12-1-1990

A history of the New Hampshire Agricultural Experiment Station 1887-1987, Station Bulletin, no.529

Collins, W. M.

New Hampshire Agricultural Experiment Station

TION BULLETIN 529 December, 1990

A HISTORY OF THE NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION 1887-1987

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF NEW HAMPSHIRE
DURHAM, NEW HAMPSHIRE 03824

ISSN: 0077-8338

A HISTORY OF THE NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION 1887-1987

by

W. M. Collins

CONTENTS

CONTENTS (Cont'd.)

FOREWORD

As current Director of the New Hampshire Agricultural Experiment Station, I have been pleased to be a participant in the events that celebrated the 100th year. I particularly wish to thank those who planned those events and those who worked on this Station history. Very special thanks go to author Walter Collins.

A planning committee of active and retired faculty decided to hold two major events: a symposium entitled "Changing Opportunities in New Hampshire Agriculture and Biological Industries" and a following workshop entitled "New Directions in Agricultural and Natural Resources Research" (see Appendix 7). The committee also proposed that a history be written to record the accomplishments of Station people from the beginning in Hanover to the present. This special Station Bulletin is the fruition of that planning.

As part of the Centennial Symposium, we awarded three New Hampshire citizens special certificates for their contributions to the state's agriculture and natural resources. Stacey W. Cole served this college for many years as a member of the Board of Trustees and had a profound influence on New Hampshire agriculture as a farmer and a member and officer in farm organizations. Elwyn W. Meader, plant breeder in the Station for 18 years, introduced and developed many new plant varieties that have had a significant influence on farming and gardening in the U.S. and beyond. Theodore Natti is a 1949 UNH Forestry graduate who served the state's forest industry in several capacities, and in his 19 years as State Forester, initiated and improved many programs that benefit sustained harvest and marketing of timber. These awards, which began in the Centennial year, will become an annual event.

The New Hampshire Agricultural Experiment Station represents a solid 100 years of accomplishments. The success story of American agriculture is well known, and many of New Hampshire's contributions are recorded in this history. The N.H. Senate and House of Representatives in General Court convened on April 30, 1987 and proclaimed 1987 to be the centennial year of the New Hampshire state agricultural experiment station (see Appendix 1).

Research is the foundation upon which agriculture must build to remain viable. As pointed out in the Centennial symposium and workshop, more emphasis will be placed on basic research as we enter our second century. Only then can we improve production effficiency and at the same time be more responsible stewards of our environment. We also will see the public play a

more important role in setting policy on management of resources and of the technologies we use for that management.

The College of Life Sciences and Agriculture and the New Hampshire Agricultural Experiment Station have three major thrusts: agriculture, biology, and natural resources. As we stand at the beginning of the next 100 years, we see ourselves well positioned to meet the challenges and to set positive directions for the future.

Thomas P. Fairchild, Director
New Hampshire Agricultural Experiment Station

T. P. Fairchild, Dean and Director

PREFACE

The writing of this history of the New Hampshire Agricultural Experiment Station was undertaken to recognize the first 100 years of the Station and look toward the second century. The history concentrates on the changes in the breadth, depth and sophistication of the Station research, on the Station and departmental leadership, and on the work and productivity of individuals and teams of scientists. Biographical information is given on some personnel who made significant contributions to the steady evolution of agricultural research. Many Station scientists received national and international recognition for their contributions and brought credit to the Station, the University and the State.

The primary sources of information were five New Hampshire Agricultural Experiment Station series of publications (Bulletins, Technical Bulletins, Research Reports, Scientific Contributions, and Research Highlights), the Bulletins of the New Hampshire College of Agriculture and the Mechanic Arts, and Bulletins of the University of New Hampshire (Catalog Issues). Historical perspectives and some biographical information were taken from E. B. Sackett's, *New Hampshire University — The Story of a New England Land Grant College.*

A number of individuals gave valuable assistance in the preparation of this manuscript: D. M. Lane, Biological Sciences Branch Librarian, Dimond Library; C. E. Stone and F. R. Hallahan, Biological Sciences Library; T. Dodge and T. MacGregor, Special Collections, Dimond Library; W. A. Condon, Chairman, Department of Animal and Nutritional Sciences; and M. E. Coburn, Secretary, Department of Animal and Nutritional Sciences. Beginning chapters include considerable information drawn from an unpublished history of the early years of the New Hampshire Station written by A. E. Rich, former Associate Dean of the College of Life Sciences and Agriculture and Professor of Plant Pathology, Emeritus. Rich also critically reviewed two draft copies of the manuscript. Two drafts were reviewed by H. A. Keener, former Director of the New Hampshire Agricultural Experiment Station and Dean Emeritus of the College of Life Sciences and Agriculture. H. W. Hocker, Chairman, Department of Forest Resources, also reviewed two drafts of the History and offered constructive suggestions. D. G. Routley, Professor of Plant Science, and W. E. Urban, Jr., Professor of Biometrics, facilitated the editing and publishing.

G. E. Frick, Adjunct Professor of Resource Economics, and D. E. Morris, Associate Professor of Resource Economics, assisted in the research and writing of the sections on Agricultural Economics and/or Resource Economics particularly in the last four chapters. R. L. Taylor, Assistant Professor of Animal Sciences and Genetics, contributed to the preparation of Figure 1.

These acknowledgments would not be complete without reference to the contributions of my wife, Charlotte, who read the manuscript, provided editorial suggestions for clarity and consistency, and manifested infinite patience throughout the process.

It is clear that not every contribution could be included in a publication such as this. The author assumes responsibility for the selection and any errors of omission, fact, or interpretation.

The idea of applying scientific investigation to agriculture originated in Scotland and Germany in the mid-1800s. In 1862 the United States Congress passed the Morrill Act to provide grants-in-aid to the states for the establishment of colleges which would teach agriculture and the mechanic arts. Twenty-five years later the Hatch Act authorized establishment of the land-grant college agricultural experiment stations. The New Hampshire Agricultural Experiment Station was formed by "legislative assent" in August of 1887 as a department of the New Hampshire College of Agriculture and the Mechanic Arts, at Hanover. The Hatch Act then provided the New Hampshire College with $15,000 annually for research.

Some 300 years ago, New Hampshire was almost completely covered by forest. By the mid-1800s, there were over 30,000 farms in the state, but by 1970 less than 3,000 remained. Industrial expansion accompanied the decline in agriculture, and much of the acreage once used for farming reverted to forest. Today, approximately 85 percent of New Hampshire is forested, a fact that impacts heavily on the present economy of the state.

Early research emphasized ways of improving fertility of "run out" soils depleted by continuous cropping. By the mid-1930s, increasing specialization in various fields of science required a cooperative attack on agricultural problems by researchers in different departments. In time, applied research failed to meet the needs, or interests, of certain segments of the agricultural community and some scientists undertook more basic investigations.

Social and economic problems of rural New Hampshire were investigated early by Station scientists even though the major research thrust was to increase agricultural production. Extending electricity to the farm and farm home was an active Station project beginning in 1925. Eleven years later, over 60% of New Hampshire farms had electricity, a higher percentage than in any other state.

The Great Depression of the 1930s, evidenced by falling milk and potato prices, credit difficulties of farmers, and depressed buying power of consumers, prompted labor efficiency studies in dairying, the state's major agricultural enterprise. Action agencies established under the New Deal requested many types of information which Station personnel were called upon to provide. The Civil Works Administration asked the Experiment Station to organize projects and conduct studies which involved groups of office and other white collar workers.

The role of the Station changed dramatically during World War II. Calling of researchers into military service necessitated project termination, suspension and/or revision. Emphasis turned to areas such as conservation of trucking facilities, gas, tires, labor, animal protein. Studies were done to find ways to increase production of roughage on dairy farms.

Following World War II, strong emphasis was placed on marketing of agricultural products because of the belief that if the high levels of production attained during the war were allowed to continue, another depression might be triggered.

In 1962, the McIntire-Stennis Act facilitated an expansion of forestry research defined to include reforestation, woodland and watershed management, outdoor recreation, wildlife habitat, and wood utilization. During the same period, research on pesticides and environmental protection was begun following earlier work in the 1940s and 1950s on DDT and other compounds for crop and livestock protection. Kendall Hall was built in 1970 and Nesmith Hall remodelled using funds earmarked by Congress under the Research Facilities Act of 1963, plus other state funds.

The Sociological and Rural Development Act (1972) focused attention on the need to help farm families organize their resources to improve their conditions materially and socially and to preserve rural social values.

In 1977 competitive research grants were authorized by Congress for "high priority agricultural research awarded on the basis of competition among scientific research workers . . ." In the 1980s the State Experiment Stations began efforts to increase support for basic biology programs. In 1985, Congress added $20,000,000 in competitive grants expressly for biotechnology.

W. M. Collins
Professor Emeritus

D. G. Routley
Professor and Editor

Chapter 1

The Station is Established (1887-1909)

Agricultural Experiment Station Building at Hanover, circa 1890

The New Hampshire Agricultural Experiment Station was established as a department of the New Hampshire College of Agriculture and Mechanic Arts in 1887. G. H. Whitcher, professor of Agriculture in the college, became the first Director of the Station. Land purchased in 1870 for use as a College Farm for teaching would be used for research by the Station.

Agricultural interests in the state were not satisfied to have the New Hampshire College of Agriculture and the Mechanic Arts attached to Dartmouth College because over a period of nearly 20 years fewer than 40 agricultural students had been graduated. Benjamin Thompson, a Durham farmer and businessman, willed his farm to the state in 1856 "to promote the cause of agriculture" by establishment of a school for that purpose on his farm in Durham "wherein shall be thoroughly taught both in the school and in the field, the theory and practice of that most useful and honorable calling." His will had been kept secret until his death in 1890. The legislature passed an Act in 1891 that provided for moving the New Hampshire College of Agriculture and the Mechanic Arts, and with it the Agricultural Experiment Station, from Hanover to the Thompson land in Durham. The move was completed in 1893.

The Station began with two departments — Dairy, and Field and Feeding. A. H. W. Wood was Superintendent of the Dairy Department and Whitcher temporarily in charge of Field and Feeding. Other personnel were F. W. Morse, chemist; C. H. Pettee, meteorologist; H. H. Lamson, microscopist-photographer; a farmer; and a clerk.

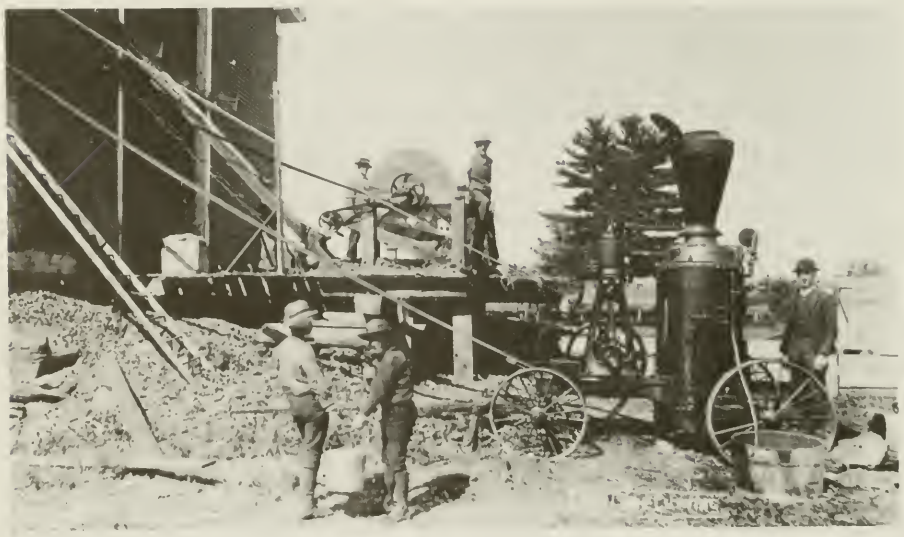
Most of the early Station scientists held only bachelor degrees, but the first bacteriologist, H. H. Lamson, was an M.D.; the first entomologist, C. M. Weed, a D.Sc.; C. W. Burkett, agriculturist, was the first Ph.D.; and C. A. Black, Ph.D., a botanist appointed in 1912, was the first woman scientist on the staff. Two women had held positions on the staff since 1903, however; E. M. Davis, purchasing agent, and M. E. Townsend, stenographer.

The research of the first Station scientists, called Agriculturists, was quite general. Early bulletins covered titles such as Ensilage; Fertilizer and Fertilizing Materials; Feeding Experiments; Effect of Food on Milk; Prevention of Potato Blight; the Flow of Maple Sap; and the Tent Caterpillar, among others. In the second report of the Director of the Station (1890), there was a section entitled "Use of Farm Yard Manure" — a subject still under investigation 97 years later.

In 1895, C. S. Murkland was President of the College and Acting Director of the Experiment Station. A year later, chemist F. W. Morse was named Vice Director of the Station. The College Farm consisted of some 300 acres of valuable land provided partly from funds given by Hon. John Conant and partly from the Benjamin Thompson estate.

In the eighth annual Station report (1896), F. W. Rane, head of the Horticulture department, wrote that exhibits of College crops were made at fairs and that plates containing 56 varieties of tomatoes were sent to the State Horticultural Society at Concord, September 22-24.

Interest in the work of the Station heightened rapidly. By 1901, 11,000 copies of each bulletin were distributed, and technical bulletins began in that year. The next year six press releases, really abstracts of bulletins, were sent to newspapers to ensure that this information reached people throughout the state. This resulted in a flood of requests for the regular editions and probably was the early be-



Making ensilage at Hanover, 1890

Station cattle with Hewitt Hall in the background

ginning of extension work in New Hampshire.

By 1900, the six departments and their heads were: Agriculture, C. W. Burkett; Bacteriology, H. H. Lamson; Chemistry, F. W. Morse; Entomology, C. M. Weed; Horticulture, F. W. Rane; and Meteorology, C. H. Pettee.

Over a very brief period, several important changes in Station administrative and scientific personnel occurred. Burkett resigned in 1901 to become chairman of Agriculture at North Carolina State. W. D. Gibbs, apparently hired to replace Burkett, was appointed Director and Agriculturist in 1902, but resigned seven months later to accept a similar position in Texas. Thus Vice Director Morse was placed "in charge" of the Station. Gibbs was replaced as Agriculturist by H. Hayward, who resigned the following year, to become Assistant Chief of the Dairy Division, U.S.D.A. Then in early 1903, Murkland resigned as President of the College. When Gibbs was asked by the trustees to return as president, he agreed to assume that office and directorship of the Station as well.

The College of Agriculture and Mechanic Arts Bulletin of 1901-1902 described the laboratories and equipment in the Horticulture and Forestry departments. They consisted of greenhouses, orchards and grounds. There were many varieties of fruits (grapes, peaches, apples, cherries) in the orchards which were young but coming into bearing. Many vegetables were being raised, with major attention being given to methods of culture and varieties. Propagation of fruits, shrubs and floricultural plants was being practiced. A tract of "60 acres of old forest growth" was owned by the College.

In the same Bulletin, the laboratories and equipment in Dairy were described as follows: "Through the courtesy of leading manufacturers of dairy and creamery appliances, all

available space is filled with various forms of cream separators, milk coolers, churns, and other appliances. In addition to the College herd, milk is received from about twenty-five farms in Durham and vicinity."

The Agriculture Department was engaged in upgrading the quality of its dairy and Shorthorn herds through culling and purchase, and in establishing a swine herd, all to be used for both instruction and research. A flock of purebred Southdown and Dorset-horned sheep would be used to determine the best breed or cross for producing early spring lambs for the Boston Market. Experimental plots for research on grains and grasses were established, including yield trials of corn and oat varieties. Research on tile drainage was conducted.

At this point, Nesmith Hall was used for the "work of the Experiment Station." Morrill Hall was erected in 1902 at a cost of about $30,000, and a dairy barn in 1905 — the cost, $10,000.

The research of Lamson in Bacteriology and Weed in Entomology appear to have overlapped somewhat. Lamson investigated fungus diseases of apples, peaches and melons, and recommended as control either spraying with Bordeaux mixture, destroying the plants, or planting less susceptible varieties. He also studied the brown-tail moth, and the San José scale, the latter a dangerous pest which affected fruit trees. In 1905, Lamson was succeeded by plant pathologist C. Brooks, at which time the department name was changed to Botany. Brooks continued emphasis on fungal diseases of fruits and vegetables.

Early orchard spraying equipment

During his years as head of Entomology, Weed was a prolific researcher and writer. He investigated insects attacking fruits and vegetables, including the greenhouse white fly which was particularly destructive to cucumbers and tomatoes. Hydrocyanic acid gas was recommended for control! His 1904 bulletin, "Experiments in Destroying Black Flies" was the first in this field from the Station. Today, some 80 years later, J. F. Burger, another Station Entomologist, still studies ways to control black flies. Weed resigned in 1904 to accept a position in the Lowell, Massachusetts Normal School. E. D. Sanderson, who followed Weed as department head, investigated brown-tail, gypsy and codling moths, garden and shade tree insects, and black flies. The department insect collection was growing rapidly.

The Chemistry Department was investigating the respiration of apples and the composition of silage, and had begun regular analyses of feed and fertilizer samples.

Horticulture was initiating breeding work on several different vegetables, including experiments with a cucumber for greenhouse forcing called the 'Granite State'. Carnations were being crossed experimentally on a large scale to find new color types. In this period, forestry came under the jurisdiction of the Horticulture department. The Hon. J. D. Lyman, member of the N.H. Board of Agriculture, speaking at an "Institute" organized by the Board in 1887, had urged that wood and lumber from farms be considered a crop to be grown, thinned and harvested at the proper time. Good forests, he said, may be profitably grown from seed. F. W. Rane, head of Horticulture, noted the pioneer work of Lyman in Station Bulletin No. 106 (1904) entitled "Forestry" and attempted to awaken farmers to the desirability of determining what farm land should be considered non-tillable "waste" land, removed from cropping, and devoted to forestry.

The following item of interest appeared in the Bulletin of 1905-06. "During fall term over 100 varieties of apples are studied by the students." Apparently some of these varieties were brought from other states for class work. Nevertheless, it was also stated that "the plum orchard has 60 varieties in bearing."

During this period, Meteorology apparently simply maintained a continuous record of temperature and precipitation.

Increased federal funding for agricultural research came with passage of the Adams Act of 1906 which would ultimately provide an additional $15,000 annually to the Station and enable more extensive planning and conduct of research. In the Experiment Station report of 1907, the head of Chemistry indicated that because of increased demand for chemists in manufacturing and pure-food inspection it was difficult to keep assistant chemists. The Adams Act made it possible to pay more liberal salaries for those engaged in research.

B. S. Hall became head of Horticulture and Forestry in 1907 following the resignation of Rane the previous year, but a year later Hall was replaced by B. S. Pickett. In 1907, President Gibbs relinquished the directorship of the Station to E. D. Sanderson who three years later resigned as Director to accept a position at Cornell University. Morse who had been with the Station for 21 years, 14 of them as Vice Director, resigned in 1909.

C. Floyd Jackson, for whom the Jackson Estuarine Laboratory was named, was appointed to the Station staff in 1908 as an Instructor in Entomology, but evidently spent most of his time in Zoology. In 1930 Jackson was named Dean of the College of Liberal Arts and in 1939 Director of the Biological Institute. Two years later the Bacteriology, Botany and Zoology departments were combined into one department of Biology with each of the former departments as divisions. Apparently, one accomplishment of the consolidated department was a basic course in biology required of all students in liberal arts. However, the Biology department, created in 1941, was split into its original three components in 1947 with Botany returning to the College of Agriculture. In 1988 all biology departments were again housed in the College of Life Sciences and Agriculture.

Thus, although research funds were limited in the beginning years of the New Hampshire Station, research was progressing on a broader front. Scientists who left the institution usually improved their position, and some members of the Station were to make significant contributions in later years.

Hayloader, circa 1904

Chapter 2

J. C. Kendall, Director, and World War I (1910-1919)

John C. Kendall, an alumnus of the class of 1902, was appointed Director of the Station in 1910. At the outset, he directed that each department would undertake one main line of research related to a leading area of agriculture and give it all or a major part of its attention. This would narrow the research effort, increase depth, improve quality, build citizen confidence and allow the Station to become an authority in certain areas. He strongly emphasized the need for research in forestry, swine, dairy and poultry and, as a culmination of persistent urging, the New Hampshire legislature in 1921 voted its first appropriation for agricultural research — $12,000 for the biennium.

Although Kendall favored demonstrations to carry the work of the College and Station directly to farmers, he believed that some of the early Station scientists spent a disproportionate amount of time on extension-type activities. Therefore, he vigorously advocated establishment of an extension program and submitted a request to the legislature for money to initiate extension work. The request was funded and the Board of Trustees appointed him Director of Extension in 1911 in addition to his duties as Director of the Station. C. W. Stone then became Vice Director of the Station. Years later, in 1939, Kendall became Director of the Extension Service which spanned all departments within the university, and relinquished directorship of the Station to M. G. Eastman.

By 1911 there were eight departments, their names and heads were: Agronomy, F. W. Taylor; Animal Husbandry, T. R. Ackell; Botany, C. Brooks; Chemistry, B. E. Curry; Dairy, F. Rasmussen; Entomology, W. C. O'Kane, Jr.; Forestry, J. H. Foster; and Horticulture, B. S. Pickett. W. H. Pew, head of Animal Husbandry until 1909, resigned to go to Iowa State College as Assistant Professor of Animal Husbandry. W. L. Slate, Jr., Assistant Agronomist, left in 1911 to accept a similar position at the University of Maine. Slate later was to become Director of the New Haven (Connecticut) Agricultural Experiment Station. In 1912, several other resignations occurred: President Gibbs entered business; Brooks moved to the Bureau of Plant Industry, U.S.D.A., Washington, D.C.; Pickett accepted a position in Pomology at the University of Illinois, and Ackell went with the Division of Sheep Husbandry, Livestock Branch, Dominion Department of Agriculture, Ottawa, Canada. Director Kendall in his report of 1912 (Station Bulletin No. 163) commented that the Station personnel had left for higher salaries and larger opportunities, not because of dissatisfaction at New Hampshire.

