school at the St. Paul (University Farm) campus was closed, and in the early to mid-1960s, the remaining schools, except at Waseca which closed in 1972, were closed. Most were converted into technical institutions within the University, offering the two-year associate degrees. The Morris School and the Duluth Station were converted to four-year campuses of the University. The

remaining stations, no longer connected with teaching, were able to devote their full attention to research affecting their regions of the state and to assist in state-wide and inter-state co-operative projects.25/

The Department and the Experiment Station continued with the Dean-Director and division structure until 1954 when Harold Macy became Dean of the Institute of Agriculture, as the old Department was renamed. The Station head, now separated from the Department Dean, ranked co-equal with the college dean and the Director of the Agricultural Extension Service. As part of the 1954 reorganization, the subject-matter divisions were renamed departments. The School of Veterinary Medicine became a semi-autonomous, later fully separate, unit of the University. The formal linkage for some years following the reorganization between the Veterinary Medicine School and the Institute was the appointment of the Dean of the School as an Associate Dean in the Institute. The Department of Agricultural Biochemistry became the Department of Biochemistry in the College of Biological Sciences during the 1960s. And, under Associate Dean Theodore Fenske, former head of the Morris Station, the work of the branch stations was more closely coordinated by the central station administration.26/

The structure created by the 1952-1954 reorganization, in which subject matter departments of the College of Agriculture, which later was divided into three colleges, of agriculture, of forestry, and of home economics, formed the subject-matter departments of the Station and of the Agricultural Extension Service, lasted into the early 1970s. During the early 1960s, the Office of International Programs in Agriculture was created, terminated in 1976, to direct the Institute's involvement in foreign development efforts. Despite the more recent changes, the basic

structure is that established in 1952-1954. And, inspite of various structural changes since 1888, the objectives of the Department/Institute of Agriculture, and the Agricultural Experiment Station have remained constant. To serve farmers, the larger agricultural sector, and the people of the state. To this end the work of the Station is directed.

THE WORK OF THE STATION

Since 1888, the Minnesota Station has worked on all major physical aspects of agriculture. Since 1902, the economic aspects of agriculture have increased steadily in importance. Sociological aspects of rural farm and non-farm life, and a wide variety of nutritional studies became a part of the ongoing research program after World War I. Farm life, studies of textiles, appliances, and related home economics-family life subjects grew in importance in the 1920s and again in the 1950s. The subject matter of the work done at the Station has remained relatively constant until recent years when urban and non-farm matters such a mass transportation and uses of sewage wastes, became part of the program.

The changes in the type of work, basic, applied, and developmental research,[27/] are more notable. Research methodology has also changed. These changes, traced by an analysis of Station and technical bulletins published by the Station, are of considerable importance. This approach, it should be noted, is biased in favor of applied-developmental work because of the intended audience of these bulletins, and because of the tendency to publish basic and basic-applied work in the various professional journals. Hence, any trend towards basic research is understated; and trends towards applied-developmental work are somewhat overstated.

Types of Research

Five major phases of research types dominance are identified. The first phase, 1888-1895, represents the first years of station operation and bulletin publication. In these years, many publications were modified versions of publications from other state stations or foreign scientists. They were similar to contemporary extension bulletins. The work reported was developmental in nature. If a (1) basic- (5) applied- (9) developmental scale is used, the average "research type" score is 7.5 for this first phase.

The second phase, 1896-1905, is an era of movement to applied research. This reflects the first era of professional development of the research staff, and coincides with Colonel William Liggett's term and Dean and Director. The average "research type" score was 5.6. During the 1906-1918 third phase, research tended to be applied-developmental (6.6). The effect of World War I on research was multifaceted, but a notable shift towards basic-applied work follows, though may not be caused by, entry into the war.

The fourth phase, 1918-1939, is broken into two parts: 1918-1933; and 1934-1939. In the 1918-1933 era, applied research, supported by a growing trend towards basic research, produced an average "research type" score of 5.4. The 1934-1939 era is an era of basic-applied research to try and find solutions to new as well as continuing problems. The stock of existing knowledge was exhausted by the early 1930s, and, with the advent of New Deal funding programs (such as the Works Progress and National Youth Administrations), a major effort was begun to replenish the storehouses of scientific knowledge of agriculture. The average

"research type" score for 1934-1939 is 4.6. For the entire fourth phase, the average "research type" was 5.2, reflecting the movement towards basic and basic-applied research.

Beginning in 1940, the fifth phase shows to distinct research types in the same years. Basic research, with a mean score of 3.9, is notable; but another trend, applied-developmental (with a core of 5.8) is also present.[28/] It is clear that since World War II, the bulletins are used to report general results, in applied terms. Basic research was usually reported in the professional journals, although technical bulletins occasionally were used for this purpose. Since 1940, basic-applied research work has received considerable emphasis. However, applied-developmental work must also be done, to make the results usable by farmers, to fulfill the Station's mission of service.

Research Methods and Subjects

The methods and subjects of research have also changed, reflecting the changing research type. Crop trials and other field experiments were supplanted by breeding experiments. Animal disease investigations moved from the farmer's barn to the Station barns and laboratories, and animal nutrition moved from comparing different feed mixtures to making chemical analyses of nutritional needs and the composition of meats and milk, and measuring the effect of diet composition on product composition and value.

The research conducted by the experiment station staff, regardless of the type or method of research utilized, had several objectives: producing higher yields, understanding diseases, reducing costs, promoting efficiency, and improving facilities. Nutritional feeding standards for animals and plants, and human nutritional need were also important research subjects.

Table 3-1: Average Research Type, 1888-1972

Year	Number of Bulletins[a/]	Total Score[b/]	Average Research Score[c/]
1888-1895	145	1,081	7.46
1896-1905	93	521	5.60
1906-1918	91	601	6.60
1906-1910	28	166	5.93
1911-1918	63	435	6.91
1919-1939	306	1,581	5.17
1919-1933	216	1,169	5.41
1934-1939	90	412	4.58
1940-1972	310	1,451	4.68
group a	131	754	5.76
group b	179	697	3.89

a/ For 1888-1900, bulletins often covered several different topics, each of which is considered a separate item.

b/ Sum of scores on a 1-9 basis as noted in the text.

c/ Sum of scores divided by the number of bulletins.

From 1868, the experimental farm was used for comparative testing of seeds to find the varieties best suited to Minnesota, with the objective of improving yields. Attempts to prevent yield-reducing diseases of otherwise suitable crop varieties led to insect life-cycle and habit studies, as well as to disease and remedy investigations. In the course of crop production analysis, the staff began to collect cost data--though experimental plots were too small for a valid study without field surveys by route-men in various areas of the state. In the 1890s, the staff studied plant mineral needs and chemical deficiencies, and chemical compositions and nutritional values (for both animals and humans) of the various crops. Uses of crops -- e.g., productivity in milling cereals--also became an early field of investigation, not a surprising occurrence given the large milling industry in nearby Minneapolis.[29/]

In the early years of the University Farm, the staff also studied animals. Haecker's work on dairy cattle was extended gradually to sheep, poultry, and other farm animals. The effects of insects and diseases (some insect-borne) were other early subjects of investigation, and led to studies of animal diseases. There were also some studies of the effects of ventilation in stock barns on livestock health (e.g., contagious abortion "tuberculosis" in cattle), of milk production costs, and later, of slaughter animal production costs.

Although studies of nutrition, disease, and production costs had limited impact at first, they eventually led to the development of the home economics and food science and nutrition departments after World War I, the Bureau of Agricultural Economics in 1911-1912, and the cooperation between the Division of Veterinary Science and the School of (Human) Medicine after World War I.[30/]

By 1900, the increasingly varied nature of research questions, researcher expertise, and of outside factors such as climate and soil conditions in the state meant that no one person could successfully master all aspects of a problem, nor could one experimental farm location give satisfactory results for the whole state. One result was the establishment of the branch stations in various parts of the state. Another was the promotion of team research efforts and interdisciplinary work. Because divisional and discipline boundaries were drawn very loosely or not at all in the first branch stations, men with a variety of training often worked jointly on projects. The project or group approach to problems was formalized in the Experiment Station by Willett M. Hays in the late 1890s.[31/]

Following World War I, when the Station worked to maintain high yields by such programs as Barberry eradication work to reduce the risk of cereal rusts, several new lines of work were emphasized. These new fields, rural sociology, home economics, and agricultural economics, all had pre-war origins, but first flourished in the 1920s. During the 1920s, with the increasing incidence of basic-applied work, crop and animal cross-breeding, and nutritional impact studies occupied many researchers. Soil surveys and other studies of land and land use expanded. The economic and social factors affecting and affected by farm and rural non-farm life and work also came under scrutiny in the 1920s and 1930s.

During the early 1930s, faced with severe budgetary problems, the Station worked to maintain productivity and yields of crops and animals. Tax, farm credit, and allied studies, done in cooperation with other state agencies, formed a major part of Station efforts. With more federal

funding, under the Works Progress and National Youth Administrations, Station researchers attempted to alleviate the impact of the depression on farmers and rural townspeople.

In the inter-war years, despite financial problems stemming from inflation and depression, the Station expanded its services. Basic and applied research became more sophisticated. Increasingly expensive machines made scientific analysis more precise. The new technologies of research made possible the investigation of fundamental questions; and the testing of materials in way which more accurately measured their strengths, weaknesses, and composition.

With the increasing demand for food and fiber products which followed the outbreak of war in 1939 came new demands on the Station. The National Emergency, followed by U.S. entry into World War II meant a mobilization of Station resources to serve the war effort. Despite the loss of a large number of staff members to military and other governmental service, work continued at a rapid pace to maintain yield levels, develop new products such as dried milk and eggs, and to find new uses for existing waste products.

Following the war, as staff members returned, the Station resumed work on the normal range of peace-time problems. Increasingly, Station workers served on international development teams, first in Europe, then in various under-developed nations, and large numbers of foreign students came to the College of Agriculture for baccalaureate and graduate training. Cereal rust work, which slackened in the late 1940s and early 1950s, was hurriedly resumed after the 1950-1952 wheat rust disasters. This work, in cooperation with the U.S.D.A., was institutionalized in the U.S.D.A. Cereal Rust Laboratory in the mid-1950s when E. C. Stakman retired.

After the war, cooperative work by Veterinary Medicine and the School of Medicine on brucellosis was intensified, and in 1958, the Station began funding this ultimately successful interdisciplinary work.[32/]

In the 1950s and 1960s, human nutrition, family life, and related studies gained new prominence in the Station's work. Non-agriculture-specific fields of research received increasing emphasis, confirming Peterson's thesis that non-farm factors have become more important in determining the types of work done at the station.[33/] These new lines included mass transportation, non-farm tax and welfare studies, regional growth-decline analyses, and fiscal resources-public policy investigations. Horticultural work on lawns and ornamental trees and shrubs; and related studies by the plant, animal, and soil departments, e.g., the uses of sewage wastes, also became common. In addition, international development assistance work, in practice, as well as in theory, involved more of Station resources, as the University lent its expertise to efforts to better life for non-Minnesotans.

All of these, both historical and contemporary, changes resulted from perception of needs which could or should be met. The perception of problems, one factor in the allocation of the Station's resources, is a complex, vital part of the knowledge creating process. An understanding of the actual allocation of resources, both human and financial, is a necessary pre-condition to examining the determinants of resource allocation.

STATION RESOURCES

Research institutions such as the Minnesota Agricultural Experiment Station produce new knowledge. In the process of producing knowledge, the Station utilizes labor and capital. In addition to these resource

inputs, a set of non-price signals also enters the knowledge production process. Initially, the research institution can be likened to a firm producing a consumption good and using capital and labor. The firm responds to market price changes for its product as well as to changes in the prices of the inputs. For the research producing unit, market prices of the good are not available. Non-price signals serve a purpose analogous to market prices in the resource allocation process and the knowledge production function.

Resource Inputs

The resources utilized by the knowledge producing unit include labor, capital, and other intermediate inputs. The sources of funds, used to purchase these inputs, and the distribution of those funds by subject-matter related subunits (divisions/departments) indicates the response of the research unit to non-price signals. Similarly, the distribution of staff between the various subunits will indicate the long-run adjustment lag between the reception of the signals and the response (in changed staff distribution, training, etc.) of the Station.

Financial Inputs

Funds are more variable in the short-run than is the staff distribution. These funds, because of the limitations of the data sources, cannot be broken down into fine categories. Instead, the sources only allow disaggregation between salaries and wages, and "supplies and travel" expenditures. Capital equipment (machines, buildings, etc.) are usually not listed in the budget books of the Station.[34/] In addition, central or all-University services such as computers cannot be readily allocated between users.

Table 3-2: Funds Available in the Fiscal Year, 1890-1970[a/]
(In thousands of current dollars)

Year	Federal	State:			Endowment and Fellowships	Fees, Sales, etc.	Total Funds
		Special	General University	Total			
1890	15.0	---	3.0	3.0	---	2.8	20.8
1900	15.0	n.a.	32.6	32.6	---	9.3	56.9
1910	28.0	n.a.	40.2	40.2	---	6.2	74.4
1920	30.0	/32.7/[b/]	257.2	257.2	---	84.1	371.3
1930	90.0	40.3	210.1	250.4	53.5	102.8	496.8
1940	146.8	50.3	333.8	384.1	10.1	62.8	612.8
1950	207.5	248.0	918.2	1,166.2	108.2	306.8	1,898.7
1960	729.4	707.5	1,733.3	2,440.8	502.7	708.4	4,381.4
1970	1,451.8	n.a.	6,055.0	6,055.0	1,1376.5	1,007.3	9,890.6

a/ For the years 1890-1940, the data is from the Annual Report of the Director of the Office of Experiment Stations; and can be cross-checked in the Station's Annual Report, for 1900-1940; for 1950-1960, see the Station's Annual Report; and 1970 is from Minnesota Science, 26 (Fall, 1970).

b/ The Station, Annual Report, gives a special appropriation of 32,565 for hog cholera serum production, but the OES Report gives a state total of 257,173. The two sources do not agree, hence the acceptance of the OES data, combined with the notation that the Station may not have included serum funds in their report to OES. Alternatively, the OES total may include the serum funds, though the totals do not agree between the two sources.

Allocation between teaching, research, and extension uses would be even more difficult. Consequently, the funds available and utilized are the only readily available indication of capital, and are as well the most important factor in capital acquisition. We now turn to an analysis of the sources of funds and their distribution between salaries, wages, and "supplies and travel."

Sources of funds

Funds for the operation of the Minnesota Agricultural Experiment Station come from four general sources: the federal government; the state government and general University funds allocated to the agricultural departments; sales; and grants and contracts from non-University sources. In Table 3-2 ("Funds by Source ..."), the unadjusted current value of funds from each general category are noted. The federal government was the primary source of funds for research in the first decades of the station's operation. The state government provided funds for buildings, much of the equipment, for teaching (supplemented by University tuition and other revenues), and for the operation of the branch stations. Sales provided considerable income for some divisions, and are especially crucial for the branch stations. The West Central Experiment Station at Morris used funds accumulated from the sale of livestock, feeds, and excess lands to purchase some adjoining land and build new livestock barns and an office building.[35/] Grants, fellowships, contracts, endowment, and gifts have provided funds for equipment, graduate research assistants, and occasionally for land and buildings. Accurate data on the amounts for grants, fellowships, etc. are difficult to obtain, and the allocation of these monies by uses is even more impossible to ascertain.