Agronomy evaluated corn varieties and their crosses for maturing quality and yield, and tested the effects of various chemicals and lime on grassland, alfalfa and pasture. A timothy selection program was initiated, the objective being to provide improved seed for New Hampshire farmers.

Research in Animal Husbandry centered on sheep breeding, a project begun by F. W. Taylor in 1906. A cooperative effort with the Carnegie Institution of Washington, D.C., beginning in 1913 with sheep breeding, was expanded in 1918 to include nutrition experiments in basal metabolism of cattle. O. L. Eckman was department chairman in 1915.

O. R. Butler, who replaced Brooks in 1912 as head of Botany, continued investigations to control economic diseases of plants with fungicides. Together with B. E. Curry and T. O. Smith in Chemistry, he studied the distribution of food materials in the apple tree at different periods of growth, research which likely led to later nutrition experiments in pomology. In other cooperative research, Smith and Butler discovered that cereal seedlings require supplemental potassium within a few days following germination, and noted the symptoms of potassium starvation in wheat, corn and buckwheat.

Advanced Registry testing of purebred dairy cows was the only Station work conducted by the Dairy Department during this period.

W. C. O'Kane, Jr. arrived at the Station in 1909 and became head of Entomology in 1910. He found that there were several species of black flies in New Hampshire and that their distribution and abundance in different areas of the White Mountains at various seasons were confounding the problem of control. In cooperation with the Chemistry Department, he found that August spraying of apples with arsenate of lead to control brown-tail moth posed no danger to consumers. He qualified this, however, by stating "under ordinary conditions" and also that there was a problem with small fruits. He also initiated investigations on the effectiveness and safety of using the insecticides pyrethrum and hellebore on plants ready to be eaten.

E. B. Sackett in *New Hampshire University — The Story of a New England Land Grant College*, noted that O'Kane's ". . . work in the Experiment Station made him a pioneer in what is now called 'sponsored research'." He organized the Crop Protection Institute which was housed in Nesmith Hall until 1963 when it constructed its own laboratory in the adjacent town of Lee.

B. S. Pickett (1908-1912), and then J. H. Gourley (1912-1921), followed Professor Rane in charge of Horticulture. Variety tests of apples, plums, and small fruits were being conducted on a large scale — 35 varieties of apples and 24 varieties of plums. Propagation of blueberries by cuttings was unsuccessful, but transplanting bushes worked well. D. Lumsden discovered several traits in muskmelons were inherited in Mendelian fashion and two varieties of squashes, 'Warren' and 'Delicious', showed clear-cut dominance for external characters. Intermediates appeared in crosses, however.

Forestry, established as a separate department in 1911 with J. H. Foster as head, had mainly a teaching role. Two experiments were begun, however; raising and planting forest tree seedlings, and making observations on the growth and yield in farm woodlots of quick growing, economic species, especially second growth white pine. K. W. Woodward became head of Forestry in 1915. C. L. Stevens, an instructor in forestry, later was to become department head.

Director Kendall, because of a special appropriation and need for

Women students assist in picking apples at the Horticulture farm, circa 1917

research in poultry, promoted R. V. Mitchell, Assistant Professor of Animal Husbandry, to Professor, placed him in charge of poultry work in the Station and made him head of the new Department of Poultry Husbandry in June 1916.

In the 1914-15 College Bulletin, under the heading New Hampshire Agricultural Experiment Station, in reference to quotations taken from the Hatch and Adams Acts, the following appeared, "At first the Agricultural Experiment Stations found it difficult to resist the popular demand made upon them to enter the extension field, to the neglect of research, but it is to the credit of those officials having the directing and executing of those laws in charge that our Stations have proved true to their trust."

Sackett, in his history, noted that R. D. Hetzel, elected president of the College of Agriculture and the Mechanic Arts in 1917, left two ". . . great legislative victories. The first of these was a change in the name of the institution in 1923; the second was the Millage Act of 1925." Both of these had a great influence on the development of the Agricultural Experiment Station and the institution.

Between 1914 and 1918, World War I had touched the lives of virtually all persons and institutions. New Hampshire farmers had responded to the national slogan, "Food Will Win the War," with substantial increases in production notably of wheat, potatoes and corn. A State Food Production Committee consisting of H. N. Spaulding, Federal and State Food Administrator, Chairman; President of the College, R. D. Hetzel; Director Kendall and Professors Gourley, O'Kane, Taylor and other persons, unified the campaign to increase food production. Other Station personnel did much field work and prepared many press bulletins, circulars and special press articles. Despite the inevitable reduction in Station staff, the research program was main-

tained without drastic change. Seven regular Station bulletins, in addition to the annual reports of seed, feedstuffs and fertilizer tests, were published. Two were "Mendelism in Melons," mentioned above, and "The Soybean in New Hampshire," by F. S. Prince, both important forerunners of work in these areas by Station personnel in later years.

Faculty harvest potatoes as part of war effort, 1917

Chapter 3

Prosperity, and Depression (1920-1940)

This was to be a period of great change for agriculture in New Hampshire and for the Experiment Station. In the early 1920s, farms were showing profit, but over a 10-year period numbers of farms had declined by 24 percent. Funding of agricultural research was in transition also. The state legislature had made its first appropriation for Station research. In 1924 the Station staff consisted of 32 persons, three of them having Ph.D.s. In 1925 the federal government established the U.S.D.A. Forest Service and the Northeast Forest Experiment Station, a branch of which is called the Forestry Sciences Laboratory now located on campus. A year later the Purnell Act provided additional funding for research, especially for marketing. By 1931, tractors were replacing draft horses, electricity was becoming a reality for the farm and home, and pasteurized milk was on its way. However, tumbling prices for agricultural products, shrunken buying power of consumers and credit difficulties made 1933 a difficult year for the agricultural sector. The Bankhead-Jones Act (1936) recognized the need for regional research. By the end of the era, the Station annual budget was $150,000, the staff totaled 75 including 11 Ph.D.s, one D.Sc. and three D.V.M.s. There were 2,000 students on campus.

T. G. Phillips, Agricultural and Biological Chemistry

Chemistry

Originally called Chemistry, the department name was changed to Agricultural Chemistry in 1920 and to Agricultural and Biological Chemistry in 1927. During the 1920s and 1930s, strong emphasis was placed on the roles of phosphorus, potassium, nitrogen and carbohydrates in plant growth, development and maturity. Cooperatively with Horticulture, it was shown that carbohydrates, not nitrogen, were a factor closely associated with fruit bud formation. Stunting of tomatoes was determined to be a manifestation of potassium deficiency, and the balance between potassium and nitrogen found to be critical to growth. Phosphorus was discovered to be essential for early plant maturity. T. G. Phillips devised modifications of a standard method of titration for determination of reducing sugars.

Agricultural Economics

Agricultural Economics was established as a department in 1927 with M. G. Eastman, '18, Dean of the College of Agriculture beginning in 1923, as head. Four courses were offered in that year and he taught all of them. In 1939, Eastman assumed the additional responsibility of Director of the Station and stepped down as head of Agricultural Economics. He retired as Dean in 1948. H. C. Woodworth who had been appointed to the Station staff in 1927 became department head in 1939.

The nationally recognized need for research in agricultural marketing culminated in the Purnell-Roberts Act, passed by Congress in 1925, which authorized funding in Agricultural Economics, Home Economics and Rural Sociology. The broad purpose of the Act was the development and improvement of the rural home and rural life.

The first Station study in the area of agricultural economics was entitled "Adjusting Farm Production in Cheshire County New Hampshire to Market Demand," by H. I. Richards and H. A. Rollins. They noted a decline in the number of farms, as well as decreasing agricultural production, and described the shift from a purely farm economy to one dominated by tourism. This was followed by several other marketing studies on live broilers in New York City, eggs through auctions, products from farm woodlots, New Hampshire berries, roadside marketing, and the White Mountain hotel market. Several other studies were made on costs for producing potatoes, roughage for the dairy farm, dairy herd replacements, wholesale milk, retail milk, and hauling milk.

H. C. Woodworth studied land use in one of the back areas of the state. He established that sub-marginal farms in southern Grafton County towns surprisingly were not owned largely by older men, but that 50 percent of the operators were under 50 years of age. In the process of land abandonment, the depression had brought many new families to the region. The farms on which these people settled were not capable of efficient operation, were mostly small self-sufficient units and no longer important from the standpoint of commercial agriculture. This research, and a survey of land holdings in Fremont and Boscawen by C. E. Walker and P. M. Hodgkins (1932), provided a basis for state policy on development of agricultural, forest, recreational and social resources.

With others in the department, Woodworth did a series of studies on management and organization of orchards and dairy farms including time and motion studies aimed at reducing the time and effort expended on dairy

barn chores. H. C. Grinnell investigated rural taxation, and identified 10 types of farming areas on the basis of enterprise and use, the latter giving a complete and comprehensive analysis of New Hampshire agriculture.

The economic depression deepened in the early 1930s and led to the "New Deal" with its accompanying economic and social changes. Station personnel were asked to provide many types of information for newly created federal agencies, one being the Civil Works Administration. Experiment Station personnel organized projects and employed staffs which compiled data and statistics. Station Bulletin No. 290 by H. C. Grinnell, entitled "Rural Real Estate Tax Delinquency in New Hampshire," which resulted from one of these projects, was a forerunner of later research on preferential assessment for open space. In 1936, following an agreement reached between the New England Agricultural Experiment Stations and the Bureau of Agricultural Economics of the United States Department of Agriculture, a full-time regional agent was employed making possible planning and conduct of regional research in marketing and agricultural economics. This person, A. G. Macleod, was housed in the Department of Agricultural Economics at the University of New Hampshire. MacLeod, in a series of papers covering several years, investigated the supply and distribution of New Hampshire milk.

The Agricultural Conservation Program, a federal project, began in 1936. In 1937, approximately 85 percent of active commercial farms in New Hampshire were enrolled in the program. A major objective of the program was to conserve and build the soil through use of lime and super-phosphate, making new seedings for hay land or pasture, improving pasture by new seeding or top dressing with fertilizer, and in various other ways. Approximately 87 percent of those farms enrolled complied with the federal program and qualified for payment of all or part of their allowance from the U.S. government. H. C. Woodworth, V. H. Smith, and E. Ranchenstein in "The Agricultural Conservation Program in New Hampshire" (Station Bulletin No. 314, 1939) indicated that the Program practices would definitely show results in 10 years, but that the significance of long-term results to New Hampshire could not be measured from data obtained solely from farms in this state because of inter-regional competition for markets.

Agricultural Engineering

Research in rural electrification was initiated in 1925 under the direction of W. T. Ackerman, the objective being to provide information relating to extension of electricity into rural areas. Power companies and other organizations cooperated in the effort. Because of the cooperative approach over 60 percent of New Hampshire farms had electricity by 1936. The milk cooler on the farm and the refrigerator in the farm home proved to be major uses of electricity, but a multitude of other uses of electric power made life on the farm and in the home easier and more enjoyable. In the late 1930s, the value of pneumatic tires on tractors and the design of farm potato storage were two of several projects undertaken.

Three agricultural engineers joined the Agronomy Department in 1934, and in 1945 Agricultural Engineering became a separate department.

Agronomy

F. W. Taylor, a graduate of Ohio State University in 1900, came to the Ex-

periment Station in 1903 as Agriculturist, and later became Agronomist and head of Agronomy, a position he held until 1933. F. S. Prince was employed in 1913, but after five years left to enter extension work in Ohio. He returned to New Hampshire in 1925 and in 1933 was appointed head of Agronomy.

The glacial origin of most New Hampshire soils had produced a variety of soil types and since dairying was the leading agricultural enterprise, soils research was clearly a fundamental need. Cooperative research between Prince and P. T. Blood in Agronomy, and T. G. Phillips, G. P. Percival and others in Agricultural and Biological Chemistry over a period of many years proved very productive. They demonstrated higher yields from pastures and hayland when fertilizers and lime were used appropriately and legumes were introduced. They showed that grass hay cut before the bloom stage, in June, had some 50 percent more digestible protein, thus more protein per acre than hay harvested in mid-July — a practice that revolutionized haying in the state. Variety tests of cereal grains, legumes, and potatoes led to recommendations of varieties appropriate to New Hampshire conditions. Plots on Paxton soils where winter rye was used as a cover crop following potatoes yielded 13 percent more potatoes than plots with no cover crop and had less sheet erosion. Spring floods of 1936 had done considerable damage in the state due to sheet erosion and gullying of pasture and farm land. In one river valley, nearly 50 percent of the area on 26 farms was covered with 16-20 inches of silt.

A detailed survey of soil types by counties, begun in 1935, involved Station personnel and by agreement the U.S. Bureau of Soils and the Soil Conservation Service, but soil mapping in the state was not completed until 1977. The surveys have been used to locate suitable soil types for various crops, for planning soil conservation practices on individual farms, and for making pertinent land information available to contractors, town governments and state agencies.

Animal Husbandry

A long-term experiment in applied genetics in sheep breeding, and studies in comparative basal metabolism characterize the research in Animal Husbandry between 1920 and 1940. E. G. Ritzman was in charge of the work. He and C. B. Davenport, Director, Department of Genetics, Carnegie Institution of Washington, D.C. outlined a cooperative sheep breeding project. Southdown and Rambouillet sheep were crossed, then selected over several generations for rapid growth, market conformation and wool quality. Later, the multi-nippled trait was introduced into the flock from six animals donated by Alexander Graham Bell. As a result of 33 years of inbreeding Bell had developed a breed of sheep possessing from four to six functional nipples and a high degree of fecundity. These traits, plus twinning, were then included in the selection program. Ultimately, they developed a strain with good growth and conformation, a high incidence of ewes with four or more functional nipples and a corresponding increase in milk yield, a high incidence of twinning, and wool of excellent quality. The Agricultural Experiment Station at Rothamstead, England obtained two rams from this stock, and a four-nippled ram was used on a Suffolk flock in Kansas. Requests for breeding stock were received from China and different parts of the U.S.

E. G. Ritzman, with cattle, circa 1918

Animal nutrition research in the department began before 1920 as a cooperative war emergency project with F. G. Benedict, Director of the Nutrition Laboratory, the Carnegie Institution. Benedict designed and Ritzman constructed an inexpensive respiration chamber (calorimeter) for large domestic animals. This apparatus, intended for short-term experiments, allowed determination of carbon dioxide production, a measure of basal metabolism. Using this equipment, comparative studies with sheep, goats, horses, swine, beef cattle and dairy cattle showed, for example, that energy expenditure of dairy cows was 25 percent greater than that of beef cows and that the swine had a very low basal metabolic rate. Season and genetics clearly influenced the rate of metabolism.

In 1932, Ritzman and N. F. Colovos designed an apparatus which permitted automatic collection of solid and liquid excreta from cows in digestion experiments, equipment which then made possible long-term experiments and broader investigations on digestibility of feedstuffs and development of balanced rations for dairy cows.

Station veterinarian, C. L. Martin, in a program administered by the state veterinarian's office, used the tube agglutination. blood test followed by slaughter of infected cattle to control Bang's disease (contagious abortion). The number of positive animals in the State became substantially reduced by this procedure.

J. C. McNutt succeeded O. L. Eckman as head of Animal Husbandry and served until 1930 when L. V. Tirrell, who had served the University from 1922 to 1926, returned to New Hampshire and was appointed head of the department. Tirrell was not a member of the Station staff — his great

strengths were in teaching and extension work.

Dairy Husbandry

Director Kendall recognized the important position held by the dairy industry in New Hampshire and saw the need for research into problems in, or associated with, dairy manufacturing. High quality ice cream is smooth textured, and because smooth ice cream results from a high viscosity mix H. F. DePew, in the mid-1920s, investigated factors which influence variation in viscosity. Other research in the 1930s included procedures for rapid cooling of milk and the costs and ways of maintaining production of grade A milk. Over a period of several years, H. C. Moore examined factors which determine the composition of milk. Quality of feed, condition of the animal, season, and inheritance were found to underlie variations in non-fat solids.

K. S. Morrow examined dry feed systems for rearing calves and found that normal growth resulted if a dry ration containing 25 percent powdered skim milk followed discontinuance of whole milk feeding at 7 weeks of age.

Morrow had been made head of the department in 1934 having been preceded by F. Rasmussen (1907-1917) and J. M. Fuller (1918-1934).

Forestry

Two long-term experiments in forestry were conducted during this period, both utilizing plots established in 1912 and others started later. They were designed to determine first which native and introduced species of trees were best suited to artificial reforestation in New Hampshire and second, the relative growth rates of white pine in thinned and unthinned stands with mixed hardwood. Most of the exotic species proved inferior to white pine and red pine. Unthinned white pine, on clay soil, was overtopped and crowded out in 10 years. Most pine wood thinnings were used either for cordwood or fence posts and it was found that straight, open-tank creosoted posts could supplement income from the farm woodlot. The hurricane of September 21, 1938 did such extensive damage to the UNH woods that replacement of some experimental plots of white pine was required.

The first department head of forestry, J. H. Foster, served for nine years (1911-1919). K. W. Woodward, head of the department beginning in 1921, relinquished the post to C. L. Stevens in 1938.

Home Economics

Courses in Home Economics had been offered for many years. Sackett made reference to a department of Home Economics in 1917. H. F. McLaughlin was appointed head of the department in 1921, but it was located in the College of Liberal Arts and would remain there until 1948 when it became a unit of the College of Agriculture.

A start in research in Home Economics was made with the appointment of M. E. A. Pillsbury in human nutrition in 1926, followed by that of A. G. Farr a year later. Together with F. G. Benedict of the Carnegie Institution, Farr studied the edible food wastes of students in college sorority and fraternity houses and found that up to 21 percent of calories and protein served was wasted — mainly because of consumption of confections between meals.

An investigation of the wearability of textile fabrics was conducted in cooperation with other Northeastern Experiment Stations.

Entomology

The life histories of several insect pests of economic significance in N.H. were studied during the 1920's by W. C. O'Kane and P. R. Lawry in Entomology. Ways of controlling infestations of these insects were investigated and in some cases recommendations for control were developed. During the 1930s, O'Kane, Lawry, J. G. Conklin, R. L. Blickle and others conducted a series of some 15 basic investigations with contact insecticides and ovicides. They fabricated equipment and refined techniques for appraising proposed contact insecticides, determined rates and amounts of penetration of chemicals through insect integuments and eggs, found that the nature of a leaf or stem is important in the performance of a contact agent, and assessed the influence of the carrier on the performance of a toxicant — information necessary for developing more effective materials. This research brought national and international recognition to them and to the institution.

"The White Pine Weevil in New Hampshire" was a Station Bulletin (No. 247) written by C. C. Plummer and A. E. Pillsbury in 1929. The white pine weevil, an insect of major importance in the state, reduced the timber grade and value of attacked trees by 30 percent. Of four possible control measures, they recommended dense plantings (1,800 trees per acre), since trees attacked were better able to recover from injury because competition for light and space stimulates straighter growth.

Botany and Bacteriology

Dr. O. R. Butler served as head of the Botany Department from 1912 until his death in 1940. During this 28-year period, his research focused mainly on control of fungus diseases of apples, potatoes and beans using the fungicides Bordeaux mixture, Burgundy mixture, and others.

Butler's papers on copper fungicides were classics and he became a world authority on copper compounds in relation to fungus disease. His research on apple scab was particularly noteworthy. Apparently he set high standards for himself, and his investigations were not doubted as to accuracy.

S. Dunn, appointed Assistant Botanist in 1927, collaborated with Professor Butler on research of bitter-pit, conducted apple and potato research and was involved in certification of some 80 acres of seed potatoes then grown in the state.

In 1936, Botany had assumed the title of Botany and Bacteriology. Following Professor Butler's death, both Botany and Bacteriology were listed in the University catalog as sections which together with Zoology constituted the new department of Biology in the College of Liberal Arts. Botany as a separate unit returned to the College of Agriculture in 1947.

Other appointees in Botany during this period were M. E. Mills (1929) and A. R. Hodgdon (1932).

Horticulture

How light intensity influences the type of growth of leaves and roots and the reproductive process of fruit trees and herb-aceous plants was the subject of Technical Bulletin No. 18 (1922) by J. H. Gourley and G. T. Nightingale in Horticulture and preceded extensive experimentation on the effect of light on plants by S. Dunn in Botany many years later. G. F. Potter, Horticulture department head from 1921 to 1938, examined the role of fertilizer and its major elements, cover crop, early thin-

ning, and other factors on apple fruit bud formation. Two statistical techniques applied to his data in 1922 — probable error and correlation coefficients — appear to be the first time statistics were used by scientists in the Experiment Station. E. J. Rasmussen and others in a series of experiments on changes in apples during storage observed that pre-cooling McIntosh in the first five days following picking aids keeping quality, that 30° (F) temperatures (cold storage) kills apple maggot larvae and that scab spots increase on apples stored between November and July. During the 1930s, an interest in pollination led L. P. Latimer to the finding that Cortland and Early McIntosh varieties are cross-incompatible because pollen tube growth is inhibited in the style. Several triploid varieties (those having 3 sets of chromosomes) of apples were found to be undependable pollinators. J. R. Hepler and others conducted extensive variety tests of vegetables. With interest in the cultivation of high bush blueberries increasing, W. W. Smith initiated a selection and hybridization program, later continued by E. M. Meader, and investigated techniques of propagation of the plants.