Over the eighty years of the Station's existence, federal funds have become a smaller proportion of the total funds available. The state's share in funding has increased over time, from branch station and non-research support to extensive support of specific research projects (the so-called "state specials or line-item appropriations), to support of general agricultural support. Funds from outside sources have increased considerably from the first years when the Minneapolis flour milling industry donated milling equipment and wheat for milling experiments and J. J. Hill donated land for the Grand Rapids branch station. In the early years, the railroads were the largest private donors to the Station, providing land, and free or low cost transport services for staff and materials, and for visiting groups of farmers, and as well for "extension trains" which toured the state in the 1890s to 1910.

After World War I, other private sources, both individuals and businesses, began to provide increasing amounts of money to the Station, in the form of grants and contracts. However, these private sources, like the governmental sources of funds, reduced their support of the Station in the first years of the depression of 1929-1939. Governmental funding did recover, to some degree, in the later years of the 1930s, but private funding did not recover and grow unit after the Second World War, when the major foundations, e.g., Rockefeller, Ford, and the quasi-governmental foundations (National Science Foundation) and non-agricultural departments (Department of the Army) began to purchase the research expertise of the Station.

Uses of funds

Expenditures of the Minnesota Station for labor and capital can be discussed on several levels. Because of disclosure problems, funding for individual projects cannot be presented. Divisional or departmental expenditures, and the total share of funds spent by each division/department will illustrate the vitality of each field of research. Aggregation of expenditures by subject matter (e.g., crop related units: Agronomy; Entomology; Plant Pathology) will help determine the responsiveness of the Station to changes in the gross structure of Minnesota Agriculture. A continuing limitation is the lack of information for expenditures on buildings, major equipment items, and large lot livestock purchases. Presumably, the "supplies and travel" items in the budget books include some small equipment (microscropes, calculators, computer time, etc.) and small lot livestock purchases for the various research projects. Because of the reporting conventions in the budget books, and the limitations upon disclosure and aggregation requirements, the breakdown of supplies and travel to reflect the acquisition of fixed capital and variable capital expenditures is impossible.

It should be noted, that in his study of the allocation of teaching, research, and extension personnel in agricultural colleges, Peterson[36/] found that departments performing farm-related research (i.e., agronomy, animal science, etc.) appeared to have a closer relationship to farm income trends (i.e. if farm income increased, their funds and personnel also increased), while departments which had a closer contact with non-farm research subjects and people had a closer relationship with non-farm income.[37/] Over the period under study, the farm sector's share of total state product (or, disposable income, etc.) has decreased, while the non-farm share has risen. Peterson confined his analysis to national behavior

since 1930. From the experience of the Minnesota Station, it appears that his findings hold for Minnesota for a considerably longer period.

In 1900, crop-related departments had 32% of the total Station budget, and animal related departments had 46%, for a total of 78% to farm-related departments. Until the 1920s, these farm-related departments had over sixty percent of all Station funds. In 1930, the crop and animal-related departments had 50.2% of the budget, falling by 1940 to 48.7%. Granted, these departments have maintained their hold on the largest share of the station budget, reflecting the relatively strong position of agriculture in the Minnesota economy, and the relatively strong position of rural areas in the state legislature before 1960.

Two groups of essentially non-farm related departments can be distinguished. One, the physical sciences-technology group, includes Horticulture, Forestry, and Agricultural Engineering among its members.[38/] This group was farm-related in the early years. It moved towards a general service orientation over the 1920-1940 period, and by 1960 was largely non-farm related. Its share of the Station budget decreased as new, social science departments were created in 1910-1920, but regained a substantial portion of funds, at the expense of the clearly farm-related departments in the 1920s and 1930s. Following a decline in the 1940s, its share again grew, reaching 34.3% of the 1970 budget. Horticulture accounted for much of this recent growth.

The second non-farm related group includes the social sciences and the College of Home Economics.[39/] Coming into existence after 1911, the social sciences group grew steadily until the 1940s. Suffering a drop of one-third in their share of the total budget in 1950, the group has

regained almost all of the lost ground, having 18.5% of the 1970 budget. Table 3-3 gives a detailed breakdown of funds expended by departments for 1900-1970.

Staff Resources

Technically, there are several groups of workers, all necessary to the production of research in a form which can be applied to agriculture. The principal researchers are the faculty of the Institute of Agriculture and the professional staff of the various branch stations. Civil service personnel and the professional workers (e.g., research specialist, scientist) do much of the support work and a significant portion of the research. Graduate and undergraduate research assistants perform many of the tedious, less-glamorous but essential portions of the research process. Given the paucity of data, only professional workers and principal researchers can be allocated between departments.[40/] Another group of research workers are provided by the United States Department of Agriculture, which stations workers at the University in the various departments. These workers usually have courtesy appointments to the faculty, but they are not counted in the allocation process because their presence is, in large measure influenced by factors exogenous to Minnesota.

Changes in the staff

In the 1880s, before the Station was established and Hatch Act funds made available, there was only one principal researcher. By 1900, ten staff members were distributed over seven divisions. Rapid growth increased the research staff to forty-seven in 1910, and to eighty-seven in 1920. Growth was slower in the 1920s and 1930s, reaching 129 in 1940. The

Table 3.3: Percentage Distribution of Funds, 1900-1970

Department	Percentage Distribution in Year: 1900	1910	1920	1930	1940	1950	1960	1970
Crop Related	32.86	9.14	16.04	20.01	19.98	29.01	26.77	29.97
Agriculture-Agronomy	28.97	4.67	7.01	6.01	7.68	11.40	9.35	13.41
Entomology	3.89	4.22	4.97	7.50	5.80	7.94	8.56	9.53
Plant Pathology		0.25	4.49	6.50	6.50	9.67	8.86	7.03
Animal Related	46.22	61.61	52.57	30.22	28.71	30.08	25.88	17.11
Animal & Poultry Hus.	35.42	13.26	36.51	13.87	10.91	9.82	13.20	13.60
Dairy Hus.	4.86	12.65	0.20	9.53	9.42	9.98	4.86	
Veterinary Medicine	5.93	35.69	15.86	6.82	8.38	10.99	7.78	3.51
Total: Farm-Related	78.62	70.75	69.04	50.23	48.69	59.09	52.65	47.08
Physical Sciences	21.38	29.22	22.92	33.03	33.14	28.24	30.61	34.34
Horticulture	11.77	9.26	4.75	5.87	8.46	9.38	10.06	11.24
Forestry		10.27	4.18	5.80	6.47	6.24	6.62	10.25
Soils	9.61	0.62	4.13	7.01	4.22	4.85	6.34	6.38
Agricultural Biochemistry		9.07	4.65	7.13	7.47	5.44	4.58	2.38
Agricultural Engineering	--	--	5.21	7.27	6.52	2.33	3.01	4.09
Social Sciences-Services	--	--	8.05	16.66	18.09	11.90	16.71	18.51
Agricultural Economics	--	--	1.72	7.06	7.68	8.13	8.86	9.04
Rural Sociology	--	--	--	--	0.78	1.01	1.03	1.31
Home Economics	--	--	6.33	9.60	9.63	2.76	3.30	3.59
Total Non-Farm Related	21.38	29.22	30.97	49.69	51.23	40.14	47.32	52.85

difficulties experienced by the agricultural sector during the interwar period could be responsible for this slow growth. After 1940, with the Second World War and the various post-war recovery programs, staff growth again was rapid, reaching 173 in 1950, and 311 in 1960. During the 1960s, the research interests of the Station shifted towards foreign development work. Because of the professional and official governmental emphasis upon industrialization as the way to development, agricultural efforts received relatively low priority and funding. Despite this, the size of the Station staff increased to 470 workers in 1970. Agricultural Economics and Soils, two of the non-farm specific departments, enjoyed significant staff growth, though they lagged behind Veterinary Medicine. This again supports Peterson's hypothesis.

Allocation of staff

Peterson's thesis of farm and non-farm related research and departmental growth is largely supported by the Minnesota experience. Crop and animal-related departments employed 70% of the principal research staff in 1900, and maintained their position as the dominant departments until the 1920s. In 1930, their share of total staff dropped to 45%, rising in 1940 to 50%, and to 58.3% in 1950. During the 1950s, the share of total staff of these two farm-related groups began to decline, but not until the 1960s did the share drop again below 50%, reaching 45.2% in 1970.

Separating Veterinary Medicine from the other animal departments, reveals that the medical departments have gained considerably in staff. As recent publicity involving a celebrity's pet dog indicates, much recent work does tend to dominate research work. As Table 3-4 indicates, the staff

Table 3-4: Percentage Distribution of Staff, 1900-1970

Department	1900	1910	1920	1930	1940	1950	1960	1970
Staff Size	10	47	87	106	129	173	311	467
Crop Related	30.00	29.79	40.22	24.53	31.01	28.32	23.47	17.77
Agriculture-Agronomy	20.00	10.64	13.79	6.60	9.30	7.51	7.40	7.07
Entomology	10.00	10.64	10.34	7.55	8.53	10.40	6.75	4.71
Plant Pathology		8.51	16.09	10.38	13.18	10.40	9.32	6.00
Animal Related	40.00	34.04	18.39	20.76	19.38	30.06	28.62	27.41
Animal Poultry Hus.	10.00	19.15	5.75	7.55	7.75	6.36	6.11	7.07
Dairy Hus	20.00	4.26	5.75	5.66	6.20	7.51	2.57	
Veterinary Medicine	10.00	10.64	6.90	7.55	5.43	16.18	19.94	20.34
Total: Farm-Related	70.00	63.83	58.61	45.29	50.39	58.38	52.09	45.18
Physical Sciences	30.00	34.04	36.80	41.51	35.66	30.64	25.40	26.77
Horticulture	20.00	4.26	8.05	5.66	9.30	6.36	5.46	5.14
Forestry		6.38	5.75	7.55	4.65	7.51	8.36	7.71
Soils	10.00	14.89	4.60	3.77	3.88	3.47	4.18	6.42
Agricultural Biochemistry			9.20	16.04	9.30	5.20	2.89	3.64
Agricultural Engineering	--	8.51	9.20	8.49	8.53	8.09	4.50	3.85
Social Sciences-Services	--	2.13	4.60	13.20	13.96	10.98	22.51	28.05
Agricultural Economics	--	2.13	4.60	6.60	8.53	6.94	8.36	11.99
Rural Sociology	--	--	--	0.94	0.78	1.16	0.96	1.50
Home Economics	--	--	--	5.66	4.65	2.89	13.19	11.99
Agricultural Journalism	--	--	--	--	--	--	--	2.57
Total: Non-Farm Related	30.00	36.17	41.40	54.71	49.62	41.62	47.91	54.82

remained constant, relative to other units of the Experiment Station, during the first two decades, then dropped during the decade of World War I. Growing during the prosperity of the 1920s, it again declined in the 1930s. After 1940, the share of Station staff in Veterinary Medicine has grown, reaching 20.3% in 1970. The farm animal departments, unified after 1960, are treated together. They have suffered a rather consistent decline in their share of staff since 1900. Inspite of the group's decline, the workers in dairy husbandry increased into the 1960s, reflecting the increase in dairy farming in the state.

The crop departments which are clearly farm-related: Agronomy; Entomology; and Plant Pathology, show disparate trends. Agronomy declined steadily from 1900 to 1930, then rose during the 1930s, before declining again. Entomology remained constant in relative share from 1900 to 1920, declined in the 1920s, rose in the 1930s and 1940s, then declined again relative to other departments in the 1950s and 1960s. Plant Pathology grew between 1900 and 1920, declined in the 1920s, and grew again relative to other departments in the 1930s, before decline resumed.

Non-farm related departments had considerably more variation in their staff levels, both relative to the farm-related departments, and absolutely. The "physical sciences" group employed 30% of the 1900 staff and increased its share until 1930 (41.5%). Decline began in the 1930s, lasting through 1960, when the relative share was 25.4%. During the 1960s, these departments grew, compared to other departments, increasing their share of staff to 26.8%. Horticulture and Forestry employed 20% of the staff in 1900, dropping to 10.6% in 1910. Rising to 13.2% in 1920, their share of staff remained between 13% and 14% through the 1960s. Agricultural Biochemistry and Soils

employed 10% of the staff in 1900, and averaged 13%-14% over the 1910-1940 period, except in the 1920s when the staff share increased to almost 20% in 1930. During the 1940s and 1950s, the share of staff in Biochemistry and Soils declined, reaching 7% in 1960. B7 1970, their share of staff had risen, to 10%. Agricultural Engineering, which is largely farm and agribusiness related, reached 8.5% of total staff in 1920, and remained at that level until the 1950s and 1960s, when it dropped, ultimately reaching 3.9% in 1970.

The "social sciences-services" group of essentially non-farm related departments consistently increased their share of staff, from 2.1% in 1910 to 14% in 1940. During the 1940s, this group declined in relative terms since both Rural Sociology and Home Economics had no increase in staff. After 1950, these departments again grew, reaching 28% of total staff in 1970. Both Agricultural Economics and Home Economics reached 56 staff members by 1970, Rural Sociology reached seven, and a new department, Agricultural Journalism, added twelve people to the total. On balance, the non-farm related departments increased their share of staff over the period, with approximately the same timing exhibited by the funding shifts.

Skill levels of the staff

The skill levels of the principal research staff members conventionally have been measured by the academic degrees held. By this criterion, a Doctor of Philosophy is more highly skilled than the holder of a Bachelor or Master of Arts or Science degree. As a rough indicator, this criterion is acceptable, although there no doubt have been cases where a Masters degree holder has been more productive than a person with a

Ph.D. With this codicil in mind, the degree will be used as an indicator of the average skill level of the Station research staff.

In the early years, there were two holders of the Ph.D. degree. Porter, the first Station Director, and Lugger, the Entomologist. Porter resigned in 1889, leaving Lugger the only Ph.D. holder on the staff. In 1909, there were again two holders of the Ph.D., and again one retired. In 1911, Dr. Freeman, Professor of Plant Pathology, was the only Ph.D., and there were three Doctors of Veterinary Medicine, and seven holders of the Masters degree. Thirty-two members of the 1911 staff held the Bachelors degree. The numbers of staff holding the doctorate increased to twenty-one by 1920, and grew rapidly with each successive decade. On balance, the training and skill of the staff, measured by the numbers of holders of the degree Doctor of Philosophy, increased between 1910 and 1970.

In the early years of the Station, several members of the Station staff had no formal academic training, i.e., attendance at and/or gradution from a college or university. In 1911, there were eleven such people. It is interesting to note that the lack of formal training in no way hindered Theophilus L. Haecker and Andrew Boss from making significant contributions to Minnesota's agriculture and to agricultural science. In more recent years, the staff has been made up exclusively of people with at least a Bachelors degree. This emphasis on "certifi cation," commendable though it is, is not the mark of excellence. As Boss and Haecker illustrate, experience and imagination can be as

valuable in producing competency as the formal collegiate programs. For Minnesota in the early years, like many developing nations currently, the highly certified, Ph.D. holding staff was a luxury which the state could not afford. As the state and the Station matured, such luxuries could be and were indulged. By 1970, even the branch stations were manned almost entirely by Ph.D. certified researchers.

With or without the Ph.D., an experienced staff is and was an asset to the Station and the state. Several individual staff members of the Minnesota Agricultural Experiment Station illustrate this point. Their roles were important, in some cases crucial, to the development of the Station, its related institutions, and to the further development of Minnesota and international agriculture. These "creative individuals" are exemplified by Edwin D. Porter, Theophilus Levi Haecker, Andrew M. Boss, Otto Lugger, Regent-Dean William Liggett, and Elwin C. Stakman.