A. F. Yeager was appointed as Horticulture head following Potter's resignation in August, 1938. Following nine years as head of Horticulture at North Dakota State and two years at Michigan State he came to New Hampshire in 1939. His employment marked the beginning of a lengthy and productive period of plant breeding research in this department.

Poultry Husbandry

Station supported research in poultry began in 1926 with the appointment of E. M. Gildow, veterinarian, as Assistant Poultryman, but the Poultry Department in the college had been established in 1916 with R. V. Mitchell as head. In 1918 pullorum disease was causing excessive chick mortality, and control and that of other contagious diseases were important if the industry was to develop. A blood testing program to identify reactor chickens, conducted by the department, in 10 years drastically reduced flock infection from the pullorum organism in the state permitting breeding flock size to increase and the industry to expand. It is virtually eradicated today.

The first research report on poultry was Station Circular No. 27 (1928) by E. M. Gildow (D.V.M.) and W. Wisnicky, poultry pathologist, entitled Coccidiosis in Chickens. Three other Station Circulars on poultry research quickly followed: No. 28 by H. O. Stuart, assistant poultry husbandman (1928), "Anti-Rickitic Value of Cod Liver Oil, Cod Liver Meal and Fish Meal"; No. 29 by H. O. Stuart (1929), "Certification in Poultry"; and No. 30 by Gildow and C. A. Bottorff, veterinarian, "Vaccination for Prevention of Fowl Pox."

A. W. (Red) Richardson was appointed head of Poultry Husbandry in 1918 and under his dynamic leadership, poultry breeders in the state, using the Rhode Island Red breed as foundation stock, selected for desired broiler qualities — rapid growth and early feathering — ultimately developing a breed called New Hampshires which achieved official recognition by the American Poultry Association in 1935.

P. I. Fitts, an instructor in Poultry from 1922-1924, was later appointed as N.H. Commissioner of Agriculture, a position he held for many years. As Commissioner he was a member of the University Board of Trustees.

T. B. Charles was named department head in 1928. During the 1930s A. E. Tepper, Charles, Stuart, F. D. Reed, and others investigated vitamin A and protein requirements of the chicken for growth, and the protein requirement of the adult hen for egg production.

Despite the generally low incomes of farmers during the 1930s, New Hampshire poultrymen continued to improve and expand their breeding operations. F. D. Reed represented the Experiment Station and assisted breeders by certifying the breeding quality of individual birds and officially inspecting and supervising the performance records of progeny of matings.

In the midst of the depression, a committee of the New Hampshire Poultry Grower's Association investigated the feasibility of organizing an egg auction in New Hampshire and made arrangements to begin operation in Derry, N.H. in June of 1934. In the second year of its operation the organization had a membership of over 400 poultrymen, and a volume of sales exceeding 30,000 cases of eggs. The cooperative was formed to aid poultrymen obtain higher prices for their product, but also stimulated interest in improving egg quality. It served the Granite state poultry industry well for a number of years. (See Station Bulletin No. 300, 1937.)

Diagnostic work, an important factor in defense against contagious diseases, often preceded research on the cause and/or control of a specific disease. The number of chickens necropsied in the laboratory was growing each year. When diseases heretofore unknown were observed, control measures were recommended where possible. Experimental vaccines were developed for fowl pox and infectious laryngotracheitis and distributed to poultrymen. Research on three new diseases — epidemic tremor, blue comb and ulcerated gizzard — was begun by Bottorff and M. S. Cover, assistant pathologist. F. E. Allen, D.V.M., became station veterinarian in 1940 and A. C. Corbett, D.V.M., poultry diagnostician in 1942.

J. C. Kendall, Director, circa 1925

In 1939, Kendall closed his term of 28 years as Director of the New Hampshire Agricultural Experiment Station, but continued to devote full time to the administration of the General Extension Service now expanded to cover all departments of the University. A portrait of Kendall painted in 1970 by J. W. Hatch, former Professor of the Arts at UNH, hangs in the lobby of Kendall Hall, dedicated in 1970.

Kendall was succeeded as Station Director by M. G. Eastman who had been Dean of the Agricultural Division and since 1923 Dean of the College of Agriculture.

Chapter 4

World War II and Beyond (1941-1957)

World War II necessitated major adjustments in research projects and personnel assignments in the Experiment Station and in agricultural production in the state. One pressing need countrywide was increased food production despite declining supplies of labor, feed, fertilizer and equipment. Research projects were suspended, terminated, revised or new ones developed to provide information directly related to the war effort. A few examples: ways were sought to improve pasture land, provide more roughage and increase milk production; a search was on for suitable substitutes for animal protein for animal feeds; methods of preserving foods to retain nutritive value, especially vitamins, were examined. Other research suggested ways of rerouting trucks gathering milk from farms or in retailing milk, to save on vehicles, gas, rubber, and labor. In the Station, maintaining staff and replacing and adding to equipment for laboratories and experimental farms was a major problem.

When the conflict ended, spin-off from the gigantic war effort became evident. Electric calculators became available for more efficient processing of data. The colorimeter, fluorometer and spectrophotometer, utilizing the photoelectric cell, made possible more rapid and sensitive chemical determinations in the laboratory. Radioactive materials and the Geiger-counter provided new horizons for investigations in plant and animal physiology. The University made use of electronic computing equipment at the Massachusetts Institute of Technology in 1957 and in 1962 UNH acquired its first IBM No. 1620 computer.

R. Eggert conducting a radiation experiment

R. F. Chandler was named Dean of the College of Agriculture and Director of the Agricultural Experiment Station in 1947. Chandler had earned his B.S. degree at the University of Maine and Ph.D. at the University of Maryland. In 1950, at the age of 43, he was elected President of the University. He resigned in 1954 to accept a position in the foreign agriculture program of the Rockefeller Foundation where he administered the International Rice Institute program in the Philippines.

H. C. Grinnell, who joined the faculty of the Department of Agricultural Economics in 1932, became Associate Director of the Station and Associate Dean under Chandler. He succeeded Chandler as Director and Dean in 1950, remaining as Dean until 1961 and retiring in 1965. The Biological Sciences Branch Library, located in Kendall Hall was named the Grinnell Library in 1972.

Agricultural and Biological Chemistry

Over the years workers in Agricultural and Biological Chemistry typically cooperated in the ongoing research of several other departments, but they had their own research projects also. T. G. Phillips searched for improved methods for determination of carbohydrates in timothy hay, and he and M. E. Loughlin established that both lignin and crude fiber content of hays provided good estimates of digestibility of energy when those hays were fed to cattle. Phillips and W. Averill identified two enzymes in squash which during storage convert starch to sugar. A. E. Teeri developed improved methods for the determination of water-soluble vitamins thiamine and nicotinic acid, and examined the influence of sulphur compounds on the accuracy of microbiological determinations of nicotinic acid. He also investigated the role of amino acids on suppression of growth of lactobacilli. Together with M. Leavitt, D. Josselyn, and N. F. Colovos and H. A. Keener in the department of Dairy Husbandry, he showed that oral administration of sulphathalidine to heifers decreased fecal excretion of thiamine, but not that of other B vitamins studied.

Agricultural Economics

After the war years the faculty of the Department was augmented and the scope of its research projects broadened.

W. Robert Parks and J. C. Holmes (1942) described the poor state of town roads in New Hampshire's communities and the constraining effects they were having on its agricultural and recreational resources. They wrote that agriculture in some areas was dying and the area declining despite fertile soils because of poor accessibility. Improved roads, not agriculture loans, were needed to reclaim the agriculture resources in those areas. In other areas better roads were considered to be the first step in developing the "great reservoir of summer and winter recreational resources."

W. Robert Parks, at the time the above publication was written, was on the staff of the Bureau of Agricultural Economics of the U.S.D.A. In a recent personal communication to this writer (W. M. Collins), he states, "That was my first job, and the UNH (Station) Bulletin was my first publication! That particular project took me to many rural towns in N.H. — an experience which taught me to love your State. It is also true that I was president of Iowa State University from 1965-1986."

H. C. Woodworth was a pioneer in the area of work simplification and cooperated with K. S. Morrow of the Dairy Department. They published four studies which analyzed chore travel on dairy farms, rapid milking of cows and total efficiency on the dairy farm. These studies provided the basis for much of the milking, feed handling and barn arrangements which are now in use. The rapid milking procedures developed made it possible to reduce milking time to less than six man minutes per cow per day (1945-1951).

W. F. Henry came to the University from the University of Connecticut in 1952 and assumed chairmanship of the department. Woodworth continued research in the department, however. With G. B. Rogers (Research Economist, U.S.D.A.) Woodworth completed three studies of the distribution and handling of grain feeds. They were concerned with increasing the efficiency of grain delivery to poultry and dairy farms (1956). This was part of the marketing research that received increased funding after the war.

W. K. Burkett (1953) found a very active market for rented agriculture land. He proposed that "town planning groups might participate in listing land suitable for agricultural use . . . and working out suitable rental agreements."

WW II also had stimulated studies on ways to minimize use of trucks, labor and fuel. G. E. Frick, S. B. Weeks and I. F. Fellows (1954) found a "trend toward greater substitution of machines for labor" which led to a reduction in the number of workers needed for farm labor. This same trend was documented in a report by J. R. Bowring, M. S. Purington and O. B. Durgin (1956), and it showed an increase in rural, non-farm labor "commuting to jobs in industrial centers."

Bowring also worked on the cost savings associated with tank truck assembly of milk (1954). The shift from 40-quart cans to large refrigerated tanks on farms created severe economic costs for small farmers.

Frick and Henry investigated the economic alternatives associated with raising or purchasing dairy herd replacements (1954). Herd life was found to be similar whether replacements were raised or purchased. Milk price levels and fixity of resources determined the best economic option and proportion of raised and purchased cows.

Agricultural Engineering

Agronomy and Agricultural Engineering were one department from 1939 to 1946 at which time Agricultural Engineering became a department with G. M. Foulkrod as head and P. A. Gilman as instructor. By 1950 the department consisted of B. Rines, head, A. G. Fox and Gilman. Both Rines and Fox were to enter business, and in 1954 R. S. Palmer was appointed head. G. L. Byers was appointed as an agricultural engineer in 1956.

Agricultural Engineering research during this 14-year period was restricted and ranged from fabrication of a carrier to transport a disc harrow, to development of plans for construction of a farm potato storage.

Agronomy

Much of F. S. Prince's research dealt with fertilization and management of pastures and forage crops with the primary objective of improving yields. In a 1941 publication entitled "Soybeans in New Hampshire," he noted that 3,500 acres of soybeans were grown in the state for forage, and, because of the scores of uses for soybean products, suggested that perhaps they could be grown profitably for seed. In Durham, many varieties matured satisfactorily and gave reasonable seed yields. But Prince also worked with potatoes, weed control and breeding of legumes; he led the Green Pastures Program in New England; he was a respected researcher, a prolific writer and author of the book, Grassland Farming in the Northeast. Prince served the university with distinction for over 30 years, retiring in 1957.

P. T. Blood, a long-time associate of Prince, and G. P. Percival in Agricultural and Biological Chemistry were co-authors with Prince on numerous publications. Blood's specialty, however, was potatoes. For several years he evaluated potato varieties for yield and attributes when processed as potato chips. He and L. T. Kardos determined that carbon dioxide, used as a sprout inhibitor during storage, did not affect potato cooking quality, but lengthened the marketing period into May or June. Kardos studied the influence of soil type on release of potassium and on persistence of legume stands, and investigated tillage as a means of developing a deeper and larger root system for legumes to improve their persistence under drought conditions. L. J. Higgins' variety trials of oats and corn indicated to farmers the disease-resistant varieties of oats and were a factor in their changing from pure lines to hybrid varieties of corn for grain and silage.

Beginning in 1952 and serving for four years, R. L. Donahue was department head. In 1956 A. B. Prince, who was appointed to the faculty in 1954, became head.

Animal Husbandry

As one contribution to the war effort, several scientists in the Agricultural Experiment Station and the Engineering Experiment Station cooperated on a project concerning the utilization of wood waste. In one segment of the project, Ritzman made a preliminary evaluation of wood yeast protein as a feed for livestock since wood yeast is a concentrated source of protein and B vitamins. The material showed promise, but apparently he never determined whether it would efficiently promote growth or milk production.

A second wartime contribution by Ritzman was "Calories in Wartime" (Station Circular No. 62), a summary of suggestions for meeting emergency conditions in feeding livestock, based primarily on research conducted by the Station over a period of 24 years. Professor Ritzman served the University from 1915 to 1945. His portrait, painted by J. W. Hatch in 1959, hangs in Ritzman Laboratory.

Dairy Husbandry

H. A. Keener came to the university in 1941 and until 1945 held a joint appointment in both Animal Husbandry and Dairy Husbandry. In 1945, the Animal Nutrition Laboratory became part of the nutrition research unit of the Dairy Department which now consisted of K. S. Morrow, head, H. C. Moore, Keener and N. F. Colovos.

In 1944 Keener, G. P. Percival and Morrow reported on a disease condition which had been attacking cattle in several areas of Carroll County for many years. The disease was characterized by depressed appetite, rough hair coat, muscular incoordination, retarded growth and decreased milk flow. The condition was found to be due to a deficiency of cobalt. When fed cobalt sulphate, animals responded quickly. Soon after, they observed the deficiency in sheep and goats and again the response to feeding cobalt was spectacular. On recommendation to feed manufacturers that cobalt sulphate (two grams/ton of feed) be added to dairy and livestock rations, the deficiency was virtually eliminated in New Hampshire in a few months. In later research, they determined that the deficiency occurred only in ruminants, that apparently cobalt was essential for production of some unidentified nutritional factor in the rumen, and that cobalt content of forage could be reduced to the deficiency level when

liberal fertilization produced heavy yields.

In cooperative research with Teeri and Percival in Agricultural and Biological Chemistry, Keener, Colovos and Morrow investigated the role of vitamins A and D on the utilization of energy and protein by dairy calves, and the influence of the type of roughage on excretion of certain vitamins by ruminants. In a search for more efficient preservation of silage, they examined the metabolic fate of radioactive sulphur (S35) when sulphur dioxide was used as a preservative.

Bovine mastitis, a highly contagious and economically important udder disease of cattle, was under investigation by L. W. Slanetz, F. E. Allen and Morrow between 1938 and 1954. Slanetz, a bacteriologist, who had received an appointment in the Botany Department in 1934, later was named head of the Bacteriology Department in the College of Liberal Arts. This group identified several hundred strains of bacteria that caused the disease. Sanitation, segregation of affected animals and treatment with antibiotics were recommended for control. The disease is a problem even today.

Botany

Station plant pathologists traditionally have been housed in the Botany Department. During the 1940s, early blight was the most important disease of tomatoes in New Hampshire. Searching for plants resistant to the disease, M. C. Richards, plant pathologist, and S. Dunn tested many selections but found none resistant. Fruit yield and fruit load, however, influenced the condition. Richards investigated leafroll, a virus disease of potatoes, and found that nitrogen nutrients suppressed and phosphate nutrients accelerated symptom expression. He evaluated fungicides for improved control of early blight in potatoes, apple scab, powdery mildew in muskmelons and spur blight in raspberries.

A. E. Rich, Botany and Plant Pathology

Richards was named Associate Dean of the College of Agriculture in 1950 and in 1951 A. E. Rich became Plant Pathologist. Rich verified *Phytophthora infestans* to be the causative organism of late blight in tomatoes and potatoes, and with A. F. Yeager and E. M. Meader in Horticulture began development of lines of tomatoes resistant to the disease. Two new varieties were named and released. He demonstrated that cultivated strawberries quite generally were virus infected resulting in a marked reduction in yield.

How to control weeds in permanent pastures, new seedings and cropland was the problem undertaken by A. R. Hodgdon, plant taxonomist, in the late 1940s and early 1950s. Hodgdon had become department head

when it rejoined the College in 1948. He recommended using a combination of herbicide and fertilization for weed control in pastures, and cultivation supplemented by an herbicide for cropland. Later he initiated a taxonomic study of blueberries in the state, and another on the flora of New Hampshire with emphasis on woody plants.

S. Dunn, plant physiologist, investigated methods of propagating woody plants, one of the plants being high sugar-producing types of sugar maples. He and W. H. Lyford, a U.S.D.A. soil scientist, initiated studies of the influence of soil texture on plant growth and, with his graduate students, Dunn evaluated wood wastes, sewage sludge and other materials as compost for soil improvement.

In 1944 Mr. and Mrs. C. W. Willson of Farmington, N.H. donated an herbarium consisting of 584 specimens, mostly flowering plants, to the University in honor of their son Charles killed in action aboard the aircraft carrier Lexington in the Battle of the Coral Sea in WW II.

Entomology

The war emergency set the pattern for research in Entomology during the early 1940s. W. C. O'Kane, J. G. Conklin and others studied toxicity of synthetic organic contact insecticides and ovicides in liquid and dust form hoping that some of these compounds could replace scarce imported supplies of pyrethrum grown in Africa. Basic research on DDT and its application to insect control on potatoes and fruits was intensive. The mosquito species *Anopheles quadrimaculatus*, the principal vector of malaria in the East, was found breeding in large numbers in areas around Portsmouth and Durham — information of interest to the military authorities. Because insect resistance against the newer insecticides was developing, R. L. Blickle searched for chemical compounds (synergists) which when added in small amounts to the older, well-known insecticides would improve their effectiveness. O'Kane retired in 1947 after some 39 years of service to the institution. In 1953 he wrote a book on the Hopi Indians. Twenty years later he died at the age of 96. Conklin followed O'Kane as head of the department.

In 1944, the late S. A. Shaw donated to the Experiment Station a collection of insects totalling 4,389 specimens. The collection consisted largely of *Diptera* (two-winged flies) and some 400 specimens of *Hymenoptera*, predominantly wasps. This valuable labelled collection has been very useful to the department and of great interest to other collectors.

Forestry

Research in Forestry covered a variety of areas during this period. Based upon detailed study of farms in the area, J. M. Chandler concluded that by making adjustments in the organization of the dairy-potato farm, including managing woodlands, many farms in Coos County could increase farm income. L. C. Swain investigated the devices and implements used in farm logging and indicated how with proper use the efficiency and safety of the operation could be improved. He also suggested that killing of unwanted forest trees could be accomplished economically by girdling and by use of chemicals, and the resulting products used for fence posts. C. L. Stevens made observations on individual tree variation in yield of sap and syrup in maples. He and R. Eggert (Horticulture) concluded from a detailed study that the flow of maple sap in early spring is primarily

due to the daily change in temperature of the air — not to root pressure, nor to the lifting power of transpiration. In that research, done in 1944, they were among the first to use radioactive tracers in plant research in New England. He and S. Dunn (Botany) collaborated on ways of propagating maples with a high sugar sap. The association between soil and timber yield of white pine in southeastern N.H., and a new way of cruising standing timber for determining volume — the variable-plot method — were studied by B. Husch.

Stevens became department head in 1938 at which time Swain was appointed to the Station staff. Husch became associated with the University in 1951 but several years later resigned to accept a position with the Food and Agriculture Organization (FAO). O. P. Wallace joined the department in 1954.

Home Economics

For faculty in Home Economics, the proportion of time assigned to the Station compared to that devoted to teaching has been relatively small. Recognition of a national emergency in human nutrition generated by WW II, however, led to a combined effort by Station personnel in Home Economics, Agricultural and Biological Chemistry, and Horticulture to investigate nutritive factors related to New Hampshire-grown fruits and vegetables. T. Levcowich in Home Economics used a taste panel to evaluate different varieties of fruits and vegetables preserved in different ways. S. R. Shimer and H. J. Purinton in Agricultural and Biological Chemistry studied the ascorbic acid and carotene content of different varieties of berries and squashes as influenced by cold storage, quick freezing and canning. This research stimulated more fundamental studies by Purinton on methods of improving the specificity of vitamin assays in foods. Later, A. M. Light (Home Economics nutritionist) and Shimer determined that in male students phosphorus had no significant effect on blood levels of thiamine or sugar. In 1952 Light was appointed head of Home Economics.

Professor H. F. McLaughlin retired in 1954 after some 31 years of leadership in the department. A dormitory was later named in her honor.

S. R. Shimer and H. J. Purinton, Agricultural and Biological Chemistry

James MacFarlane, a late blooming pink lilac

Horticulture

From 1941 to the mid-1950s, the thrust of horticultural research under the leadership of Professor Yeager was the breeding of new varieties of hardy, disease-resistant plants which would produce high yields of superior quality fruits and vegetables. Another objective was identification of existing varieties which matured early, were productive and adapted to the harsh climate of northern New Hampshire. In this research, Yeager and Meader worked as a team. In 1947 Meader spent one year on a contract with the U.S. Army Military Government of Korea during which he gathered a wide variety of plant breeding materials. On his return he came through Japan and added to his collection. In subsequent years at New Hampshire, the introduction of these valuable genetic materials contributed to the development of a great many new or improved varieties of soybeans, fruits, vegetables, nuts, flowering herbaceous plants and shrubs (see Appendix 6).

Although Yeager and Meader were trained plant breeders, other department members also contributed to the breeding program. J. R. Hepler, a horticulturist, bred a hybrid eggplant named 'New Hampshire', and began selections which later resulted in the 'Merrimack Wonder' pepper. L. P. Latimer developed 'Blaze' strawberry; W. W. Smith, with Meader, selected and hybridized blueberries; and W. D. Holley, J. MacFarlane, H. S. Clapp and E. D. Risley originated new varieties of shrubs and flowers.