With the possible exception of Dr. Lugger, of whom little is known before his arrival in Minnesota, all these men came from rural, predominantly farm backgrounds. Only three of them held the research Doctorate in Philosophy: Porter, whose degree may well have been honorary; Lugger, from a German University; and Stakman, from the University of Minnesota. In agricultural research, formal training to the doctorate has become increasingly important. However, the key variable remains, as it was in Porter, Liggett, and Haecker's time, the researcher's interest in farmers and farm problems.

Porter and Liggett were primarily administrators. Haecker and Boss were researchers who began their careers in animal work. Lugger was interested in insects, and to a lesser degree in plants; Stakman also was

interested in plants, and especially their diseases. These men were different in personality, training, and abilities. Some common features can be delineated.

Creative Individuals--An Interlude

Edwin D. Porter was appointed the fourth Professor of Agriculture in 1881. He established close working realtions with the leading men and organizations in Minnesota, and brought the expertise, such as it was, of the agricultural colleges to the farmers through the Farmers' Lecture Courses. He persuaded the Regents of the University to acquire new, more suitable land for the experimental farm. Responsible for organizing the College and Station under the terms of the Hatch Act of 1887, he also hired the first members of the Corps of Experimentation. Under his administration, the School of Agriculture was opened, and the union between the College and the Station was delineated. Though the structure he built in 1888-1889 has been modified considerably over time, he laid the foundations of the Institute of Agriculture, Forestry, and Home Economics, and pointed out the directions it should/would take in fulfilling its missions of teaching, research, and extension in the service of the people of the state, and of other states and nations.

Colonel William Liggett, one of Porter's successors, was a St. Paul lumberman and entrepreneur. Deeply involved in public service and politics, he was a Regent of the University, and served primarily upon the Agricultural Committee of the Board. When Directors McLain and Smith resigned, frustrated with the quarrelous staff, Liggett was appointed the Chairman of the Corps of Experimentation. Judicious use of his authority

as a Regent, his prestige, and (most important) his considerable diplomatic skills, enabled Liggett to re-establish the central authority of the Station-College administration. In 1896, the Office of Director of the Station was re-established, and Colonel Liggett, already Dean of the Department and the College, became Director of the Station. He held the joint position of Dean of the Department and Director of the Station for eleven years, retiring in 1907, less than a year before his death. A guiding personality in the early years of the College-Station, he recreated and strengthened the central administrative arrangements which, with minor modification, have continued. Respected by his staff, by the legislature, and by the general public, his tenure as Dean, Chairman and Director, enchanced the position of the Station in the eyes of the farmers and their organizations, and made the work of the Station and College more acceptable throughout the state.

Theophilus Levi Haecker joined the Station staff in 1891. From 1901 to 1915 he was head of the Dairy and Animal Husbandry Divisions of the Station. The dairy cattle feeding standards which he developed in the 1890s were used nationally into the 1930s. A strong advocate of cooperatives, he was the "father" of the cooperative creamery movement in Minnesota. Skilled in disseminating the knowledge gained from his experiments, Haecker made a significant impact on Station-farmer relations. Andrew Boss, in 1935, wrote of Haecker:

> He exerted an influence upon practical dairy feeding practices that was equal to or greater than that of any other man in this country.[41]/

Andrew Boss graduated from the preparatory School of Agriculture at University Farm in 1891, and was appointed farm foreman in May of that

year. Without academic training beyond the high school level, Boss was appointed Assistant (Professor) in Agriculture in 1897; Associate Professor in 1902; and was promoted to Professor and Chief of Agriculture and Animal Husbandry in 1905. He later served as the Chief of the Division of Agronomy and Farm Management, and was the Vice Director of the Station for many years. In 1894, Boss offered the "first meat course...in any agricultural school or college in the United States or Canada." He and Professor Willet M. Hays, later Assistant Secretary of Agriculture, U.S.D.A., initiated studies of farm management, beginning with experimental plots in the 1890s, and route surveys in 1902. These studies, the foundation of agricultural economics, continued until 1948, when a new series of farm management studies were initiated by George Pond and others.[42/]

Dr. Otto Lugger came to the Minnesota Station and College as Chief of the Division of Entomology and Botany in 1888. Formerly an entomologist, with the USDA, Lugger traveled extensively throughout Minnesota combatting insect infestations. A pioneer in flax wilt research, Lugger opened the field and attracted the attention of others who, benefitting from his mistakes, including an incorrect working hypothesis, made significant progress in determining the causes of flax wilt. In the years before insecticides, grasshopper plagues were frequent, greatly feared occurrences. Lugger's knowledge was in great demand. The willingness of this German professor to get his feet dirty in the farmers' fields greatly endeared him to the farmers of the state and had considerable public relations impact, as did his successes in combatting the plagues of grasshoppers and other insect pests.[43/]

Elvin C. Stakman came to Minnesota as a student. After graduation from the College of Arts, Letters, and Sciences, he taught high school for

time, then returned, to the College of Agriculture, where he received his doctorate in Plant Pathology in 1913. Serving first under Dean Freeman, then Chief of the Division of Plant Pathology, Stakman soon became Freeman's successor. He worked closely with the U.S.D.A. as a collaborator, pathologist in charge of Barberry Eradication, and as pathologist-agent for the Bureau of Plant Industry, in attacking cereal rusts. Until his retirement, the joint Minnesota Station-U.S.D.A. research efforts on cereal rust were conducted by Stakman and the Division of Plant Pathology. This joint program, informal under Stakman, was institutionalized as the U.S.D.A. Cereal Rust Laboratory, so that it could continue as an effective part of the international and national efforts to combat cereal rust infestations. Internationally known for his expertise, Stakman helped establish the Rockefeller Foundation's program in Mexico in the early 1940s, the program which Norman Borlaug, one of Stakman's students became famous for.[44/]

All six men were noted for their commanding presence, leadership ability, and diplomatic skills. Each, by formal and/or informal training, made himself an expert administrator-researcher. Working within the institutional framework of the land grant college-experiment station, each of these men contributed to the modification and development of that structure. Porter's and Liggett's contributions are clear in this regard. Less obvious are Boss's subtle modifications. Boss also contributed to the formation of a discipline, farm management-agricultural economics.

Porter built the basic institutional structure, and Liggett rebuilt and modified that structure. Lugger's work with farmers, and Haecker's work disseminating his research findings and proselytizing cooperatives pointed the way towards the institutionalization of agricultural extension.

Boss, as Vice Director, modified the structures to accept basic and applied research, and moved the Station in that direction. In the process of solidifying the structure, Boss left room for the idiosyncracies of the individual researcher. Stakman's modus operandi thrived within, perhaps despite, the framework Boss developed. When Stakman, a forceful, imaginative person, retired, the work he had led was institutionalized to ensure its continuation.

As the Station matured, the characteristics of the outstanding individuals, the research entrepreneurs, has changed. The first innovators were commanding figures, and their immediate successors worked within the basic framework they developed. Haecker, Lugger, and Stakman all were research workers with administrative responsibilities. Boss, also a researcher, affected the entire structure of the College-Station-Extension Service. Most recent individuals have largely worked within the institutional framework of the Department or Institute of Agriculture to modify that structure. These modifications with the exception of the changes which Dean Harold Macy introduced in 1952-1954, have been small ones, but no less important. Throughout the entire process of structural innovation and change, the objective has been to create and recreate an orderly system which allows central direction and the freedom and flexibility which the creativity of individual and team researchers demands.

Resource Inputs Over Time

As indicated, the staff and funds allocated to farm-related research has tended to decline as the farm sector's share of income in the state has declined. Non-farm related departments have tended to increase their share of staff and funds as the non-farm sector's income has risen. The

allocation of staff and funds within the Station have not moved consistently. The farm-related departments have tended to have a larger share of funds then their share of staff would indicate. On a per-staff member basis, the farm-related departments have maintained their commanding hold on the Station's budget, the result of need for more facilities, support personnel, and expensive animals than in the other, non-farm departments. Much of the allocation of resources does parallel the structure of the state economy and the agricultural sector, indicating that factors outside the Station, i.e., some form of non-price signals, are influencing the allocation of resources and the subjects of research.