Plant propagation, plant nutrition and cultural practices and variety testing were not neglected, however. Latimer found hay mulch superior to sawdust or sod systems for apple trees and showed that complete fertilizer applied to hay-mulched trees depressed yield. He determined that leaf scorch of apples, caused by magnesium deficiency, could be controlled if the grasses used for mulch were fertilized with soluble magnesium compounds. R. Eggert, a plant nutritionist appointed in 1951, in an early use of radioactive materials, showed that phosphorus applied in foliar sprays was absorbed in large quantities and translocated especially to buds and blossoms. Sun scald on apple tree trunks in winter was reduced by aluminum foil which reflected light and reduced heat absorption. W. W. Smith, a blueberry specialist, experimented with fertilization of high and low bush types, dusting to control the blueberry fruit fly and use of chemicals to control weeds in blueberry fields. Smith also tested apple rootstocks for New Hampshire apple varieties and developed improved grafting techniques for apple trees.

In the area of ornamentals, MacFarlane and Holley released two

new varieties of chrysanthemums. Holley wrote a very popular Station bulletin entitled "Growing House Plants" and developed a purple variety of lilac called 'Ann Tighe'. Risley produced the 'Granite Pink' bee balm, and with Yeager two new lilacs — 'Anna Amhoff' and 'Nellie Bean'. Some years later a beautiful bright pink, later blooming lilac was named after James MacFarlane who conducted floriculture research at the university for many years.

Use of greenhouse facilities accelerated breeding, especially of seed propagated vegetables, from seven years to a bit more than two years because one generation was raised in the field, followed by two in the greenhouse in winter. Thus, by 1950, the department had originated some 30 improved varieties of horticultural plants, and the breeding work underway assured many more to come.

Poultry Husbandry

W. C. Skoglund replaced T. B. Charles as department chairman in 1950 and began investigations on the effect of artificial light and other factors on growth and egg production. In 1951, he initiated the New Hampshire Broiler Test, partly supported by the Experiment Station, to provide information of mutual interest to both breeders and broiler growers. This official test provided a useful service to the industry for 13 years.

Shortage of animal protein during the war led nutritionists to search for suitable substitute sources of protein. R. C. Ringrose, who followed A. E. Tepper as nutritionist, found soybean oil meal and Torula yeast to be satisfactory sources of vegetable protein for both growing chicks and laying pullets, but not for breeders. This led to an investigation with H. A. Davis on the choline requirements of the laying hen. With graduate students, Ringrose evaluated use of methionine to improve growth and feed efficiency of broiler rations and feed restriction to delay sexual maturity and increase egg size of pullets.

C. W. Hess was appointed in 1942 as the first poultry geneticist in the department. He began development of an improved meat-type chicken and initiated a selection program for improved feed efficiency. In 1949 he resigned to accept a position with the U.S.D.A. in Beltsville, MD. W. M. Collins was appointed geneticist in 1951.

Responding to processor demand for whiter plumaged broilers, Collins and graduate student F. F. Cherms identified plumage color genes which would reduce the incidence of colored feathers in crossbred chickens. In other research during this period Collins indicated yellow shank pigmentation of broilers, of concern to buyers of live poultry, was inherited and could be improved through selection.

"Blue Comb," a disease of pullets soon after beginning to lay, was causing mortality of about 5 percent in 1945. E. W. Waller, pathologist, isolated a filterable agent from affected live birds and then developed a vaccine which gave some protection against the disease. W. R. Dunlop, who joined the department in 1950, began working on two virally caused respiratory diseases of chickens that caused serious losses to poultrymen. Dunlop, and then graduate student R. G. Strout, developed spray vaccines against these diseases which they used in combination for experimental mass immunization on both broiler and replacement flocks. Commercial companies shortly thereafter began producing and marketing vaccines against these two diseases and these researchers turned to other investigations.

Chapter 5

Beginning of the Keener Years (1958-1963)

Several departments in the college changed names in 1957-58. The Department of Agricultural and Biological Chemistry was renamed Biochemistry. Three "husbandry" departments — Animal, Dairy and Poultry — became Animal Science, Dairy Science and Poultry Science, respectively.

H. A. Keener was named Director of the Agricultural Experiment Station in 1958 and Dean of the College and Director of the Station in 1961. At that time the Cooperative Extension Service became a unit of the College of Agriculture with S. W. Hoitt as Director.

H. A. Keener, Dean and Director

A two-year program in agriculture, beginning in 1895, was taught by regular faculty members. Later, the program qualified as a vocational agriculture course with federal aid and was reorganized with a separate staff. P. S. Barton became Director of the unit in 1941 at which time it was called the Applied Farming Course. In 1953 it became the Thompson School of Agriculture, a division of the College of Agriculture. Its name was changed to the Thompson School of Applied Science in 1966. Members of the Thompson School faculty have at times consulted, or served, in a technical capacity on Station research projects. Moreover, the Thompson School shop has been used particularly to fabricate equipment for Station-supported research.

By 1959, 50 percent of the Station's professional staff had Ph.D.s. As Director Keener has indicated, the services of these Station scientists are most efficiently used when they are assisted by college graduates with scientific degrees. Graduate students contribute importantly to Station research in most departments in the college. Graduate students become more useful the longer they remain, but they also obtain excellent training for careers in science.

A new department of Soil and Water Science was formed in 1963, consisting of the Department of Agricultural Engineering and those persons from Agronomy more specifically interested in soils. A. B. Prince was named chairman of the new department.

Agricultural Economics

In an examination of the Federal Soil Bank Program in Coos County, R. A.

Andrews and G. E. Frick (1960) found that "the Program has eased the transition of some people and many acres of land out of agriculture. Desirable forest stands were established and conservation resources enhanced."

In response to major floods due to the hurricanes in the 1930s, six major flood control projects were initiated by the Federal Government. Many of these took valuable river bottom lands. G. B. Rogers measured the impact of these reservoir areas on agriculture. He found that much of the land could be used productively by adjacent farms but the intensity of cropping had to be decreased.

E. T. Bardwell and Rogers (1959) looked at the costs and economics associated with size in chicken processing. They designed and analyzed model dressing plants. They predicted the disappearance of smaller operators since "volume sale prices will be relatively lowered and centralized buying would exclude these operators."

C. R. Burbee and Frick studied the ability of broiler growers to accumulate capital (1962). They found that "payments should average more than the minimum used in this study to assure growers a satisfactory level of living and accumulation of capital." As predicted, the broiler industry in New England has all but disappeared.

Looking at the assembly of poultry, Rogers and Bardwell (1963) reported the volumes of poultry, miles traveled, personnel and truck costs used. They established "a least-cost system for a particular supply area." They showed how assembly costs could be reduced by 20 percent if volume per truck mile doubled. Creating exclusive territories and increasing firm volumes to 100 percent would effect a cost saving of 40 percent.

Biochemistry

G. P. Percival and D. Josselyn determined that the cobalt content of forages can be increased by application of cobalt sulphate to the soil. If applied through fertilizer, it need not be added to animal feeds. A. E. Teeri and associates, searching for new sources of nutrients, found seaweeds to be an important potential source of water-soluble vitamins for either animals or humans. When he studied the nutritive value of various species of saltwater fish consumed in New England, he found them equal to or superior to lean meat in certain water-soluble vitamins and proteins. He later developed a microbiological method for determination of protein which is simple, rapid and measures the availability of protein to animals.

For most of this period, A. E. Teeri was department head, but E. J. Herbst was appointed head in 1963. D. G. Routley, appointed as Assistant Professor in 1957, was later to transfer to Plant Science and, in addition to his departmental duties, became editor of Research Highlights, a publication of the Agricultural Experiment Station and McIntire-Stennis Cooperative Forestry Program.

Agricultural Engineering

During this period, a rather wide variety of research projects were undertaken by the department. R. S. Palmer noted that although rainfall during the growing season in New Hampshire should be adequate for plant growth, the precipitation may be spaced such that plant damage results. He suggested that forage crops be used to estimate soil moisture deficiencies. With this information, one could calculate the probable amount of irrigation water

needed, thus providing a useful guide to designers of irrigation systems, and assisting in determining when to irrigate.

H. N. Colby devised plans for using a photoelectric cell for control of poultry house lighting when natural lighting conditions required supplementation with artificial light.

G. L. Byers and S. A. Miller studied the effect of tractor weight and drive wheel slippage on soil compaction. They found that rate of water infiltration was influenced more by slippage than by compaction and that this decreased plant yield. Tractor traffic was shown to damage legume plants and reduce subsequent yield.

J. J. Kolega, recognizing the critical nature of air temperatures for plant growth and survival, animal and insect development, building design etc., developed air temperature guides for New England based upon past official records. He stressed that knowledge of limits and frequency of different values was important for maximum use of the environment.

The department head from 1955 to 1962 was J. J. Kolega. Byers was head until he transferred to the newly created Department of Soil and Water Science in 1963.

Agronomy

The quality of potatoes is associated primarily with starch; increasing the starch increases mealiness and therefore improves the quality whether boiled or baked. F. S. Prince and P. T. Blood found that potatoes from plots that received potassium sulphate, not the chloride or muriate of potash, had the highest quality ratings. It was the absence of chlorine, not the sulphur in the sulphate of potash, which influenced quality. Apparently, chlorine has a depressing effect on starch formation. Potato quality was also increased by planting a cover crop, but decreased by the use of manure.

R. Feuer, a graduate student, found that because of recent past fertilization many New Hampshire soils appear to have adequate available potassium and also "potassium supplying power." On the other hand, graduate student W. H. Mitchell determined that boron, a trace element, may be deficient (in water-soluble form) in some New Hampshire soils. Magnesium, another trace element, was shown to be needed for growth of potatoes, corn and apples, but that heavy applications of manure lessen the need for addition of magnesium.

G. M. Dunn, plant geneticist, and others, conducted variety trials of three forages — smooth bromegrass, alfalfa, and Ladino white clover — testing them for adaptability, yield and resistance to disease. Following these tests, and based on observation of large differences in the amount of infection between individual bromegrass plants, D. A. Emery and Dunn began selection with the objective of breeding for resistance to brown leaf spot, a fungal disease caused by *Pyrenophora bromi*. Dunn, F. W. Calder and RA Kilpatrick, plant pathologist with the U.S.D.A., compared variation among the small, medium and large types of white clover (*Trifolium repens* L.) and concluded that strains and varieties of the large type, such as Ladino, were superior to the other types for initiating a clover breeding program for the northern states.

The effect of rate of nitrogen fertilization and date of harvest on yield, persistency of stand and nutritive value of bromegrass hay was investigated by a team and reported in Station Bulletin

No. 472. Yield and persistency were investigated by N. K. Peterson and P. T. Blood, and nutritive value by N. F. Colovos, H. A. Keener and H. A. Davis.

Growth chambers for better control of temperature, light and humidity in basic research with plants were designed and constructed by A. B. Prince and P. T. Blood.

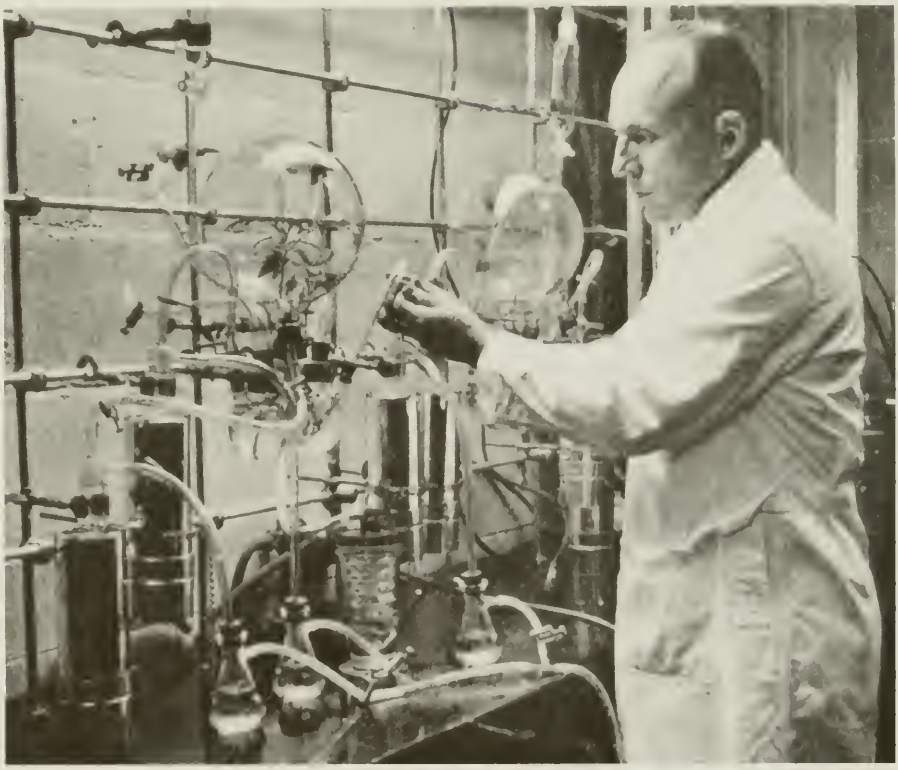
When R. L. Donahue resigned as head of the department in 1956, A. B. Prince was appointed to replace him. Prince continued as head until 1963 when he transferred from Agronomy to the new Soil and Water Science department, and Agronomy merged with Horticulture.

Animal Science

Emphasis during Tirrell's tenure was placed on teaching and extension activities. G. L. Smith and H. E. Kimball were the other members of the department.

Botany

A. E. Rich studied black root rot, a serious disease of strawberries, and showed it to be partly due to nematodes. Apple scab is a fungus disease known for approximately 100 years. Rich tested new organic fungicides and varied spray schedules, searching for more effective control of this pathogen. He and pathologists at the University of Maine collaborated on a bulletin entitled, "Apple Virus Dis-



A. B. Prince studies the movement of water in soils and plants by radioactive tracers

S. Dunn with dwarf pea plants growing under various colored lights

eases — An Illustrated Review" (UNH Technical Bulletin 101; U.Maine Bulletin 595). With graduate students J. Barrett and R. McCrum, he demonstrated the viral nature of several apple diseases. Rich identified a serious problem of garden peas caused by a soil fungus *Fusarium solani* f. *pisi* and initiated a breeding program which culminated in a resistant cultivar named 'Sure crop'.

The University herbarium, a collection of some 20,000 dried, mounted and systematically arranged plants, was an invaluable resource for the research of A. R. Hodgdon and others because it provided a workable reference collection for comparing new specimens. Hodgdon authored Station Bulletin No. 447, "Woody Plants of New Hampshire," and was involved in projects on spring flowers of New England and New York, and on identification of wild blackberries of New Hampshire. He observed that many weeds, poisonous plants and useful wild plants in the state had been neither collected nor identified.

S. Dunn investigated the effects of wavelength (color) and intensity of artificial light on plant growth, flowering and fruiting, and the influence of varying wavelengths on herbicide action. Dunn and R. Eggert (Horticulture) researched methods for propagating woody plants. Sugar maples

survived only one of the procedures, and then only with difficulty, while apples and hazel-filbert hybrids propagated relatively well. R. W. Schreiber knew that plant chloroplasts make sugars, but sought to determine whether or not they manufacture protein.

In 1956, J. F. Reed was appointed Professor of Botany, Dean of the Graduate School, and Coordinator of Research. Although he held an appointment in the Experiment Station, teaching and administrative duties consumed most of his time. In 1959 he was named Dean of the College of Liberal Arts, in 1960 Vice President and in 1961 Acting President.

Dairy Science

H. A. Keener, in a five-year experiment, evaluated factors which influence the Vitamin D content of forage crops. Results were in agreement with the then current practice of making the first crop of forage into grass silage, the second into field-cured hay. The grass silage would be high in feeding value, but contain less Vitamin D than second cutting field-cured hay. Notwithstanding the important role of grass silage as one means of preserving forage, Keener and H. C. Moore expressed concern that it must be made such that it is free of odor caused by butyric acid. For some reason, milk from cows fed grass silage of high moisture content has an objectionable silage flavor. Keener, N. F. Colovos and graduate student R. B. Eckberg experimenting with dried citrus pulp for dairy cattle, found it useful in a concentrate mixture when the price was favorable.

Colovos predicted that through energy metabolism research all feedstuffs eventually would be evaluated on a standardized and direct energy basis.

C. H. Boynton was extension dairyman in 1945 and for a short period conducted research in animal physiology partially supported by the Station. J. B. Holter joined the department in 1962 as a dairy nutritionist. Professor Morrow relinquished his administrative duties in the department in 1963.

Entomology

Horseflies are pests of cattle and horses. Of the 39 species known in New Hampshire, seven attack livestock and appear in sequence during the summer. R. L. Blickle conducted tests of various repellents and devised a "backrubber," a self-treating device which allowed an animal to treat most parts of the body. It worked well, but did not control flies on the underside and legs. In 1957, Blickle reported an established infestation of American dog tick in certain areas of the state, important because in other states spotted fever has been associated with this tick. Blickle and R. G. Strout developed a procedure for controlling Northern fowl mites in laying hens.

J. G. Conklin, now department head, reported the apple mealy bug (1956) and the livestock face fly *Musca autumnalis* (1960) as pests new to New Hampshire.

W. R. Lee, geneticist, introduced genetic markers into honeybee populations using artificial insemination. The study was directed toward more effective use of honeybees for pollination of agricultural crops. Honeybee hives should be dispersed throughout a field or orchard for most efficient use of each colony.

G. T. Fisher brought a practical and industry viewpoint to the department when he began as chairman in 1969. Apples, and the insects affecting

them, are his main interest. He is looking for more efficient and safer insecticides and new nonchemical control methods.

Forestry

Can changes in land use and forest conditions be ascertained from aerial photographs? B. Husch and C. Gibbs contrasted aerial photographs of Madbury, N.H. taken 10 years apart and concluded that these photos appeared to reveal such trends accurately. Husch, over a period of several years, investigated selected environmental factors — temperature, soil type, soil moisture, photoperiod — on growth of white pine trees in southeastern New Hampshire. All were important, but their relative value changed during the growing season. Although forest products are generally measured in volume units, this practice has disadvantages, some of which Husch believed would be circumvented by substituting weight as the unit of measure. In a pilot study, he showed that the weights of standing trees could be reliably estimated and that the results justified further study of the concept.

Around 1955, L. C. Swain and O. P. Wallace became interested in the marketing of forest products and buying practices of wood-using industries in New Hampshire. Wallace and his graduate students detailed the importance of white pine lumber in the industry, the problem of selling the lower grades of lumber, the percentage of lumber utilized by wood-using industries purchased in the state, and the significance of the decline in number of sawmills in the state. The project was supported by Hatch regional marketing funds.

The importance of seedbed preparation on seed germination and survival of white pine seedlings was investigated by silviculturist H. W. Hocker, Jr. In an experiment covering four years, he found that conelet production of white pine trees could be stimulated and sustained by fertilization. J. P. Barrett and P. H. Allen used regression technique to predict future yield from extensively managed white pine stands.

P. E. Bruns provided the leadership for the department for some 10 years beginning in 1958, a period in which the scientific staff reached a total of eight.

Home Economics

Using University of New Hampshire women students, A. M. Light and S. R. Shimer (Agricultural and Biological Chemistry) investigated the effect of substituting vegetable fat for pure carbohydrate on blood phospholipid levels. B. Byers and Light used a taste panel to compare four varieties of horticulture beans, bred by Meader and Yeager in the Horticulture Department, with several other varieties following processing. They found the New Hampshire varieties equalled or excelled the other varieties tested.

M. Wybourn followed A. Light (now A. Light Smith) as department head in 1961.

Horticulture

Plant breeding continued to be the main emphasis of horticultural research and capitalized on the groundwork laid earlier. The overall objective was to change the plant to fit the environment. In addition to hardiness and early maturity, another objective was improved insect and disease resistance — a goal not always obtainable. Techniques utilized to reach objectives varied depending on the plant material. In some instances, colchicine

A. F. Yeager with Horticulture students

was used to make sterile hybrids fertile; in others seeds were irradiated to increase variability; or a diploid x tetraploid cross was used to produce a triploid, thus creating new genetic material. Yeager and Meader continued leadership, but several graduate students were involved in originating the new vegetable varieties. Moreover, L. P. Latimer contributed to the fruit breeding, and E. D. Risley, R. B. Pike and O. M. Rogers to improving and developing ornamentals.

By 1961, approximately 100 plant varieties had been introduced by the Station (a few by number for trial only). Included in the vegetable category was the 'Doublerich' tomato with twice the vitamin C content of ordinary tomatoes, the red-fleshed 'Sweetheart' beet with sugar content comparable to that of the sugarbeet, and the 'Golden Midget' watermelon with its built-in indicator of ripeness — it turns from green to yellow. But some of the research underlying development of a new variety produced unexpected results. While attempting to breed a hardy hybrid peach, Yeager found that the color of the peach seedling, even before emerging from the soil, would be either white or yellow, and directly associated with the color of the flesh of the fruit at maturity. Because the consumer insists on a yellow-fleshed peach, the white seedlings are discarded and the cost of peach breeding is greatly reduced.

Apples were commercially important in the state, and thus one long-term project was breeding resistance to apple scab. Blueberries, also important commercially in New Hampshire, were bred for hardiness and early fruiting. Meader crossed low bush with high bush blueberries to produce a half-high plant less susceptible to winter damage. Several new varieties of strawberries and raspberries were bred and released by the department.

Meader collected seeds of the wild species of Chrysanthemum (*Chrysanthemum sibiricum*) in the mountains of Korea in 1947 and from this material some 15 new varieties of hardy, colorful plants have been produced. Extending the flowering season and originating new colors was the focus of lilac breeding, continued by O. M. Rogers following Yeager's retirement, and new varieties were created. Risley bred new varieties of roses and Monarda (bee balm). Pike, who worked with rhododendrons and azaleas, selected them for superior form, and hybridized them for new colors, late blooming and hardiness.

On an experimental farm in Coos county, Latimer tested newer varieties of tree fruits — pears, apples, plums, cherries — over an eight-year period to determine which ones showed winter injury and damage. He also worked out best culture methods for the 'Durham' raspberry and for pear production. R. Eggert investigated fertilizers and cover crops for apples and J. L. Pearson developed a method for propagation of late-blooming lilacs from softwood cuttings.

At the time of his retirement from the university in 1958, Yeager had been the recipient of several awards for his contributions to plant breeding including, the Stevenson Memorial Medal, Manitoba, Canada; the Award of Merit from the Vegetable Grower's Association of America; the Wilder Medal of the American Pomological Society; and in 1956 election to mem-

The first casaba melon variety to mature in New Hampshire

bership in the American Academy of Arts and Sciences.

For brief periods following Yeager's retirement, both W. W. Smith and R. Eggert held appointments as head of Horticulture. In 1963 Horticulture and Agronomy merged to form Plant Science with some personnel moving to Soil and Water Science.

Poultry Science

Poultry diseases directly affect the cost of commercial poultry production, the rate of growth of the industry and the financial stability of the individual poultry farm enterprise. The department made a strong effort to keep its disease research program current. As with humans, respiratory diseases of poultry are a continuing problem. Following the development of methods for mass vaccination of flocks against infectious bronchitis and Newcastle disease, attention turned to the chronic respiratory disease complex (CRD), then economically important to poultrymen. W. R. Dunlop was the first to isolate the chronic respiratory disease virus and to show that a pleuro-pneumonia-like organism (PPLO), complicated by vaccination and the CRD virus, produced air sac disease. This was followed by an effort to produce PPLO-negative chicks by treatment of breeders with an antibiotic to suppress hatching egg transmission of the agent. By 1957, infectious synovitis, a hock-joint disease, was new to New Hampshire. The application of cell culture technique as

Testing for Pullorum disease in the UNH Diagnostic Laboratory

part of the laboratory procedure for poultry disease research was by now standard and would be valuable in investigating the synovitis problem.

R. G. Strout, investigating the synergistic effect of drugs for controlling the intestinal parasite Eimeria which produces coccidiosis, began research to propagate the several stages of the parasite life cycle in a cell culture system in the laboratory.

One million breeder chickens were tested for pullorum disease in 1955, and nearly 4,000 birds were examined in the Diagnostic Laboratory.

In the field of poultry management, W. C. Skoglund investigated the role of light intensity, wavelength and duration on growth, feed efficiency, mortality and egg production. He also examined the effect of hatching temperature and humidity of eggs prior to incubation on hatchability and chick quality. The New Hampshire Egg Production Test, begun in 1959, provided a means by which breeders of egg-type chickens could obtain unbiased estimates of the genetic potential of stocks being sold to commercial poultrymen.

An experiment was begun to answer this question: Can restricting the feed of a pullet grown for flock replacement be beneficial? Data obtained by R. C. Ringrose, nutritionist, indicated that the major advantage of such restriction was a 20 percent reduction in feed use. However, pullet weight was decreased by one-half pound and sexual maturity was delayed by 8-9 eggs, but egg production was unaffected. Later, after extensive research, Ringrose determined that the protein and energy content of a ration should be in proper balance for highest feed efficiency of the growing chicken. Niacin, a water-soluble vitamin, is needed by poultry, but at that time the requirement for this vitamin was not known. Ringrose developed a niacin-deficient experimental diet on which the birds remained healthy and survived. The research culminated in a 1965 paper entitled, "The Niacin Requirement of the Hen."

In the early 1960s, following retirement, Ringrose turned to fish nutrition. Recreational fishing in New Hampshire had outstripped natural reproduction of trout, the most popular fish. In cooperation with the N.H. Fish and Game Department, he inaugurated a program to develop a suitable dry pellet feed that was inexpensive and easy to prepare and store.

In the New Hampshire and other Broiler Tests, a random sample of the commercial product of each breeder is evaluated for traits of economic importance. Using the New Hampshire Broiler Test facilities, W. M. Collins and Skoglund determined which of the traits being measured were detecting genetic differences among stocks. Based upon their findings, the facilities were remodeled to provide duplicate pens for each entry thus improving the Test. In other research, Collins selected adult males for more efficient use of feed, and compared the efficiency of recurrent vs. closed flock selection for improving broiler stocks.

Chapter 6

Environmental Conservation, Computers, and Regional Research (1964-1974)

New programs of study for undergraduate students in the College of Agriculture emerged during this 11-year period commensurate with a heightened awareness of the need for conservation of the environment, greater planning in community development, increased use of electronic computers in research, and advances in science in general. Changes also occurred in the number and structure of the departments in the College. Upon the retirement of K. S. Morrow as head of the Department of Dairy Science, and of L. V. Tirrell as head of the Department of Animal Science in 1963-64, these two departments, together with Poultry Science, were consolidated into one department of Animal Sciences with W. C. Skoglund as chairman. At the same time, the Department of Agricultural Economics was renamed Resource Economics.

Beginning in 1961 Director Keener began negotiations to purchase land in nearby Madbury for use as an experimental farm. Ownership of the property, now consisting of approximately 200 acres, was completed in 1973. The land, known as the Kingman Farm, is used for research by scientists in Biochemistry, Botany and Plant Pathology, Forestry and Plant Science.

Late in the 1960s a decrease in the number of undergraduate students had raised a concern about the future of the College. Dean Keener, believing that fewer departments could be administered more efficiently, by 1971 had reduced the number of departments in the College from 13 to six plus a new Institute of Natural and Environmental Resources. According to D. G. Routley, Editor of Research Highlights, "The Institute was created in 1969 to provide an interdisciplinary atmosphere where scientists could combine their skills and specialties to solve natural resource and environmental problems." Included in this unit were Forestry, Resource Economics, and Soil and Water Science. The Institute was headed by a Director, the first being O. F. Hall who had succeeded P. E. Bruns as chairman of Forestry. The six remaining departments were Animal Sciences, Biochemistry, Botany, Entomology, Home Economics, and Plant Science. Although the consolidation effort was not welcomed by all Station scientists, it worked reasonably well for a decade and a half.

In 1969, with legislative approval, the College acquired a new name — College of Life Sciences and Agriculture — a title better describing its orientation and activities.

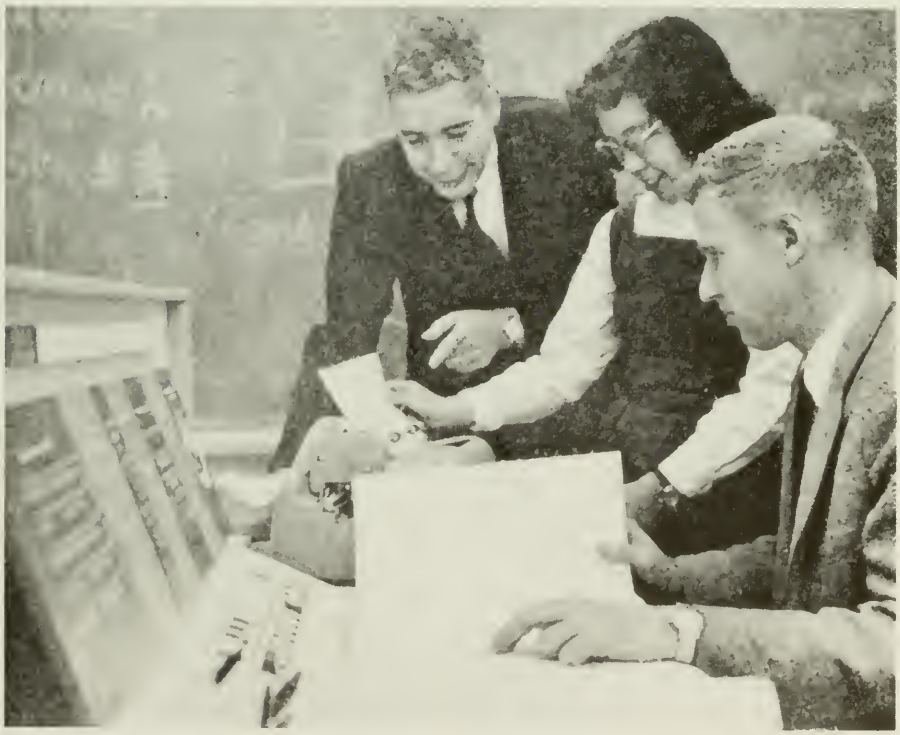
A Genetics Seminar Committee, organized in 1959 with W. M. Collins as chairman, had the objectives of promoting student interest in genetics and strengthening genetics teaching and research. Two years later Dean Keener requested that the committee study the need for a graduate program in Genetics and, if needed, develop plans for the program and recommend a procedure for its operation. Thus in 1964 the Genetics Group became a recognized unit of the University with

responsibility for granting advanced degrees in genetics under the aegis of the Graduate School. Many of the graduate students in genetics have received financial support from the Agricultural Experiment Station and contributed to the total research effort of the College.

The concept of regional research, begun in the 1950s, took on greater significance during this era. For New Hampshire, this meant the Northeast region, and a percentage of Hatch funds was earmarked for this purpose. Scientists in the region submitted proposals to their Station Directors addressing themselves to a pressing problem of interstate or regional concern. An Administrative Advisor was appointed for the project and a Technical Committee formed consisting of scientists representing institutions in the Northeast interested in cooperating in the project. The Technical Committee developed goals and objectives for their experiments, and assigned responsibilities to members who met annually to review progress.

Later, Congress authorized Special Grants for selected individual projects which identified new problem areas and fresh research opportunities. Examples were water resources development and human nutrition.

The first medium for publication of results of original research by the Station was the Experiment Station Bulletin series. By 1964, according to W. E. McGrath, Branch Librarian, Biological Sciences Library (1956-1964), the Station was issuing 17 different series, but the majority of pa-



R. A. Andrews and students use the electronic computer in Agricultural Economics

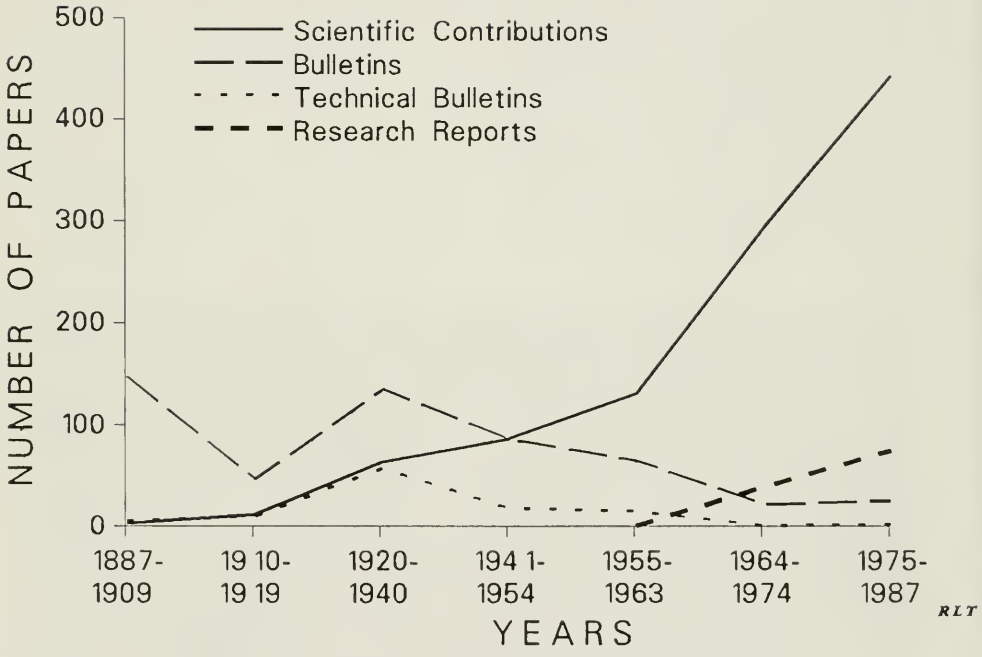


Figure 1.

Number of papers contributed by Station Scientists which appeared in each of four major series of publications of the New Hampshire Agricultural Experiment Station, 1887-1987. (Figure prepared by R. L. Taylor, Jr., from data compiled by W. M. Collins).

pers now appeared as Station Bulletins, Technical Bulletins, Research Reports, and increasingly as Scientific Contributions in various Scientific Journals (see Figure 1). According to W. E. Urban, Jr., Technical Bulletins were officially dropped in 1966 and Research Reports standardized to 8″x11″ (regional interest) and Station Bulletins 6″x9″ (national interest).

Sources of funds for agricultural research during this period were the U.S.D.A., the state of New Hampshire, commercial grants, and other federal agencies such as the National Institutes of Health, in Washington, D.C. Since 1951, or earlier, Hubbard Farms, Inc. of Walpole, N.H. supported a graduate research assistantship in Animal Sciences and later a summer undergraduate research fellowship.

Agricultural Economics

During this period, Agricultural Economics endured two name changes. In 1964 the group became known as the Department of Resource Economics. This was a more descriptive name indicating the broad research efforts of the Department. A second reorganization occurred in 1969 and will be discussed later.

H. C. Grinnell, who had retired as Dean, wrote an economic appraisal of public education in the State (1964). Grinnell said, "There are extreme variations among school districts, more particularly with respect to such economic factors as total equalized valuation, equalized valuation per capita, trends in population, and the distribution of taxable property as classified by the Planning and Development Commission in 1957. It is because of these variations that some districts are more able than others to provide better facilities, pay higher salaries and have fewer pupils per teacher, and without an appreciable increase in the tax rate."

His second publication in 1967 described the patterns of expenditure among rural N.H. school districts. "When relating the number of pupils or population to expenditures per pupil, the average indicates some economies of scale. The deviations from average are great particularly among districts of small population and a correspondingly small number of pupils. This divergence declines and, in fact, becomes quite narrow among the larger districts. The amount of variance, however, cannot be explained on the basis of population alone."

C. R. Burbee, E. T. Bardwell and W. F. Henry continued working on the general project of "Marketing New England Poultry." Firm size, supply density and transport distance were evaluated as to their influence on efficiency and cost. They found that "combining the costs of processing and assembly develops a more complete picture of marketing costs than either of the enterprises taken separately." The chick hatchery study evaluated hatcheries with output of 1.3 million to 21.7 million chicks per year. Economies in hatching and distribution are such that production density would make it economical for a poultry integrator to "construct and operate its own broiler production facilities close to the premises and hatching facilities."

With the arrival of the first University-owned computer in 1962, new areas and types of methodology were available to the Station's economists. Simulation analysis was used in a forage production and utilization study by C. Cloud, G. E. Frick and R. A.

Andrews. Historical weather patterns along with crop yield, quality and milk output were used to determine the optimum time to begin forage harvesting.

Linear programming as a technique could be exploited with the new university computer. D. H. Harrington and Andrews (1967) used linear programming to optimize dairy farm incomes and value additional amounts of major resources with different milk prices, milk responses and quantities of farm resources. They established "break-even prices which may be paid for cropland and cows of varying qualities. Discounting methods were applied to the marginal value products to determine break-even prices of durable assets."

Andrews and Frick, using linear programming, worked with a Northeast study committee to evaluate potential milk production and market equilibrium (1968). They concluded that "short-run supply shifters are more important in determining quantities supplied in the Northeast than is the elasticity of the supply functions."

Henry resigned as chairman in 1965 and was succeeded by J. R. Bowring. In 1969 the Department was merged into the large multidisciplinary Institute of Natural and Environmental Resources. This fostered interdisciplinary efforts. Andrews and R. R. Weyrick, a forester, applied linear programming to values and costs of surface water use and treatment.

With the expanded horizons of the Institute, many new research topics were undertaken. R. H. Forste investigated the expenditures of lake trout ice fisherman (1968). The average expenditure per lake trout ice fisherman was $29 and this was based on a $5,000 to $7,000 average income. The 2,120 fisherman using Newfound, Sunapee and Winnepesaukee Lakes averaged 2.02 trips per season.

A major State Park was developing during the late 1960s. C. T. K. Ching, E. F. Jansen, Jr., and Frick looked at the effects of the Pawtuckaway Park on the surrounding towns. One study estimated park user expenditures in the surrounding towns. In 1969 the 24,000 day users spent only $.32 per person in the surrounding four towns. The people who camped at the Park totaled 49,900 camper nights and averaged $.89 per person per night. Other studies found small effects on adjacent property values or on municipal expenditures and revenues of adjacent towns. For most measurable characteristics, the park showed little impact on the adjacent towns. The authors concluded that the extreme rural character of these towns minimized the disturbance.

A state park with facilities for both summer and winter recreation

In 1968 an amendment to the State's constitution permitted a preferential land assessment program,

promoting investigation of that concept in New Hampshire. Ching (1968) indicated that taxing land according to value tended to encourage landowners to put some land to more profitable use (e.g., housing development), a move not necessarily in the best interest of society. He noted that preferential assessment does reduce the tax burden on the private land owner maintaining open space land for the public good. Two years later Ching and Frick, using a computer model, concluded that on the average, use value assessment would increase tax rates only slightly, but that increases would be greatest in the smaller towns.

In a review of the New Hampshire Current Use Program, covering the 78 towns involved, D. E. Morris, Frick and D. A. Burwell (1974) argued that "use value assessment would be more equitable if administered on a state or regional basis rather than a municipal basis."

The world fuel crisis prompted J. P. Davulis, Andrews and Frick to develop procedures to minimize the costs associated with bulk feed delivery to dairy farms. They used shelf-life of the feed, bin size and herd density to estimate savings with alternative assumptions. They estimated that 25 million tons of mixed feed was used per year involving 100 million miles of travel using 16 million gallons of fuel. They concluded that if frequency of delivery was reduced, energy savings of 1.1 to 3.7 million gallons could be realized annually. Exclusive delivery territories would enable savings of 10.5 million gallons.

Davulis, Andrews and Frick also examined the effect of spatial density on marketing costs and supply firm resource use. The structure of the Livestock Marketing System was appraised in 1974 by Andrews, C. Yunker, Davulis and Frick. They described the marketing channels and the quantities of meat produced. New Hampshire production as a percentage of New Hampshire consumption of beef and veal was 7.8 percent, lamb and mutton 1.7 percent, pork 2.0 percent and poultry 0.6 percent. Obviously, New Hampshire was not self sufficient for these products.

J. Dorrer and Bowring appraised the effectiveness of New Hampshire's Manpower Development and Training Act between the fiscal years 1970-1972. On a criterion of wage increases and unemployment, the program "provided opportunities for unskilled and low income workers to stabilize and improve their association with the active labor force."

Animal Sciences

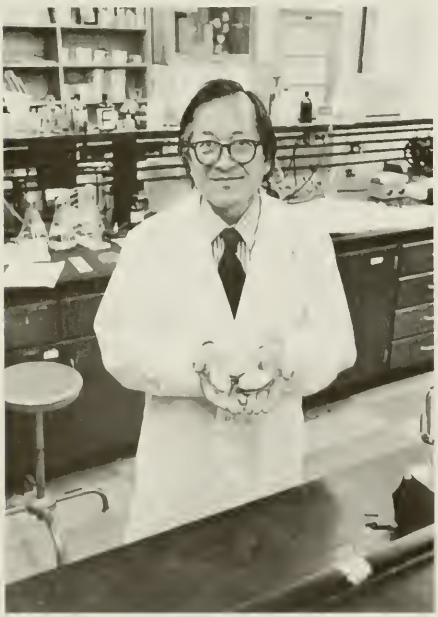
Dairy nutrition research focused on: (1) the nutritive value of the ration of the lactating dairy cow as affected by different levels of urea, and types and quality of concentrate ingredients; (2) metabolism experiments to determine digestibility and nutritive value of various ration ingredients; and, (3) the effect of various minerals on the metabolism of copper in dairy cattle. Many publications resulted from this research during this period and several investigators and associates participated, including N. F. Colovos, J. B. Holter, W. E. Urban, Jr., H. A. Keener, H. A. Davis, J. E. Vanderveen, H. H. Hayes, R. M. Koes and B. S. Reddy. Since the number of investigators involved in these experiments typically ranged from two to five, this research served as a good example of the team approach to solving problems.

In poultry nutrition, the availability of niacin in several ingredients of

the ration of the laying hen was determined.

New Hampshire Broiler Test facilities were used by W. C. Skoglund and others in the department to establish growth and feed standards for broilers. Genetic research revealed that both single and multiple genes affected the concentration of water soluble vitamins in eggs and of cholesterol in egg yolks.

The value of tissue culture technique was underscored by its increased usage in several areas of poultry disease research. In parasitology it was used to study the development of the coccidian *Eimeria tenella* in both sexual and asexual stages of the life cycle in culture. In heart research the technique was applied to an investigation of the role of smooth muscle cells and of mitochondria in aortic cells from atherosclerotic White Carneau pigeons. Cell culture was also used to propagate the mycoplasma organism in research on chronic respiratory disease.



M. Ikawa, Biochemistry

Biochemistry

The research investigations in this department were now becoming increasingly more fundamental than applied and frequently oriented more toward health than agriculture per se. E. J. Herbst, department chairman from 1962 to 1974, analyzed polyamines by thin layer chromatography and showed that they inhibited enzymatic degradation of ribosomes of *Escherichia coli*. He also studied the effect of spermidine in the synthesis of ribonucleic acid. M. Ikawa's research was oriented toward toxic chemicals produced by microorganisms. He and J. J. Sasner, Jr. (Zoology) had been collaborating on a study of toxins produced by microscopic red algae in marine coastal waters. During the summer and fall, under proper conditions, a tremendous growth of these algae produces what is referred to as "red tide." Shellfish ingest the algae and concentrate the toxins in their tissues. When clams and other shellfish are eaten by humans, a condition called paralytic shellfish poisoning results which may cause illness and even death. Ikawa, Sasner and graduate students developed a method for measuring the toxins which were 100 times more sensitive than the older mouse test, required less material, was much faster and had the added possibility of performing the analysis directly on the shore.