NON-PRICE SIGNALS

Research institutions in the public sector are not guided by market prices in the production of knowledge. In place of market prices, a variety of non-price signals operate to induce changes in research topics, areas, and resource allocation between topics, departments, etc. Legal constraints and inducements to research are one such set of signals. Another set of signals includes requests from farmers, from farmer cooperatives, private industry, and governmental agencies for research in a particular area or on a particular subject. Feedback mechanisms which provide the researchers with measures of the utility of their work also serve to direct and redirect research efforts. Changes in the state and regional agricultural sector, such as shifts in crops, between animal types, and between crop and livestock farming, all provide signals to the agricultural experiment station and agricultural research system.

Non-price signals are items external and/or internal to the Station. External signals include requests and commands from both the state legislature

and the federal congress; state executive requests, contracts, and orders; and federal, especially U.S.D.A. requests, grants, contracts, and orders. Also included in the set of external signals are individual requests from farmers, farm groups, and agri-business firms, and grants and contracts from groups and firms. Foundations, through grants, both approved and rejected, also serve to direct research and resource allocation. Internal signals encompass reports from Agricultural Extension Service agents of problems and needs of farmers; staff perception of needs in advance of or at the same time as farmer recognition; and "peer" pressure to do "appropriate" research within the context of the researcher's own discipline.

Initial Signals

Legal constraints and inducements include such devices as prohibition of specific lines of research, or encouragement of other lines, often through the appropriation of money for specific projects. At the Minnesota Station, the legislative appropriation has frequently been used to guide or force research on a variety of topics. In the production of new knowlege, the Station's allocation of labor and capital are limited or extended by this legislative, and executive, interference in the process of research selection.

Farmers, directly or indirectly, have requested information from the Station. When the need is urgent and shared by many farmers, the direct requests are often supplemented by indirect requests. Indirect requests can be transmitted through the extension agents, through farmers' organizations and cooperatives, or through legislators and the executive branch. When the Schools of Agriculture were in operation, the students served as another source of information on the problems faced by farmers, and provided a formal contact between branch station staff and farmers.

Farmers' organizations, farm cooperatives, and private industry also provide stimuli to direct research. Either through requests for information or through the granting of funds or contracts to finance research on topics of their choice, these groups have become more important in guiding research efforts. Frequently, the Station staff and the extension service work closely with trade groups and groups of farmers, e.g., livestock producers, either as observers, or as members of the groups. This close contact often produces research work based on long-term familiarity with the needs of farmers, cooperatives, and the processing industries. These private signals, unlike many of the governmental signals, can be ignored. Crucial needs often are signaled directly through private and individual channels, and indirectly through legislative or other governmental channels as well.

Individual researchers, through their knowledge of their fields of expertise, often select research topics which meet the needs of various groups. In some cases, the need which is obvious to the researcher, has not yet become obvious to the farmer or agribusinessman. Another factor in the selection of research topics is the personal interest of the researcher in a particular problem or line of work. This interest may result from long exposure to related problems, or from an increase in the popularity of the problem amongst the researcher's fellow subject-matter colleagues, nationally and internationally, not just locally. Regardless of the basic motive, the researcher frequently selects lines of work which yield knowledge which is of immediate or long-run benefit to farmers and other knowledge consumers.

Some illustrations of initial signals may be helpful. In 1889, Otto Lugger began studying flax wilt at the request of farmers, relayed as an

indirect external signal through the governor of the state via the Board of Regents. The production of hog cholera serum by the Station originated in state legislative decision and appropriation. State and federal urgings resulted in the development of rural sociology and home economics divisions and research, and in agricultural economics work on land use, rural taxation, and related matters.

Federal urgings and orderings can be seen in the development of regional cooperation in research, in the furthering of cereal rust research, and in the beginnings of basic research.[45/] U.S.D.A. supervision of the uses of research funds provided by the department limited uses in undesired fields while encouraging, perhaps forcing work in other lines.

Other examples include the state legislature forcing soybean research by special appropriations for that line of work. Brucellosis work represented a fusing of various interests and signals which led to Station support of that line of research. The Diary Herd Improvement and Minnesota Crop Improvement Associations have sponsored some work, and horticultural work, especially fruit breeding, was stimulated and encouraged by the State Horticultural Society.

Some significant work was begun out of staff interest in the subject. Agronomists studying the physical production of crops found that costs of production were important. Finding the data from experimental plots of limited value, they began collecting data from cooperating farmers, aided by the U.S.D.A. Bureau of Statistics. Out of this came the farm management work of the Station. Some soils studies, funded by private sources, were started by staff scientists for professional reasons or in response to a perceived need.

T. L. Haecker came to Minnesota in 1891 to serve as an animal husbandryman with allied work in dairying. In the 1890s, dairying began to increase in importance in Minnesota, and Haecker, in two ways, led the development. First, he encouraged the formation of creamery cooperatives owned by participating dairy farmers. In addition to providing the farmer with a better price for his product, the cooperatives owned by participating dairy farmers. In addition to providing the farmer with a better price for his product, the cooperatives formed a model for other types of cooperative ventures. Second, Haecker developed a dairy cattle feeding standard which increased milk yield and produced a better level of butter fats.

These non-price signals were transmitted from external sources in several non-exclusive ways, using farmer originizations, extension agents, legislators, and other direct and indirect routes. Appropriations or refusal to appropriate money can direct research into or away from various subjects. Political pressures upon administrators and other Station staff members, threatening funding termination, etc. are also potent, though infrequently used methods of directing research and resource allocation.

These non-price signals are analogous to price changes facing the firm in their impact upon Station work. Price changes are more direct and immediate, ignored at the peril of business failure. Changes in the non-price signals do not usually carry this terminal threat, and are not usually as immediate and direct.

Feedback Signals

Feedback mechanisms which inform the researcher of the success or failure of his efforts also serve to direct research work. If the work is useful and the application successful, the researcher will be encouraged

to continue such work. If the results were not useful and/or the applications were failures, the researcher should be encouraged to determine why his advance did not work, why his knowledge production was deficient. In both extremes, the results are positive. Work which is repeatedly rejected by the knowledge consumers (farmers, businessmen, etc.) will signal to the Station and to the researcher that a misallocation of resources has occurred. If the signals point to misallocation, other signals will at the same time be pointing to areas of research in which those resources could be used more efficiently.

Changes in the feedback mechanisms occurs slowly over time. The initial feedback mechanisms were haphazard, operating by chance rather than by design. The Schools of Agriculture provided an formal mechanism through which feedback signals could be transmitted. The Farmers' Lecture Courses-Farmers' Institutes-Agricultural Extension Division of the Station-Agricultural Extension Service, over time, provided an increasingly coherent and useful formal structure for disseminating the knowledge product of the Station and a structure through which farmers and other consumers could make their needs known and could comment upon the utility of the knowledge product of the Station (i.e., feedback responses).

Non-price signals were and are effective in directing research and resource allocation at the Station. Unlike price signals, which reflect consumer utility, non-price signals reflect expected consumer utility and/or producer (i.e., researcher) utility. Because research in public institutions originates in expected fulfillment of needs or expectations.

By contrast, privately sponsored and conducted research is ultimately based on profits expected from the research. While both operate on the basis of expectation, the private sector tends to favor research which has a high probability of returns to the company for its investment. Public research tends to center in areas in which the profit cannot be captured, since the benefits accrue not only to the producer of the knowledge, but also to the user of the knowledge, and to the larger society which uses farm products.