Other forms of algae found in some bodies of fresh water in New Hampshire cause death of fish.

Botany and Plant Pathology

Taxonomy was the major research interest of A. R. Hodgdon, chairman of Botany. In a joint research effort, he and R. B. Pike added to the known

flora of the Wolf Islands, New Brunswick, and made a floristic comparison of three bird islands in the Gulf of Maine.

Plant Pathology was not included in the name of the department until 1973, but A. E. Rich and his graduate students and associates were productive researchers having published some 20 research papers during this decade. Their investigations concerned primarily the identification and control of viral and fungal diseases of potatoes, apples, and strawberries. But they also documented that use of highway salt in winter for control of icing resulted in injury to roadside trees. They attributed the decline of maples along U.S. Route 4 in Northwood, N.H. to severe salt injury, and found that some tree species were more tolerant to chloride than others.

Plant growth, maturity and reproduction are dramatically influenced by the wavelength, intensity and duration of light. This was shown by S. Dunn, physiologist, and his colleagues using various species of plants. Later research revealed that light influenced the accumulation of carbohydrates and alcohol-soluble constituents in leaves.

R. W. Schreiber's investigations centered on the chloroplast, seat of photosynthesis and starch and nucleic acid formation in higher plants — and more specifically on in vivo synthesis of lipoprotein in the membranous network of the chloroplast.

Station scientist A. C. Mathieson studied the composition, seasonal occurrence and reproductive periodicity of benthic marine algae (photosynthetic, lower plants occurring on the bottom underlying a body of water) in New Hampshire, Newfoundland and the Chesapeake Bay regions.

Entomology

The association of distance to the intensity of foraging of honey bees on natural food sources was studied by W. R. Lee, who found that the relative attractiveness of a food source decreased rapidly as the distance from the apiary increased.

R. L. Blickle described a new species of *Hydroptibidae* (caddis fly) found in New Hampshire and Maine; R. M. Reeves and V. G. Marshall redescribed *Brachychthonius lydiae* (mites); J. E. Kierans reported on some avian ectoparasites found on birds of New England; and H. B. White and W. J. Morse consolidated the literature on some 130 species of *Odonata* (dragonflies) in the state, 23 of these being reported for the first time.

Forest Resources

Forests are an abundant natural resource in New Hampshire and eastern white pine is an important forest species here. Because it requires many years to reach maturity, however, foresters need reliable ways of arriving at estimates of future yields. J. P. Barrett and his associates researched methods of predicting growth and yield of various sized stands of forest trees, ways of improving the accuracy of their estimates, and various techniques of sampling trees in a stand.

Forest land resources and outdoor recreation activities could and should figure significantly in the state's total future economic growth, and B. B. Foster, forest economist, urged critical examination of the roles these resources should take. He also researched the profitability of Christmas tree plantations, and used linear programming techniques to arrive at least-cost blends or mixes in paper making.

Forest economist O. P. Wallace, Sr. examined the economics of marketing lumber by retail. He underscored the trends occurring in the forms of lumber materials available, the extent of competition from western firms, and studied factors influencing forest land prices in New Hampshire. In an investigation of a 13-mile woods section of the Androscoggin River, he and D. P. Olson (wildlife management) stressed that the most essential quality of that particular stretch of river was its "wild flavor" and its setting, and that because of its uniqueness that character should be preserved.

Other areas of research in forestry and wildlife concerned silvicultural practices for improving germination of white pine seeds and quality of balsam fir for Christmas trees; comparative performance of devices for remote sensing moisture in lumber; the food of New Hampshire bobcats; and sea-duck populations on New Hampshire's 18-mile coastline.

Plant Science

Frequent droughts and declining water supplies in the Northeast prompted biochemist D. G. Routley and associates to investigate the effects of water shortage on plant growth and composition. Ladino clover, selected for study because it was rather widely used as a pasture legume, shows early signs of wilting in droughts, and does not survive well in the region, yet has a high nitrogen content, a favorable attribute. They concluded accumulation of proline, the dominant free amino acid in Ladino clover, may serve to protect the plant from stress of reduced water availability.

Exploring the use of tissue culture for study of single gene resistance of

J. P. Barrett (left) and graduate student J. Gove, Forest Resources

tomato to *Phytophthora infestans*, Routley and graduate assistant R. S. Warren determined that tissue culture can be effective in investigation of disease resistance, but isogenic susceptible and resistant lines are required. They also developed a fast, easy and reliable fluorometric method for determining the activity of O-diphenol oxidase, an enzyme that plays a major role in disease resistance in plants.

G. M. Dunn used as genetic material corn, bromegrass and legumes. Using inbred lines and their crosses, he and his graduate students investigated the genetic bases of forage yield and combining ability, and in a severe infestation of Northern corn leaf blight the effect of gene dosage on resistance to the causative organism *Helminthosporium turcicum*. Ladino clover, a major pasture crop in the U.S. at that time persisted poorly. Dunn, RA Kilpatrick (a cooperative investigator from the Crops Research Division, U.S.D.A.) and A. E. Rich, plant pathologist, studied the effects of various treatments on root rot in this legume, a disease known to affect resistance, and agents that affect survival of clover during low temperature exposure. Kilpatrick evaluated some 50 species of red clover for resistance or susceptibility to leaf and stem spot caused by *Stemphylium sarcinaeforme*. Eight species were rated resistant suggesting that breeding for resistance to the disease should be effective.

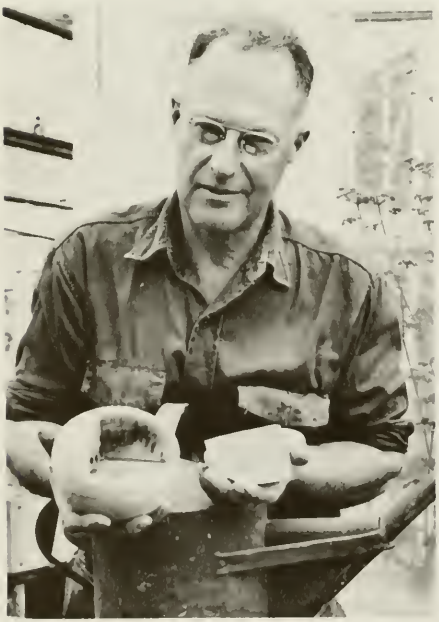
L. C. Peirce conducted a quantitative genetics experiment with tomatoes testing whether selection pressure was equally effective if applied to high density and low density plots having a mixture of genotypes.

Haploid sporophytic plants, with one instead of the usual two sets of chromosomes, are relatively rare in nature. But to O. M. Rogers, cytogeneticist and plant breeder, a method of producing haploids quickly and regularly would be of great value both in breeding programs and cytological research. Protein synthesis is inhibited when basic dyes are administered to biological systems. In one investigation with graduate assistant J. H. Ellis, pollen nuclear division was prevented in some pollen tubes with toluidine blue in *Vinca rosea* L., in vitro.

Still unanswered, however, was whether, in vivo, pollen tubes would enter the embryo sac and stimulate the egg to develop into a haploid plant. Later, graduate assistant J. D. Gearhart and Rogers found that generative nuclear division in Tradescantia paludosa could be suppressed with certain phenothiazine and acridine derivatives. The phenothiazine dyes were used because they inactivate the nucleus without apparent damage to the cytoplasm; the acridine dyes because they can produce mutations.

E. M. Meader had been a Station plant breeder for 18 years at the time of his retirement in 1966. During this time he had bred, or contributed to the breeding of, nearly one-half of the some 100 varieties of fruits and vegetables introduced by the Station over a 40-year period — an exceptional accomplishment. He had developed varieties of fruits and vegetables adapted to cool, short seasons and cold winters, including 'Reliance' (a hardy peach), 'Fall Red' and 'Fall Gold' (everbearing raspberries), 'Royalty' (purple podded bean with resistance to Mexican bean beetle), two varieties of peppers, the 'Meader' blueberry and 'Meader' per-

simmon, squashes and cucumbers. In one year alone (1965), he introduced five new vegetable varieties. He assembled plant germ plasm from around the world and distributed it to other breeders — a real contribution to horticultural science. In 1972, the Arnold Arboretum of Harvard University awarded him the James R. Jewett prize for research on native american plants. And for his major contribution to the field of fruit and fruit growing he was honored in 1976 with the Milo Gibson award by the North American Fruit Explorers — the first person to receive this recognition. In 1978 he was awarded an honorary Doctor of Science degree by the University. The Gold Seal Award for Horticulture was presented to Meader by the New Hampshire Federation of Garden Clubs in 1979. Meader received the UNH Agricultural Experiment Station Centennial Award in 1987 at a ceremony commemorating the 100th anniversary of the Station in recognition of his role in "making agricultural and biological enterprizes a vital component of the Granite State economy."



E. M. Meader, Plant Science

Soil and Water Science

At the beginning of this era, agronomic and soils research was centered in the department of Agronomy. Initially, soil survey data were utilized solely for agricultural purposes, but their application broadened dramatically because of the rapidly changing pattern of land use. A. B. Prince and W. A. Ranney noted that the use of irrigation in agriculture had increased, and that population and industrial growth in the region had created additional demands for water. They focused public thinking on the necessity of using water judiciously and allocating supply to meet future demands. S. A. L. Pilgrim (Soil Conservation Service), A. B. Prince and soil chemist N. K. Peterson emphasized that rural land was being used more intensively, and increasing pressures on natural resources necessitated that available soils information be used maximally by private citizens and public officials.

The first detailed study of New Hampshire tidal marsh soils was made by C. H. J. Breeding, F. D. Richardson, and Pilgrim. Tidal marshes constitute a unique ecosystem. Their survey contained information useful for assessing the suitability of different areas of the tidal marsh for a variety of potential uses.

Hydrologist F. R. Hall developed mathematical models which would permit prediction of the groundwater depletion curve from field measurements by hydrologic and geographic variables; and models which would facilitate study of the relationship between dissolved particles and discharge in streams.

L. W. Slanetz, Microbiology

Microbiology

For several years, L. W. Slanetz and associates had worked on the development of a vaccine to be used in dairy cattle against *Staphylococcus mastitis.* Early in this work, supported in part by Station funds, they had shown that the enzyme β-hemolysin typically is produced by staphylococci which had been isolated from animals, but was especially distinctive of strains isolated from cases of bovine mastitis. Because of the strong association between this enzyme and staphylococci which cause mastitis, W. R. Chesbro and students purified and studied hemolysin, in one aspect of this research which was focused on control of the bacterial infection. They learned that hemolysin destroyed macrophages and tended to degrade the staphylococci cell walls.

Food containing *Staphylococcus aureus* is not suitable for human consumption. Chesbro developed a simple, sensitive method for extracting and measuring staphylococcus nuclease, an enzyme isolated from foods containing *Staphylococcus aureus*, and applied the technique to foods, such as potato salad and ham which are sometimes implicated in staphylococcus food poisoning.

Slanetz in 1969 became Director of the newly formed Division of Health Studies and Dean of the School of Health Studies the next year.

Zoology

Pasture plants such as alfalfa and Ladino clover contain substances with estrogenic effects which may cause infertility and/or various other reproductive problems in several different

farm animals. Estrogen is the female sex hormone; coumestrol is a plant estrogen. P. A. Wright, an endocrinologist in the zoology department, and graduate student W. W. Leavitt, in research partially supported by U.S.D.A. regional research funds, determined that pure coumestrol had the effect of blocking anterior pituitary gonadotropic function. It caused uterine growth, however, prior to inhibiting release of the gonadotropin from the pituitary.

Analytical Services

In the year 1900 F. W. Morse, chemist and Vice Director of the Experiment Station, reported that "several lots of poultry foods had been analyzed during the last two years for protein, fat and fiber. Five of seven were meat and bone meal, one was meat scraps and the last was ground dried fish" (Station Bulletin No. 79). Thus began a service supported in part by the Agricultural Experiment Station. Forty-eight years later H. A. Davis became chemist in charge of the Analytical Services Laboratory in the Station, having begun analysis work in the Department of Agricultural and Biological Chemistry in 1932. His responsibility was to supervise testing of feeds, fertilizers, soils and seeds and report the results of these tests to the New Hampshire Commissioner of Agriculture annually. Thousands of such samples are tested each year.

In 1965 Davis and W. E. Urban, Jr., Station Statistician, published in the Journal of the Association of Official Agricultural Chemists a paper entitled "Determination of Total Nitrogen in Fertilizers." Five methods for analysis of total nitrogen in fertilizers were submitted to collaborators in 12 laboratories. The study covered several years' data. Appropriate, modern statistical methods were used to assess the importance of three factors — years, techniques, and samples — and their interactions. Although no one method was "best," they recommended that the "chromium powder" technique be adopted as official and that two others be studied further.

Chapter 7

Basic Research, Health Research and Biotechnology (1975-1987)

The New Hampshire Agricultural Experiment Station has had 14 directors during its first 100 years, two of whom had lengthy terms of service. J. C. Kendall, who served 28 years in that capacity (1910-1939), was followed in years of service by H. A. Keener with 20 years (1958-1978). Kendall Hall, constructed in 1970, and named after Director Kendall, houses the Department of Animal and Nutritional Sciences. (Appendix 1 gives the Directors of the Station and Deans of the College of Agriculture, 1887-1987. Appendix 2 indicates the Vice, Associate, and Assistant Directors of the Station, Associate Deans of the College and Assistants to the Director, 1887-1987.)

Director Keener earned his B.S. degree at The Pennsylvania State University (1936), his M.S. at West Virginia University (1938), and his Ph.D. at Pennsylvania State University (1941), and was appointed an instructor of Animal and Dairy Husbandry at the University of New Hampshire that same year.

Keener spent 17 years as a professor of dairy husbandry prior to succeeding H. C. Grinnell as Station Director. As Dean and Director he emphasized that the process of food production was a matter of domestic and international concern. Because the quantity of food produced in New Hampshire is only a small fraction of that consumed in the state, he felt that our productivity should be increased. Since in New Hampshire transportation and processing costs represent a substantial portion of the consumer price of food, both public and producer stand to benefit from research on food production. Hence, research conducted by scientists in several departments in the college touches the lives of all of us.

Acreage available for agricultural production in the state was known to be decreasing for some time, but the specifics of the change although unknown were of concern to leaders in several sectors because of their relationship to the economy, their impact on the environment and loss of food producing potential. In a study in 1978 conducted by the Station, with the advice and cooperation of several state agencies and individuals, G. G. Coppleman, S. A. L. Pilgrim and D. M. Peschel, using aerial photographs, determined land changes between 1950 and 1970. The focus was on the most productive agricultural land and changes which had occurred over the 20 year period. They found that (1) 27 percent of the best land in 1950 went out of production; (2) approximately 17 percent of agricultural land in Rockingham and Hillsborough counties in 1950 was lost to developments by 1970, thus was no longer available for production; and (3) developed land in 1970 was 2.5 times greater than in 1950 and represented 4 percent of the state's total acreage.

When Keener retired as Dean and Director, L. C. Peirce who had been chairman of Plant Science since 1964, was called upon to serve in an acting capacity. As early as 1904, F. W. Rane had stressed the economic potential of

forests to New Hampshire farmers and urged their immediate action to decide what land to farm and what to convert to forestry. Moreover, he said ". . . New England has a charm for everyone . . ." Three-quarters of a century later, Peirce focused new attention on our forests and lands because "they are major elements of the state's scenic beauty, recreational activity and rural charm." But he emphasized their economic value as well, thus they require sound management if coming generations are to use and enjoy these resources. He pointed to the Institute of Natural and Environmental Resources (INER) as the college administrative unit having major responsibility for research on management of farm and urban forests, soils, watersheds, wildlife, etc.

K. C. Feltner held the position of Dean and Director from 1979 to 1983, a period in which the Occupational Education Program in the College became a department (1982) and later its name was changed to Vocational/Technical Adult Education. The Department of Home Economics was renamed the Department of Family and Consumer Studies. In 1983, the INER was terminated as an administrative unit within the College and replaced by two others — the Department of Forest Resources and the Department of Resource Economics and Community Development. H. W. Hocker was named chairman of the Department of Forest Resources and E. F. Jansen, Jr. became chairman of Resource Economics and Community Development. Forest Resources thus consisted of specialists in forestry, wildlife, soils and water resources. At that time the two hydrologists in the Institute joined the Department of Earth Sciences in the College of Engineering and Physical Sciences. Several researchers from the Forestry Sciences Laboratory, Northeast Forest Experiment Station, Forest Service, U.S.D.A., located in Durham, hold appointments as adjunct professors in the department. D. P. Olson served as director of INER from 1973 to 1979 and O. B. Durgin from 1979 to 1983.

Feltner, writing in Research Highlights in 1982, noted that many persons not associated with the University may have a vague understanding of the concept of the present Agricultural Experiment Station. He described it succinctly when he said, "... Many are under the false impression that the Station is a separate activity housed in a single building. In fact, it is a coordinated program of research involving scientists, administrators and facilities throughout the College of Life Sciences and Agriculture."

T. P. Fairchild, chairman of the Department of Animal Sciences, served as interim Dean and Director from March to September 1983, at which time S. J. Kleinschuster was appointed to that position. His tenure was short. He resigned in 1985 to accept a similar position at Rutgers University. During his administration, the Department of Animal Sciences became the Department of Animal and Nutritional Sciences. T. P. Fairchild was then appointed Dean and Director.

In 1987 the Departments of Microbiology and Zoology became units of the College of Life Sciences and Agriculture, a move designed to centralize and strengthen the biology program in the College and University. At the same time Family and Consumer Studies, shortened to Family Studies, became a unit of the School of Health Studies.

Evelyn Handler was the University's first woman president.

Writing in Research Highlights (Summer, 1982) she noted that because of the Morrill Act of 1862, agricultural production in the United States was revolutionized. This helped lay the foundation for the industrialization of the country and "its ultimate emergence as the world's first economic superpower." She underlined the "breadth of interest" of the college faculty and the role played by the Agricultural Experiment Station in basic and applied research.

The University of New Hampshire achieved Sea-Grant College status in the 1979-80 academic year, and thus became a sea-grant as well as a land-grant institution.

The University of New Hampshire at Durham and the University of Maine at Orono now have a joint Sea-Grant College Program that supports research, teaching and service projects. Funding comes from the University of New Hampshire, the National Oceanic and Atmospheric Administration of the Department of Commerce, other federal units, foundations and private donors. Some faculty, graduate, and undergraduate research in the College of Life Sciences and Agriculture is sustained by these funding sources. Durham's proximity to the Isles of Shoals, the coastline, its tidal river and the Great Bay estuarine system and other marine natural resources make the University of New Hampshire ideally situated for marine research.

Still another indicator of change has been the striking increase in the use of the electronic computer in research by scientists, graduate research assistants, and research technicians. It is a strong force for expanding the possibilities in many kinds of investigations. J. A. Warren, Director of the Office of Biometrics, writing in Research Highlights (1983) noted that computers in 1960 were bulky and scarce, but that in the intervening years they have been transformed dramatically. He said they require far less space, their performance capabilities have been increased, and because of support facilities their users less frequently need the help of a computer specialist. The power and ease of use of computers increased strikingly after this was written.

W. H. Watson, III (left) and graduate student A. Vetrovs, Zoology

The hallmark of research in the Agricultural Experiment Station has been its diversity. Each department in the College has a mission and each scientist is a specialist investigating problems peculiar to his or her discipline within the mission. Hence there is a broad range of research projects in the Station at a given time. Nevertheless, underlying trends in research have become apparent. One of these has been a recent shift toward investiga-

tion of more fundamental problems. One facet of that is an exciting biotechnology revolution underway across all of science.

The American Association for the Advancement of Science has said, "The newfound ability to manipulate cellular machinery has been termed a biotechnology revolution." N. P. Clarke, director of the Texas Agricultural Experiment Station, College Station, TX, referring to biotechnology, stated that "Today's agriculture needs a new infusion of science and technology and new capabilities that will restore and enhance the competitiveness of U.S. agriculture in the world marketplace."

One criterion of research productivity is the number of a scientist's publications. One measure of stature is the publication of a book. Between 1895 and 1987 some 40 scientific books and monographs have been published by New Hampshire Agricultural Experiment Station scientists. These are listed in Appendix 3.

In the Station's 100th year there are some 70 research projects being pursued by 72 scientists, 94 percent of whom have either the Ph.D. degree or a veterinary medicine degree. Most also teach and/or have responsibilities in Cooperative Extension. In addition there are research technicians, graduate students and secretaries all supported by an annual budget of approximately $3,000,000. Research dollars arise from a variety of sources. T.P. Fairchild, Dean and Director during the closing years of this the first century of agricultural research in New Hampshire, noted that the Station is a "powerful mechanism" for solving problems affecting the lives of people in the state and nation, and indeed that its scientists impact importantly on the teaching and extension efforts of the College of Life Sciences and Agriculture. A chronological listing of highlights of the work of the Station is given in Appendix 4.

Animal and Nutritional Sciences

Research in the animal sciences now frequently involves teams of scientists, has become more basic, and increasingly is health-related. Ongoing investigations in nutrition, cell biology and genetics are directed toward reducing disease and/or improving the health of animals and humans. Nutritionists H. J. Thompson, A. R. Tagliaferro and mathematician-computer specialist L. D. Meeker are using the laboratory rat to study the role of single nutrients, in particular selenium and vitamin A, in preventing mammary cancer. Each nutrient, and their combination, has inhibited tumor development. Tagliaferro is also conducting studies on the association of diet and exercise on the thermic effect of food and body fat.

A two-man research team, R. G. Strout (parasitologist) and R. C. Ringrose (poultry nutritionist), in cooperation with the New Hampshire Fish and Game Department and the federal Sea Grant College Program, have changed the direction of their research — at least temporarily. They are exploring whether Coho salmon populations can be established on the Atlantic coast as an expanded source of food. Coho salmon, indigenous to the Pacific Ocean, have a three-year cycle in contrast to a four or five-year cycle for Atlantic salmon; Strout and Ringrose are particularly concerned with nutrition and disease problems associated with raising Coho salmon here. They have developed a vaccine for vibriosis, a serious bacterial disease in growing salmon, and have de-

termined the optimum protein level for growing Cohos.

Large animal nutrition research is conducted by C. G. Schwab and J. B. Holter. Schwab's major interest is protein nutrition of young calves while Holter's is primarily formulation and testing of rations for the lactating cow for more efficient milk production. Schwab's research team includes veterinarians W. A. Hylton and J. J. Moore, animal nutritionist J. Nocek (Agway, Inc.) and graduate research assistants. Their research has revealed methionine to be the first limiting amino acid for the calf and that calves have mature rumenal function by one week after weaning. In a recent field experiment, Schwab and graduate student C. Bartlett gathered some 80,000 bits of data necessitating the use of a computer to store and efficiently analyze the data.

As a dairy nutritionist, Holter is committed to improving the efficiency of milk production because of high costs of feed and labor in the Northeast. Along with W. E. Urban, Jr., H. A. Davis, W. A. Hylton, H. H. Hayes and W. Johns, III he has researched the nutritive value of corn silage, haycrop silage and hay, singly and in combination, and examined ways to reduce the amount of purchased protein in the ration of high producing dairy cows. More recently he has developed programmable electronic aids for formulating dairy rations for dairymen, Extension and feed industry personnel.

White-tailed deer in New Hampshire are valued for aesthetics and hunting, but according to Holter, information on the protein and energy requirements for these animals is scarce. Thus, Holter, W. E. Urban, Jr., Station Associate Director and Statistician, H. Silver (N.H. Fish and Game Department), H. H. Hayes and others have determined the protein requirements of deer fawns, predicted metabolic rate from telemetered heart rate, and measured body growth under varying levels of protein and energy. The species thrives on land not well adapted to agriculture, but if the herds are to be intensively managed, estimates will be needed of the carrying capacity of habitats, which in turn, are dependent on knowledge of nutrient requirements.

Reproductive physiologists at the Station are investigating breeding problems of dairy cows and horses. The research of department chairman W. A. Condon and associates is aimed at regulating the length of the estrous cycle of the cow as a way of better controlling the time of breeding and, ultimately, increasing the production of milk and calves. Their major interest is in the hormones progesterone and prostaglandin. A question still under scrutiny is why supplemenation of the cow's ration with β-carotene, a precursor of vitamin A, apparently improves milk production. His research is heavily dependent on use of cell culture techniques.

W. E. Berndtson, reproductive physiologist, works primarily with horses, both mares and stallions, but also with beef and dairy bulls. Roughly 30 percent of pregnancies in mares are aborted, many because of problems associated with old age. He has perfected the technique of transferring an embryo from one mare to another, an important research tool which has promise of improving reproduction efficiency in horses. In other research he is attempting to isolate factors which have a direct role in sperm production.

An important indicator of change in the direction and sophistication of Station research is the number of investigations having as their objective the improvement of health of humans and/or animals. As indicated earlier, E. M. Gildow conducted the first research on coccidiosis at the University in 1928. The disease was becoming increasingly important as flock size increased and confinement rearing became more prevalent in the rapidly growing industry. He recognized that a fuller understanding of the life cycle of the causative organism (*Eimeria*) was needed if control was to be achieved. For over 30 years R. G. Strout, parasitologist, has worked with coccidiosis, still a serious parasitic disease of chickens that is similar to malaria in humans. He and his colleagues, studying the basic biology of the organism, have succeeded in growing the intracellular parasite in cell culture — no small accomplishment — making it possible to monitor drugs and conduct experiments not possible using chickens. Much of their research has been basic and pertinent to the development of improved anticoccidial drugs. Most recently they have shown genetic control of the immune response to the coccidia *Eimeria tenella*, information which ultimately may lead to development of a vaccine to control the costly disease.

S. C. Smith, lipid biochemist, and coworkers have searched for some 25 years for causes of coronary heart disease, or atherosclerosis, a major health problem of the middle-aged and elderly. The basic objective of the research group has been determination of the mechanisms underlying the changes occurring in the arteries dur-

W. E. Berndtson, Animal and Nutritional Sciences

ing development of atherosclerotic lesions. For their animal model they use pigeons — the White Carneau atherosclerotic-susceptible breed and the Show Racer atherosclerotic-resistant breed. Lipid chemistry, a cell culture system, and electron microscopy are among the techniques used to monitor changes in the cells during progression of the disease. They have discovered that smooth muscle cells from aortas of susceptible pigeons accumulate more fatty material than corresponding cells from resistant animals. They do not yet know the cause of this accumulation, but results point to a defect in the chemistry of susceptible cells. The defect could be exacerbated by one or more environmental risk factors, such as smoking, and/or a hereditary predisposition to the disease.

The Veterinary Diagnostic Laboratory, named after R. W. Smith, N.H. State Veterinarian for 44 years (1921-1964), has as its primary mission diagnosis of diseases having potential for spreading to other animals or humans. It is supported by the Experiment Station, the New Hampshire Department of Agriculture and the N.H. Veterinarians Association. The veterinarians often must furnish a quick response because they never know when their work may result in control of a disease before it reaches epidemic proportions. Although the bulk of the work involves examination and diagnosis of tissue samples referred to the Laboratory, the veterinarians do have a research commitment. L. L. Stackhouse was Laboratory Director between 1970 and 1980. J. J. Moore, current Director, assisted by R. E. Wells and R. W. Fite, is involved in mastitis research, testing of an artificial bypass vessel, and development of a vaccine for waterfowl.

W. M. Collins, avian geneticist, headed a research group consisting of veterinarians W. R. Dunlop and A. C. Corbett, microbiologist R. M. Zsigray, and immunogeneticist W. E. Briles (Northern Illinois University), investigating the genetic bases for the regression of a cancer of the connective tissue in chickens, research partially supported by the National Cancer Institute. (W. E. Urban, Jr., Station Associate Director, was helpful in the beginning phase of this research in developing a tumor profile index, a measure of change in a tumor over time.) They discovered that age, sex, nutrition and several genetic factors underlie the disappearance of virus-induced tumors. Some of the genetic factors function by controlling the immunological response to foreign substances in the blood. Following Collins' retirement in 1983, immunogeneticist R. L. Taylor has continued genetic studies using this system and he and others have evaluated the role of cellular immunity in chickens using delayed wattle reactions.

Swine have attributes which make them a good model for humans, and miniature swine are important animals for basic research. Station animal nutritionist A. H. Parsons utilizes them to evaluate the effect of endurance training on the incidence and severity of atherosclerotic lesions in major arteries. S. C. Smith and R. Kertzer (exercise physiologist, Department of Physical Education) participate in the project.

T. L. Foxall, using the miniature swine model, is seeking a cellular mechanism by which serum lipids injure arteries and lead to atherosclerosis. Specifically, he is investigating the association between dietary lipids

and serum lipids and their effects on changes in the arterial endothelial cell.

R. A. Cady, statistical geneticist, is researching ways to make the dairy farmer a more efficient manager by improving the decision making process and by using computer simulation to investigate the influence of management techniques on the genetic evaluation of dairy cattle for quantitative traits.

N. R. Deuel's research focuses on documentation of the biomechanics of locomotion in riding horses, especially the area of kinematics which deals with aspects of motion apart from consideration of mass and force. She used cinematic methods for kinetic analysis of several gaits in superior equine athletes, and illustrated the different gaits with computer-drawn diagrams.

W. C. Skoglund served the University and State of New Hampshire as a teacher, researcher and administrator for a period of 31 years, first as head of the Poultry Husbandry Department (1950-1963) then as chairman of the Department of Animal Sciences until his retirement in 1981. Skoglund made his mark by giving aggressive, consistent leadership to the department and the poultry, dairy and livestock interests in the state. In 1986 the W. C. Skoglund Livestock Activity Center was named in his honor.

W. C. Skoglund, Animal and Nutritional Sciences

Biochemistry

Virtually any field of science today consists of scientists working in rather narrow areas — a necessity for making original contributions. Natural toxins, blood clotting, and research involving bacteria, yeast and corn using genetic engineering and recombinant DNA technology are some of the recent areas of investigations in this department.

M. Ikawa has specialized in toxic chemicals produced by microorganisms which are potentially poisonous to humans, with emphasis on those released by microscopic red tide algae found in coastal waters that cause the condition known as paralytic shellfish poisoning. Ikawa, collaborating with J. J. Sasner, Jr. (Zoology), developed a highly sensitive bioassay for measuring tiny quantities of the shellfish toxin and then worked out an alternative method which was sensitive to individual toxins for both monitoring and general research purposes. Ikawa and his group have also discovered that blue green algae, which inhabit freshwater, also produce toxic blooms, and perhaps surprisingly, that different strains of this same species produce unlike forms of the toxin.

G. C. Klippenstein (department chairman, 1975-1977) was a basic scientist and an authority on the chemistry of enzymes. Initially he worked with hemerythrin, an iron containing protein (metalloprotein) found in some invertebrates. Together with W. A.

Hendrickson, of the Office of Naval Research, he determined the three-dimensional shape of hemerythrin, an accomplishment which clarified the role of iron in carrying oxygen. Klippenstein then turned to another metalloprotein, ribonucleotide reductase, an enzyme which exerts some control over the synthesis of DNA (deoxyribonucleic acid). If DNA production could be inhibited, they reasoned, this might have application in the treatment of cancer, a disease in which cell growth is uncontrolled. Klippenstein chose the calf thymus as his source of the enzyme, but to study it required purification — in this case a long, tedious, complex process. Klippenstein never completed this work because in 1982 he died suddenly at the age of 41. But in the previous year he and his associates had published a paper entitled, "Purification of the two complimentary subunits of ribonucleotide reductase from calf thymus."

The interest of another protein chemist in the department, J. A. Stewart, is focused on developmental biology, the larger problem addressed being the reduced brain function resulting from dietary protein deficiency of the pregnant mother on the number of brain cells and brain weight of the offspring at birth. The mouse is used as the model. One finding was that maternal restriction of protein in female mice prior to mating and during pregnancy resulted in offspring at birth with decreased brain weight and protein content.

Stewart served as department chairman from 1977 to 1986 when he became Associate Dean for Research and Agricultural Experiment Station.

D. M. Green, a biochemical geneticist and department chairman since 1986, utilizes the soil bacterium *Bacillus subtilis* as a tool in the technique of genetic engineering. At a certain stage in the cell cycle the bacterium will accept new genes giving the genetic engineer the opportunity to study gene function, i.e., what controls gene activity. Using modern techniques, he developed a method for separating proteins, mostly enzymes, in bacteria. Green has studied two genes in *Bacillus subtilis* which control some nine other genes, to make several different proteins involved in the exchange of genetic material. The method, which showed the complexity of nuclease species not previously described in this organism, gives excellent resolution.

E. J. Herbst has studied polyamines, specifically spermidine and spermine. He was the first to show that production of these compounds occurred at the same time and rate as nucleic acids, substances which along with proteins are essential for rapid growth. Stimulated by the suggestion that extraordinary amounts of polyamines are produced during growth of tumor, he searched for compounds which would inhibit production of polyamines. Herbst then investigated the mechanism by which one of these compounds, *a*-difluoromethylornithine (DFMO), depresses cancer growth. Research elsewhere has shown that DFMO prevents the growth of the malaria parasite in humans and coccidia in chickens.

Both classical genetics and the new recombinant DNA technology are used by biochemical geneticist C. L. Denis working with yeast to determine how enzymes are turned on and off in both normal and abnormal phases of growth and development — thus his research has a tie to cancer. Some of the enzymes activated during unregu-

A. S. Klein (left) with undergraduate student Tracy Labonte

lated growth of human cancer cells also function in normal yeast growth.

Three younger biochemists — T. M. Laue, A. S. Klein, and A. P. Laudano — are just getting their research underway. Laue, a physical biochemist, is interested in the mechanism of blood clotting, an extremely complex process involving interactions among molecules that has implications in diseases such as hemophilia and heart attacks.

Like Green and Denis, Klein utilizes genetic engineering methods in her case to study genes which participate in the synthesis and regulation of red and purple pigments found in ornamental and sweet corn. Her research includes the introduction of new genes into corn, technology which may eventually lead to ways of shortening and improving the process of traditional plant breeding.

Botany and Plant Pathology

Specializations in this department — physiology, taxonomy, morphology, phycology, ecology and pathology — provide a diversity essential because (1) new information is more likely to be discovered by researchers who specialize and (2) most Station scientists have teaching responsibilities, and, in botany, courses such as taxonomy and morphology are fundamental to an undergraduate major.

Biotechnology tools, including cell and tissue culture, genetic transformation experiments and use of plant growth regulators are basic to the research of S. Minocha, plant physiologist and geneticist and current chairman of the department. Starting with groups of cells in culture in the laboratory, he and his students are endeavoring to grow whole plants such as lilac, white pine, paper birch and poplar. Plant growth hormones have been studied for their role in the regulation of lettuce seed germination. Greater understanding of plant growth processes should lead eventually to im-

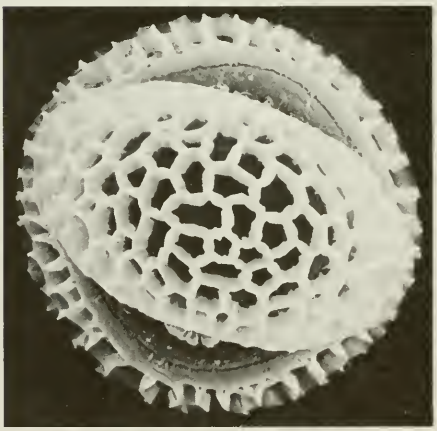
proved forest trees and other plants important for the production of food and fiber.

Taxonomy of plants requires constant revision as new information becomes available thus providing new insights into plant relationships. Analysis of seed morphology utilizing scanning electron microscopy has helped taxonomist G. E. Crow in this process. Over one period of six years he and C. B. Hellquist produced a computerized listing of the aquatic vascular plants of New England, an important identification aid to conservationists, fish and game personnel, botanists, consultants and students. But Crow has a continuing interest in rare and endangered plant species in New Hampshire and New England. Of some 1,500 native, vascular flora in New Hampshire he considers approximately 400 to be rare and in need of habitat protection if they are to be saved. In 1969-70 the herbaria of Bowdoin College and of the Portland (ME) Society of Natural History were permanently loaned to the Station, a gesture that greatly enhanced the holdings of the Hodgdon herbarium. Based upon a reevaluation of the "type" specimens in the expanded herbarium, Crow developed a data base from which he can now extract needed information efficiently and quickly.

Photosynthesis, a process of tremendous significance to agriculture, is the field of interest of L. S. Jahnke, physiologist. He works with algae, believing that if the process can be modified in a simple plant easily grown in the laboratory it might be attainable in more complex plants.

W. K. Fagerberg, physiologist, is asking why, and how, plants adapt to changes in environmental conditions; e.g., temperature, availability of water, light intensity. Regulation of plant metabolism is accomplished by the individual cell. To detect the effect of daily changes of light and shade on the cell, Fagerberg uses both light and electron microscopy. Leaf swelling and an increase in chloroplast membrane surface area are two of the light-caused changes he has discovered, but their significance and how they relate to the chemical process in the cell is not yet understood.

Pollen grain structure is one of the areas of research of A. L. Bogle, plant morphologist and department chairman from 1976 to 1982, who uses scanning electron microscopy (SEM) for improved clarity of detail. His SEM pictures of witch hazel pollens of the world, together with descriptions, appear in an atlas published by Harvard University. He and graduate assistant C. T. Philbrick completed a study of pollen morphology and descriptions of maple species indigenous to New England. This kind of research may aid in understanding the mechanism of pollination and reproduction of field



A pollen grain under SEM

and forest plants and clarify some of the morphological discrepancies in the literature. He has done anatomical and histological work on the development of canker in peach trees, a serious disease in which the complex nature of the host-pathogen interaction has hampered selection of resistant stocks.

A question intriguing T. D. Lee, reproductive ecologist, is what limits fruit production in plants. While it is well established that many angiosperms begin developing more fruit than they can mature with available resources, little is known about the process of fruit abortion. Lee has found that fecundity of a plant is determined by the number of fruits it matures and the number of viable seeds each fruit contains, that is, both fruits and seeds may be aborted in processes that are modified or limited by environmental conditions. Investigations on fruit and seed abortion may provide information which will increase productivity of agricultural crops and be crucial to survival of endangered New Hampshire species.

A. C. Mathieson, a marine phycologist and former Director of the Jackson Estuarine Laboratory at Adams Point, is an authority on seaweed, specifically Irish Moss (*Crondrus crispus*) which is used both for human food and livestock feed. Between 1974 and 1987 Mathieson and his associates and graduate research assistants authored a list of some 45 publications. One of these (Mathieson and E.J. Hehre, 1986) summarized their research findings for the period 1965-1983 in the form of a detailed synopsis of the state's algal flora. More than 200 taxa were recorded including eight new state and/or geographical records. Funding in support of their research has come from the Experiment Station, the UNH Office of Sea-Grant Programs, and the National Oceanic and Atmospheric Administration (N.O.A.A.).

A. L. Baker and undergraduate student R. Green

Like M. Ikawa in Biochemistry, concerned with algal populations on the New Hampshire shoreline and their relation to human health, A. L. Baker, freshwater phycologist, investigates microscopic algal and bacterial organisms which foul New Hampshire lakes and ponds in summer. He uses sophisticated equipment to gather a large number of samples of the organisms, and a computer to store and analyze the data. He then determines the quality of the water and is able to recommend whether, which kind, and when corrective action is required to improve the water quality for recreation and other purposes.

When A. E. Rich became Associate Dean of Resident Instruction in 1972 his position in Botany was taken by R. O. Blanchard, a mycologist and forest pathologist. One of Blanchard's tasks has been to monitor the diseases of trees in New Hampshire, determine their seriousness and, when necessary, advise on methods of treatment. But investigating the causes of tree diseases has been a major aspect of his work. He has researched the mechanism of biological control of decay fungi in red maples, studied harmful air pollutants (oxidants) of white pine, evaluated factors affecting canker formation in American beech, and investigated the association between electrical resistance and periodic growth rate in balsam fir. He found that electrical resistance was useful for early detection of Dutch Elm Disease. Scientists of the Northeast Forest Experiment Station associated with Blanchard include A. E. Shigo, L. O. Safford, W. C. Shortle and H. W. Pottle. In a publication entitled, "Diseases of Forest and Shade Trees in New Hampshire," Blanchard has provided a list of common trees and woody shrubs and a summary of diseases and their control. He became Associate Dean of the college in 1982 following Rich's retirement.

W. E. MacHardy, appointed plant pathologist in 1972, has worked on fungal diseases of flowers, fruits and vegetables. With others he established a computerized procedure for retrieving plant disease data for New Hampshire utilizing a database management system. He designed weather monitoring instrumentation for field use to improve control of plant diseases while at the same time reducing the amount of chemicals used through integrated pest management. He also has developed simple, quick, non-computerized techniques for determining apple scab infection periods and fabricated an inexpensive recording spore trap for investigating patterns of spore discharge by the apple scab fungus. He then established the theoretical framework and later a working model to forecast potential spore discharge as a basis for altering the rate and timing of fungicide application in the commercial orchard.

T. C. Harrington, a mycologist, succeeded Blanchard. He has studied the distribution of rhabdocline and Swiss needle casts, the two most important diseases of Douglas fir Christmas trees in New Hampshire. Most nursery stock in New Hampshire is highly susceptible, but both diseases may be controlled by fungicides. Harrington has also studied red spruce-balsam fir decline in the White Mountains, a poorly defined disease of unknown etiology. Although acid deposition may be the primary cause of the decline in some instances, he has proposed that mechanical damage to crowns and roots from swaying in high

winds may be an overlooked but important cause of the disease in higher elevations.

Entomology

Black flies are annoying pests that cause economic losses in camping and resort areas throughout New England. Of the several species of black flies found in New Hampshire J. F. Burger, medical entomologist, learned that virtually all larvae of one could be eliminated without the use of chemicals. One species is not a major nuisance to humans. He determined that a new commercially available larvicide (*Bacillus thuringiensis*) eliminated one population of black flies and reduced biting near the treatment area without killing other stream insects. His in-depth investigations of horseflies has allowed him to revise his classification of species from New Hampshire, North America and the Orient including some which are vectors for transmission of surro, an important hemorrhagic disease of horses. He has studied the life history of a fly occurring on the west coast, the first known predator of intertidal barnacles. He believes that the ecologically diverse alpine zone in the Mt. Washington area affords a unique opportunity to investigate pollination systems and plant-insect relationships.

P. C. Johnson, insect ecologist and chairman of the department since 1985, is participating in the interdisciplinary group using integrated pest management techniques to decrease the amount of insecticide used in apple orchards and concomitantly reduce damage to foliage and fruit by pests and improve product quality. He is developing a model for control of the

P. C. Johnson monitoring apple maggot fly with a "sticky trap"

apple maggot which includes emergence and weather data and traps that would allow an orchardist to estimate when to spray. Because the apple aphid (*Aphis pomi*) may be controlled by biological methods, he is working to lower pesticide use. Johnson is also developing a model relating degree-day accumulation to emergence of the apple aphid from the egg, and assessing the importance of one of its predators.