IMPLICATIONS

The Minnesota Agricultural Experiment Station's development offers some implications for other Stations, and especially for less developed nations planning or having recently created an agricultural research system. These implications are not per se tied to the land grant college model, though that has colored the Minnesota experience. First, researchers do not, in the early years have to have the highest credentials, i.e., the Ph.D. What is important is that they be qualified to do research intelligently, and that they are interested in serving the agricultural interests, all of them, not just the wealthiest, rather than their own careers.

Second, central direction of research administration is necessary. However, that central direction should be flexible, allowing researchers to propose, on the basis of their own knowledge of farm problems, and on the basis of other non-price signals, lines of work. The central decision-making should allocate resources and select personell not on the basis of politics but rather competency, and should give the staff wide ranging freedom of choice, reserving only the approval-disapproval function

to the central administrators. An addenda here is that in the early years, the administration need not be complex, but rather simple, with few non-research administrators. Minnesota functioned with one "secretary" and a director.

Third, the staff should not be encouraged to go the route of basic research, however, that is defined within the context of their various disciplines. In the early years, they should be encouraged, perhaps forced, to do applied and developmental work, which has a vastly higher pay-off to the society of the average LDC. The developed countries are quite capable of and have the resources to fund the basic research. For the LDC, the first order of business is not the enchancement of scientific reputations, but rather the improvement of their agricultural sector and its productivity. For this, basic research is not necessary. What is necessary is the modification of existing technology to the conditions of the country.

In the early years of Minnesota, these factors are found operating. The result is spelled out in the growth, the phenomenal growth, of the agricultural sector of the state. Not all of this growth in output and increased productivity is due to the Minnesota agricultural research system. Much is due to the efforts of the private sector, developing appropriate technologies, marketing them, and providing extension type contacts with farmers. LDCs should not "put all their eggs in one basket," the basket of public research. The private sector, motivated by profit, is as interested in the successful development of the agricultural sector as any patriotic bureaucrat. Only in the exceptional case should the public sector be given monopoly status in agricultural research.

FOOTNOTES

*Parts of this chapter were taken from "Science for the Farmer: The Development of the Minnesota Agricultural Experiment Station, 1868-1910," Agricultural History, 42 (1974):202-214, with permission of the publisher.

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1/ The federal-state agricultural research system is discussed in I. Arnon, Organization and Administration of Agricultural Research (London: Elsevier Publishing Co., Ltd., 1968), especially pages 5-18; H. C. Knoblauch, et. al. State Agricultural Experiment Stations: History of Research Policy and Procedures, U.S.D.A. Miscellaneous Publication No. 904 (Washington, D.C.: U.S. Government Printing Office, 1962); A. C. True, A History of Agricultural Extension Work in the United States, 1785-1923, U.S.D.A. Miscellaneous Publication No. 15 (Washington, D. C.: U.S. Government Printing Office, 1928); and A. C. True, A History of Agricultural Experimentation and Research in the United States, 1607-1925, U.S.D.A. Miscellaneous Publication No. 251 (Washington, D. C.: U.S. Government Printing Office, 1937).

2/ Maury E. Bredahl and Willis L. Peterson, "The Productivity and Allocation of Research at U.S. Agricultural Experiment Stations," University of Minnesota Department of Agricultural and Applied Economics Staff Paper P76-3 (St. Paul: 1976); Robert E. Evenson, "The Contribution of Agricultural Research to Production," Journal of Farm Economics, 49(1967): 1415-1425; Zvi Griliches, "Research Costs and Social Returns: Hybrid Corn and Related Innovations," Journal of Political Economy, 66 (1958): 419-431, and "Research Expenditures, Education, and the Aggregate Agricultural Production Function," American Economic Review, 54 ( ): 961-974; Willis L. Peterson, "Returns to Poultry Research in the United States," Journal of Farm Economics, 49 (1967): 656-669; A. Schmitz and D. Seckler, "Mechanized Agriculture and Social Welfare: the Case of the Tomato Harvester," American Journal of Agricultural Economics, 52 (1970): 569-577; and Theodore W. Schultz, Economic Organization of Agriculture (New York: McGraw-Hill, 1953).

3/ For a detailed discussion of these problems in a theoretical context, see Lance E. Davis and Douglass C. North, Institutional Change and American Economic Growth (New York: Cambridge University Press, 1971). The discussion here draws on Knoblauch, et. al., State Agricultural Experiment Stations, pp. 1-80; Fitzharris, "Science for the Farmer...," Agricultural History, 42 (1974): 202-205; and Andrew Boss, Minnesota Agricultural Experiment Station, 1885-1935, Bulletin 319 (St. Paul: Minnesota Agricultural Experiment Station, 1935), pp. 5-11.

4/ Edgar C. Dunn, "Peter Gideon: Pioneer Horticulturist," Minnesota History, 44 (Fall, 1974): 96-103.

5/ James Gray, The University of Minnesota, 1851-1951 (Minneapolis: University of Minnesota Press, 1951), p. 59; University of Minnesota, Board of Regents, Biennial Report for 1881-1882, pp. 7-8.

6/ Davis and North discuss this at some length in Institutional Change, pp. 20-37.

7/ See Knoblauch, et. al., State Agricultural Experiment Stations; and True, History of Experimentation and Research ...

8/ Histories of the various Land Grant Colleges, e.g., Gray, The University of Minnesota, illustrate the impact of the Civil War.

9/ Paul Waggoner, The Agricultural Experiment Station and the Human Condition; a Centennial Lecture Presented to Sigma Xi (Durham, N.H.: New Hampshire Agricultural Experiment Station, 1975).

10/ True, History of Agricultural Experimentation and Research ... pp. 82-106, lists a number of state stations established before the 1887 Hatch Act, but does not list the Minnesota Station, despite his inclusion of other "paper" creations, i.e., those without funding.

11/ Boss, Minnesota Agricultural Experiment Station, pp. 5-7; Minnesota State Agricultural Society, History of the Minnesota State Agricultural Society, 18 -1910 (St. Paul: McGill-Warner, Co., 1910), passim, Fitzharris, "Science for the Farmer," pp. 202-205.

12/ James Gray, The University of Minnesota, 1851-1951, pp. 13-35, 55 ff.; University of Minnesota, Board of Regents, Ninth Annual Report ..., 1868; p. 9; Andrew Boss, Minnesota Agricultural Experiment Station, 1885-1935, Minnesota Agricultural Experiment Station Bulletin 319 (St. Paul, 1935), pp. 5-8; W. S. Chowen, "A Brief History of the Part Taken by the Patrons of Husbandry in the Establishing of the Experimental Farm and Farm School ...," and C. P. Bull, "An Unbalanced Credit for the Development and Establishment of the Central School of Agriculture, University of Minnesota," Supplement 7, Example 3b, AL1.1 #1 and Supplement 10, Example 6, AL1.1 #2, University of Minnesota Archives, Minneapolis; Agricultural College [Glencoe], Board of Regents, First Annual Report..., 1867, passim.

13/ Regents, 1868, p. 10; Regents, 1869, p. 8; Regents, 1871, pp. 6-7; Regents, 1872, pp. 10, 35; Regents, 1874, pp. 8-10; Regents, 1881-1182, pp. 7-8; "Directors of the Station," Agricultural Experiment Station Info. File, University of Minnesota Archives; Bill W. Kennedy, "The Land-Grant Movement and Its Influence on Scientific Agriculture in Minnesota," The Minnesota Academcy of Science Proceedings, 30:1 (1962), p. 93.

14/ Gray, University of Minnesota,59; Regents, 1881-1882, pp. 7-8; "Directors of the Station," Info. File, University of Minnesota Archives; Kennedy, "Land-Grant Movement," 92-97.

15/ University of Minnesota, Department of Agriculture, Biennial Report, 1881-1882 in Agricultural Experiment Station, Biennial Report, 1885-1886 (St. Paul, 1887), pp. 113-14.

16/ Ibid., 116-27; Regents, 1881-1882, pp. 12-14, 90-95.

17/ Regents, 1878, 9; Regents, 1881-1882, pp. 12-13; Regents, 1883-1884, pp. 12-14; University of Minnesota, Department of Agriculture, Biennial Report, 1881-1882, pp. 116-27.

18/ University of Minnesota, Agricultural Experiment Station, Biennial Report, 1886, pp. 133 (hereafter, Station, Biennial).

19/ Station, Biennial, 1886, pp. 128-29; Regents, 1885-1886, pp. 27-28; Regents 1887-1888, p. 7; C. P. Bull, "History of the School of Agriculture," typescript, Example 11b, AL1.1 #15, University of Minnesota, School of Agriculture Papers, 1885-1947, University of Minnesota Archives; Andrew Boss, "Achievements of the Minnesota Experiment Station," in Agricultural Research Through Fifty Years, 1885-1935, Minnesota Agricultural Experiment Station (St. Paul, 1936), typescript in the Agricultural Experiment Station Info File, University of Minnesota Archives; Kennedy, "Land-Grant Movement," pp. 93-95.

20/ Station, Biennial, 1887-1888, and subsequent years, passim; University of Minnesota, Agricultural Experiment Station, Annual Report, 1896, pp. viii, xiv (hereafter, Station, Annual); T. Kommedahl, J. J. Christensen, and R. A. Fredericksen, A Half Century of Research in Minnesota on Flax Wilt Caused by Fusarium Oxysporium, Agricultural Experiment Station Technical Bulletin 273 (St. Paul, 1970), pp. 7-8; Corps of Experimentation, "Minutes of the Experiment Station Corps, 1885-1909," 30 January 1892,1 (unpaged); [10], AL1.1, vol. 42, and ibid., 17, December 1888, 11:10, AL1.1, vol. 43, University of Minnesota, School of Agriculture Papers, 1885-1947, University of Minnesota Archives.

21/ Regents, 26 April 1888 in Station, Biennial, 1887-1888, pp. 58-61; Station, Annual, 1890, p. 10.

22/ Station, Annual 1890, p. 10; Corps of Experimentation, "Minutes of the Experiment Station Corps, 1885-1909," 22 October 1889, 11:43, AL1.1, vol. 43, University of Minnesota, School of Agriculture Papers, 1885-1947, University of Minnesota Archives.

23/ Conversations with Deans H. J. Sloan and H. Macy, 28 November 1972; and with Dr. W. Hueg, Director of the Minnesota Agricultural Experiment Station, 11 January 1973; "Faculty Letter, Spring 1964/65, College of Agriculture, Forestry and Home Economics, Appendix A, Comments by Director Sloan and Dr. Hueg Summarizing Experiment Station Activities," Agricultural Experiment Station Info File, University of Minnesota Archives.

24/ See Station Annual, 1896, 1910, 1911, 1912; University of Minnesota, Department of Agriculture, Agriculture in Minnesota (St. Paul: 1929), p. 34; Station, Annual, 1957-1960.

25/ Interviews with Superintendents Ralph Smith (Morris), 18 July 1973; Youngquist (Crookston), 30 July 1973, Matamalaki (Grand Rapids), 31 July 1973; Nelson (Lamberton), 27 August 1973, and Anderson (Waseca), 27 August 1973; and former Superintendent Mark Thompson (Duluth), 21 August 1973.

26/ Editors, The Moccasin, "A History of the West Central School of Agriculture, Institute of Agriculture, University of Minnesota," The Moccasin, 1963, vol. 50, passim; Station, Annual, 1952-1960; discussions with Emeritus Dean Harold Macy in 1973-75.

27/ For example, basic (fundamental) research is the work on how genes combine, applied research uses this knowledge of genes to develop breeding techniques, and developmental research applies these breeding techniques to the production and maintenance of new strains of plants or animals.

28/ In Table 3-1, group b (1940-1972) is the basic research group; group a (1940-1972) is the applied group.

29/ Station, Biennial, 1885-1886, passim; Boss, Minnesota Agricultural Experiment Station, 1885-1935, 8-10, 14-34; University of Minnesota, Agricultural Experiment Station, The Minnesota Agricultural Experiment Station (St. Paul, University Farm, 1925), unpaged, [11, 17, 23-25]; "In all such work the Station has the close cooperation of the Minnesota Crop Improvement Association" (ibid., [7]).

30/ University of Minnesota, Agricultural Experiment Station, The Minnesota Agricultural Experiment Station, [17, 21-29].

31/ Boss, "Achievements of the Minnesota Agricultural Experiment Station," 9-10.

32/ Interview with Dr. Wesley W. Spink, 7 September 1973; and Modern Medicine, 31 (9 Dec. 1963); pp. 86-87.

33/ Willis L. Peterson, "The Allocation of Research, Teaching, and Extension Personnel in U.S. Colleges of Agriculture," American Journal of Agricultural Economics, 51(1969): pp. 41-56.

34/ Minnesota Agricultural Experiment Station, "Budget Books," 1920-date, in the Office of the Director; for 1888-1919, see Station, Annual, and the annual reports of the Board of Regents.

35/ Interview with Ralph Smith, Superintendent of the West Central Station (Morris), 18 July 1973.

36/ Peterson, "The Allocation of Research...."

37/ Peterson defines departments as farm related or non-farm related on the basis of their relationship to farm or nonfarm income in the state, except for Horticulture, Poultry, and Dairy, which were most closely related in regression analysis to production changes in the respective industries. These categories are changed in that Agriculture, Agronomy, Entomology, and Plant Pathology are designated farm crop related; and Animal and Poultry Husbandry and Dairy Husbandry (now known as the Animal Sciences) are designated farm animal related. See notes 38 and 39 below.

38/ For the purposes at hand, Horticulture, Forestry, Soils, Agricultural Chemistry, and Agricultural Engineering are designated the physical sciences-technology group, and are assumed to have moved from farm-related to non-farm related status between 1900 and 1970.

39/ Agricultural Economics, Rural Sociology, the units in the College of Home Economics, and Agricultural Journalism are treated as the social sciences-services group in this analysis.

40/ Staff data comes from the listings of the staff in the various Station Annual Reports, and from U.S.D.A., Professional Workers in State Agricultural Experiment Stations, Miscellaneous Publications Series (to 1949); Agricultural Handbook Series after 1949.

41/ Boss, Minnesota Agricultural Agricultural Experiment Station, 1885-1935, p. 35.

42/ Oscar B. Jesness, et. al., Andrew Boss, Agricultural Pioneer and Builder (St. Paul: Itasca Press, 1950).

43/ Kommedahl, Christensen, and Frederickaen, A Half-Century of Research in Minnesota on Flax Wilt ..., Minnesota Agricultural Experiment Station Technical Bulletin 273 (St. Paul: 1970), pp. 7-8; and Boss, "Achievements of the Minnesota Experiment Station," in Agricultural Research Through Fifty Years, 1885-1935, Minnesota Agricultural Experiment Station Bulletin 327 (St. Paul: 1936).

44/ E. C. Stakman, Richard Bradfield, and Paul C. Mangesdorf, Campaigns Against Hunger (Cambridge, Mass.: Harvard University Press, 1967). There is at least a fairly good popular biography of Norman Borlaug, which covers Stakman and his influence in considerable detail.

45/ The "Act of 1935 Providing for Agricultural Research and More Complete Endowment and Support of Land-Grant Colleges, popularly known as the 'Bankhead-Jones'Act" begins. "Section 1. The Secretary of Agriculture is authorized and directed to conduct research into laws and principles underlying basic problems of agriculture in its broadest aspects...." Or, the Stations were directed to use the additional monies to fund basic research. Knoblauch, et. al., State Agricultural Experiment Stations, p. 223, From the beginnings of the Office of Experiment Stations, A. C. True pushed for basic research, see Charles E. Rosenberg, "The Adams Act: Politics and the Cause of Scientific Research," Agricultural History 38 (1964): pp. 3-12.