R. M. Reeves, a forest entomologist, represents one of six disciplines in the Station examining the effect of annual controlled burns as a tool in forest management. He has shown that the distribution and number of spiders, ground beetles, etc., do change as a result of the treatment but not seriously so because other kinds of insects replace those lost. In spruce budworm research he has found that of 37 species of adult carabid beetles associated with the spruce bud-worm, seven are potential predators. Reeves is also an acarologist, meaning he works with mites.

D. S. Chandler, taxonomist, has discovered a substantial number of new species of beetles in this state and elsewhere and investigated the effect of logging on such fauna of the forest floor.

Forest Resources

Even today, the majority of New Hampshire's acreage is forested. There are several hundred lakes and wetlands plus wildlife and other natural resources, all of which have both aesthetic and economic significance. To use these resources most efficiently, yet conserve our forests, water, and agricultural lands, thoughtful management is necessary. But some method of monitoring changes is necessary. Using aerial photographs taken in 1953 and "images" obtained from electronic signals obtained from satellites in 1974, P. E. Bruns, G. G. Coppleman, W. B. Beck and K. J. Peterson found, using Dover, N.H. as an example, a 72 percent increase in residential, commercial and public service lands, but losses in agricultural, unimproved open, and forest areas. They concluded that "remote sensing", i.e., gathering information from a distance, could be employed by land use planners, forest managers and other agencies for detailed information on land use changes. In 1985, because of an upsurge in land development in the state, there has been a renewed interest and support for remote sensing techniques by state planning groups.

W. Befort, a remote sensing specialist, preferred small format, large-scale pictures which "provide an inventory of standing timber, evaluation of forest damage and assessment of tree regeneration following cutting." Taking his own pictures at low altitude with a 35-mm automated camera using fast, high resolution color film, individual trees could be identified with 90 percent accuracy. He developed a set of "keys to interpretation" of his photographs which would eventually include all the forest species of New England. With foresters trained in the use of the technique, many kinds of forest applications are expected.

H. W. Hocker, silviculturist, and graduate students have investigated the influence of thinning, tree competition and fertilization on growth response of eastern white pine.

Chainsaw harvesting of forest trees leaves branches, needles and bark in the forest. Whole tree harvesting reduces an entire tree to chips, but when

P. E. Bruns employs remote sensing satellite images for land use planning

these are trucked to a mill valuable organic matter and vital nutrients are removed from the land. Also, the forest floor is torn up and exposed by the latter method. C. T. Tattersall, forest ecologist, is studying how this nutrient loss will affect growth of forest stands, and what decisions and modifications in technology may be required to return part of the trees to the soil during logging. Oak Ridge National Laboratory, the U.S.D.A. Forest Service, Great Northern Paper Co. and the University of Maine are cooperating in this research.

With the number of New Hampshire farms declining, the influx of persons from southern New England and New York, and the increase in new housing developments, many people in the state are seriously interested in how land in N.H. is being used and how this will affect their future and that of the state. O. P. Wallace, forest economist, and B. E. Lindsay, resource economist, in research based on a sample of towns surveyed in all counties in 1979, reported that most undeveloped land is purchased by professional and blue-collar residents, and that they want frontage on an all-season road.

Although Christmas tree growing in northern New England is a relatively new enterprise, it is a multimillion dollar industry. According to T. E. Howard, forest economist, three-fourths of New Hampshire Christmas tree growers have their farms under current-use assessment, an advantage in the face of high property taxes. Howard recently assessed the status of forest-based limited partnerships in the U.S. which in the past have attracted large investment capital. But tax reform may have reduced the value of the limited partnership and resulted in shift of major ownership to highly endowed tax-exempt financial institutions.

Town forests in New England were first established in the 17th century, but many of them today are "largely unknown, unmanaged and forgotten." In New Hampshire only 40 percent of town forests are managed. J. P. Barrett and his associates, however, suggest that income from timber harvests could help cover the cost of recreational, educational and timber management activities of town forests. C. D. McBane and Barrett have a paper entitled "Town Forests and Community Life — A Management Guide" (New Hampshire Agricultural Experiment Station Research Report No. 109, 1986) which gives suggestions for developing a management plan for multiple use of a town forest. In other research, Barrett has focused on ways of improving estimates of growth and yield, computerizing forest inventory, tree stand quality and monitoring growth and health of white pine in New Hampshire.

Forest tree breeding today is a slow process requiring some 20 or more years before progress can be assessed. Electrophorisis technique, or isozyme analysis, is used increasingly in genetic studies of forest trees to reveal genetic structure. To apply the procedure to breeding programs necessitates knowing how isozyme variants are inherited. Allozyme variants in 10 enzyme systems of loblolly pine studied by W. T. Adams and R. J. Joly were found to be controlled by some 17 different genetic loci. Their results suggest that application of the technique could improve the accuracy of selection of forest trees and speed genetic advance.

Forest geneticist R. T. Eckert is using enzyme analysis to study the effects of air pollution on white pine in the Great Smokey Mountains in Tennessee and on red spruce in higher elevations in the Northeast, both areas

T. E. Howard (left) and L. B. Merrick, Christmas tree grower

of high air pollution. Eckert believes that acid rain resulting from air pollution causes a release of aluminum into the soil solution, and that since aluminum is toxic to some plant roots, tree growth is inhibited. His laboratory experiments suggest that soil aluminum can indeed affect uptake of essential nutrients, cause trees to grow more slowly and become more susceptible to stresses such as drought, fungi, insects, and air pollution. Thus acid rain may predispose trees to decline from other stresses. He is now using isozyme analysis to determine the genetics of individual red spruce trees, rather than seedlings, and evaluate the impact of air pollution and other forms of stress on tree health.

Hardwood species such as oak, beech, birch and maple are plentiful in New Hampshire forests. But according to J. L. Hill, wood technologist, products made of hardwoods require low moisture wood obtained by drying in kilns, a critical process representing a major production cost in the manufacture of hardwood products. A research team consisting of Hill, a graduate student and two scientists from the College of Engineering and Physical Sciences have devised a practical solution to the drying process. The procedure has been automated by use of a personal computer to control kiln temperature and moisture and thus reduce drying time and avoid damage to the lumber. When kiln drying costs as much as one dollar per board foot of lumber, accurate control of the process is essential to reduce degrading and produce high quality lumber. Thus automated control of the kiln drying process reduces cost, improves quality and provides a procedure which should be useful to the wood processing industry.

Since the 1970s, disposal of sewage sludge has been of environmental concern and an important problem faced by many New Hampshire communities, one being disease-causing organisms. Municipal sewage, treated properly however, is not a health hazard to humans. Sludge, particularly that of industrial origin which may contain inorganic constituents, such as lead, copper, chromium, nickel and cadmium, could pose a potentially serious threat to plant, animal and human health. Applying a method developed by the U.S.D.A., Beltsville, Maryland, R. D. Harter, soil chemist, and George Crombie, then Durham public works director, perfected an economical procedure for composting sludge. Since sludge can be considered a complete fertilizer, except for potassium, the material is now used for compost for flower beds by both the town and residents of Durham. When sewage sludges from New Hampshire towns were analyzed for several inorganic elements, half contained potentially toxic elements, lead being most common.

Harter, along with a large team of soil scientists from the Northeast, are cooperating on a research project entitled, "Soil properties affecting sorption of heavy metals from waste." His interest here is in more basic problems in soil chemistry. This research has practical applications because, according to Harter, "the ability of a soil to hold a retained ion against leaching or plant uptake is crucial, and important in land areas to be used for disposal of potentially toxic wastes."

Harter, with others, has investigated the role of forest soils in retaining nutrients after clear-cutting, and the effect of fire on forest soil and nutrient cycling.

S. A. L. Pilgrim and N. K. Peterson, using information from soil surveys covering a 40 year period, grouped New Hampshire soils into 22 general soils areas and identified those qualifying as prime farm land.

The McIntire-Stennis Act of 1962 was designed to encourage forestry research in the Agricultural Experiment Stations, the first appropriation coming in fiscal year 1964. "Forestry research" included investigations relating to improvement of "conditions of water flow and to protect resources against floods and erosions." G. L. Byers, water resources specialist, was named chairman of the University of New Hampshire Water Resources Research Center in 1964. One of his responsibilities in the Experiment Station was collection of weather data which was made available to foresters, hydrologists and others requesting the information, a service which the University has performed for some 75 years, 50 of those being continuous. Byers and D. L. Goodrich in 1977 authored a Station Research Report "Selected Climates in New England." The publication summarized weather data, mainly temperature and precipitation, recorded at 14 official weather stations located in eight of New Hampshire's 10 counties.

Solid household rubbish, formerly disposed of in dumps by burning, a procedure now prohibited in some communities because of concern for air quality, is being deposited in sanitary landfills. This changes the problem from contamination of air to pollution of water. F. R. Hall, Station hydrologist, and L. Cushman at Plymouth State College, established an experimental sanitary landfill at Ashland, N.H. which receives both household and commercial waste. Leachate from garbage was observed three months after the project began, and although early emphasis was on the landfill site per se, more recently they assessed the environmental impact at greater distances. Hall has also investigated the effect of road deicing salt on certain plant species; and on accumulation of the more toxic heavy metals in large rivers and ground water reservoirs from commercial wastes.

Hydrologist S. L. Dingman is concerned about the impact that additional housing developments along the Merrimack River in New Hampshire will have on water quality in the waterway already known to be highly polluted. Ultimately, data gathered will be organized into maps to give a picture of the system useful for future planners. Dingman is also investigating the relationships among elevation, climate, hydrology and forest vegetation in New Hampshire and Vermont with emphasis on the properties of streams important for water resource management. He has determined that the effect of elevation is such a dominant factor that it can be extremely useful for predicting many parameters of stream flow.

Forest managers count on help from scientists to determine when either planned or unplanned forest fires are appropriate and useful. Over a period of 12 years D. P. Olson, wildlife ecologist, and R. R. Weyrick, forest management, have conducted approximately 40 prescribed or controlled burns, small well-contained surface fires, in white pine and mixed hardwood stands. They have developed a model 80-year white pine rotation using prescribed burning. Controlled fires can be an efficient procedure in the management of

New Hampshire bobcat

wildlife and plant communities by creating browse for white-tailed deer and other wildlife species, especially under power lines.

The size of the deer herd in the Granite State is coupled to the severity of winter weather, deer kill in a given season, and changes in habitat. But to wildlife physiologist W. W. Mautz knowledge of the efficiency with which an animal uses its natural foods, its requirements, and its food supply are crucial determinants of the number of animals a given area can support. He believes that food evaluation studies should play an important role in wildlife management decisions. Mautz uses telemetry on free roaming deer to provide an indirect measure of energy expenditure. In other research he found that stored fat is a major factor in winter survival of white-tailed deer and that acorns are an important and nutritious fall food for deer and help build reserve fat which reduces mortality in late winter. He conducts research with other animal species — the snowshoe hare, bobcat, fisher and beaver, among others. Funding for the research is provided by the N.H. Fish and Game Department, the Station, and the McIntire-Stennis Cooperative Forestry Program.

Wildlife ecologist J. A. Litvaitis has done research with the coyote, bobcat and lynx. Recently he found an association among bobcat age, sex and weight and the prey eaten by them in winter, and determined bobcat habitat use to be influenced by snowshoe hare distribution. In New Hampshire, although lynx are considered rare and are an endangered species, appropriate habitat is available.

Plant Science

During the tenure of A. F. Yeager and E. L. Meader the major research em-

phasis was the breeding of plants for improved productivity, resistance to disease, and the development of new and superior, early maturing varieties of horticultural plants, flowers and ornamentals. By 1987, 111 new varieties of horticultural plants had been introduced by Station scientists (see Appendix 5). Nutrition, production, and management research also were productive research areas, however. Today there are six geneticists in the department each with a different specialty. From 1979 to the present, O. M. Rogers has been chairman of the department.

G. M. Dunn, D. G. Routley and B. J. Long, geneticist, plant chemist and graduate research assistant, respectively, investigated the genetic and biochemical basis for resistance to northern corn leaf blight, a fungal disease. They found that multigenic resistance corn lines produced greater amounts of substances resistant to the fungus than did monogenic resistance lines and suggested that the factor involved was "phytoalexin-like" in nature. Because it was known that hydroxamic acid (DIMBOA) in corn plants was toxic to some fungi, they developed a rapid method for screening lines for DIMBOA, implicated this material in resistance to northern corn leaf blight, and then showed that the material played a major role in plant resistance to the corn leaf aphid as well.

With plant pathologists, Dunn selected among Ladino clover lines for resistance and hardiness and studied selection and basic genetics of brome grass, a hay plant. He had a strong interest in the breeding of hardy azaleas, and developed an early-maturing, open-pollinated, ornamental corn variety called 'Sunapee'.

Routley has experimented with composted sewage sludge for growing ornamentals, grass, vegetables and other plants. Since 1975 he has served as Editor of the Station publication Research Highlights.

Between 1974 and 1987 Y. T. Kiang and his graduate students have produced more than 20 research publications. These include papers on the effect of deicing salt on the genetic differentiation of roadside grasses, vegetative propagation of white pine by cuttings, and the crucial importance of saving wild rice in Taiwan from extinction because it can serve as a valuable source of germ plasm for the improvement of domesticated rice varieties.

In the U.S. soybeans and their products have high economic value, surpassing corn as a source of total farm income. Kiang has published numerous papers on his soybean research and has attained national recognition particularly in the use of isozymes in genetics and breeding. Soybean genetics is still in the formative stage, but findings should have broad application both basic and applied.

Kiang has contributed to the genetics of the honey bee. In recent research he coupled his interest in the honey bee with that of the soybean indicating that "the foraging behavior of pollinators can affect pollen dispersal, cross pollination, genetic structure and interspecific hybridization."

A tradition of tomato breeding, begun by A. F. Yeager in 1940, has been continued by L. C. Peirce. Peirce came to the university from Iowa State University in 1964 as chairman of Plant Science at which time he initiated a

research program with tomatoes and asparagus. He has tested various breeding systems, selecting for fruit size, earliness, and yield in tomatoes. He originated 'Sunset', a highly productive, early bush variety of tomato with good size and color. 'Sunset' is an excellent tomato for New England, and though it has some shortcomings, research is continuing in an effort to breed improved varieties. Routley and Peirce have evaluated factors which influence resistance to late blight, a very destructive disease of tomatoes, and found a positive association between blight resistance and total carbohydrate content of the leaf.

In asparagus research, Peirce determined the inheritance of a green stemmed nutrient mutant and introduced a new cultivar 'Emerald' having bright green spears and excellent yield and winter survival. Depressed production and the inability to replant asparagus in old fields is believed to be a consequence of infection by two soil-borne organisms. He is investigating the problem using tissue culture techniques. Peirce was named interim Dean of the College and Director of the Station in 1978. In 1987 he authored a book entitled, "Vegetables: Characteristics, Production and Marketing."

Lilacs in the Granite State normally bloom in early May. O. M. Rogers, breeder of ornamentals, is selecting lilacs with the objective of extending the flowering season from May into late June. The 'Jesse R. Hepler' variety of lilac, released by the Station in 1976 features slow growth, rounded shape, mildew resistance, and it blooms in late June with light lavender flowers. Another late blooming lilac developed by Rogers by crossing and selection over a period of 11 years, 'Agnes Smith' has also been released by the Experiment Station. It is vigorous, hardy, mildew-resistant and has white flowers.

J. B. Loy, a physiological geneticist-plant breeder, works primarily with watermelons, muskmelons, pumpkins and squash. He has evaluated the effects of growth regulators, light quality, and photoperiod on seed germination, fruit set and other traits, and their control of sex expression in watermelons and muskmelons. To avoid the tedious task of hand pollination in the production of hybrid seed he developed a strain of muskmelon that produces virtually all female flowers and which, when planted with another strain that produces all male flowers, allows bees to make the cross. The female strain is perpetuated by treating a few plants with chemicals causing them to produce some male flowers, thus inducing self fertilization. Hybrids tested have matured early and yielded quality fruit. But since the harsh New Hampshire spring retards plant growth, O. S. Wells (Cooperative Extension Vegetable Specialist) and Loy have experimented with plastic row covers to protect transplanted plants and make growing muskmelons more successful and allow earlier planting of other vegetable crops.

Loy has bred an open-pollinated strain of squash called 'Autumn Pride' released by the Experiment Station in 1981. Its unique features are bush-type growth and large Hubbard-type fruit.

Legumes are a group of plants which, because of a symbiotic relationship with a special group of bacteria called rhizobia, are capable of converting atmospheric nitrogen to the ammonium form useful to the host plant. Unfortunately, since major food

O. S. Wells and J. B. Loy protect pepper plants with a floating row cover

crops such as corn and cereal grains lack this capability, much of the nitrogen needed for growth must be provided as commercial fertilizer. T. M. Davis, a cellular geneticist using biotechnological methods, believes that legumes possess symbiosis genes which allow them to fix nitrogen. To determine why common agronomic plants cannot use rhizobia to provide their nitrogen needs he uses genetic engineering techniques that eventually may allow transfer of the symbiosis genes to non-leguminous plants. He's made a start toward that goal. Upon irradiating chick pea seeds he found six different genes which influence the symbiotic process. However there are many strains of soil-borne rhizobia with varying capabilities of fixing nitrogen, Davis, working with R. P. Blakemore in Microbiology, believes genetic engineering may make possible development of both a strain of bacteria and a variety of legume which together create a highly efficient nitrogen fixation system and thus a more productive plant. Although transferring this process to non-legumes may not be easy, the prospect of doing so is exciting, and if accomplished would serve to maximize use of solar energy and reduce our dependence on fossil fuels. Indeed, very recently, scientists elsewhere have discovered a bacterium which can derive its energy from the sun and convert atmospheric nitrogen into plant nutrients.

How can the yield of agronomic crops be optimized and the need for lime and fertilizer reduced in the Northeast? This is the basic question underlying the research of G. O. Estes, plant nutritionist, and his students. He has found varietal differences in ability to grow at lower temperatures, and shown variation among corn genotypes in efficiency of nutrient uptake suggesting that selection for

physiological efficiency in nutrient use should improve productivity and economy of fertilizer use. Research with wood ashes on corn soils indicated that dairy farmers, using manure and wood ashes supplemented with small amounts of phosphorus, could reduce costs and improve efficiency. J. R. Mitchell (Cooperative Extension agronomist) and Estes determined that manure plus starter fertilizer gave high corn yields and reduced the need for nitrogen — the most important operating cost in corn production. Dairy farmers rely heavily on alfalfa as a forage crop. Analyzing the relationships among soil organic matter, aluminum and alfalfa root dry weight, Estes found that with high levels of organic matter, aluminum is less toxic and productivity is improved.

In the second quarter of this century, Station agronomist, F. S. Prince concluded that soybeans could not be grown for seed in this state because of the short growing season. More recently, Station agronomist D. W. Koch found that high protein soybeans, mixed with corn, improve the quality of silage for dairy cattle, but confirmed that growing soybeans as a cash crop here in New Hampshire was not recommended. Interestingly, Y. T. Kiang is breeding large-seeded soybeans to mature in late summer for use as a new vegetable for home gardeners and vegetable growers.

Koch found that hay drying time can be substantially shortened by applying a chemical mixture to the stems during mowing. Other advantages are that the drier hay contains more digestible nutrients and is less apt to heat in the bale.

Mitchell and Koch compared a plowless (no-till) method for sod seeding of forages as an alternative to conventional plowing. All vegetation is killed with herbicides, lime and fertilizers are applied to the surface, and the seeds are drilled into the sod. Farmers using the system, however, complained that the more desirable perennial grasses and legumes (preferred for pasture because annual seedings are costly) were not responding because surface-applied fertilizer and lime were not reaching the roots. Five different annual crops evaluated by Mitchell and Koch, one of which was a Brassica called 'Tyfon', improved the soil condition for subsequent planting of legumes which require good seedbed conditions. Moreover Tyfon appeared to produce a toxic chemical which prevented the growth of weeds but not of perennials. Sheep fed on Tyfon produced more meat per animal than hay-grain fed lambs and this pasture plan saved the cost of feed, lime and fertilizer.

Apples are well adapted to New England conditions and are an important fruit crop for Granite State orchardists. The 'Mcintosh' is a popular apple which, during late season controlled-atmosphere storage, suffers from soft flesh, mealy consistency, cracking of fruit and less juice content, all of which result in substantial fruit loss. Station fruit specialist J. E. Pollard has investigated the effect of pectin-hydrolizing enzyme activity and other factors on this condition. A growth retardant, daminozide, is widely used by commercial orchardists to control tree size and regulate harvest, but information on the influence of retardants on calcium nutrition — an important factor in maintaining fruit quality during late season storage — is meager. Pollard showed that in the short-term, daminozide

application resulted in calcium accumulation by vegetative tissues but that when used consecutively for 5-6 years the foliar concentration of some elements increased while that of others decreased, indicating a need for further research.

Recognizing that the growing of small fruits in New Hampshire offered an attractive opportunity for orchardists and part-time farmers, Pollard evaluated management systems with the objective of increasing fruit yield and quality yet decreasing the requirement for hand labor.

The planting of semi-dwarf apple trees has been strongly urged by W. Lord, Cooperative Extension fruit specialist — they can be more densely planted, mature earlier, are easier to prune, spray and pick, and have fruit quality equal to that of full-sized trees. His research has shown that, although late summer pruning of semi-dwarfs has a few disadvantages, it keeps tree size small, improves fruit color and quality and may increase winter hardiness.

Some scientists in Plant Science have found that providing an answer to a perplexing question is often as difficult as developing a new plant variety, equally challenging, and sometimes just as rewarding.

Resource Economics and Community Development

In 1983 the economists in the Institute of Natural and Environmental Re-

G. O. Estes (right) with graduate student S. S. Lee do controlled temperature research

sources were moved into a Department of Resource Economics and Community Development. Thus the social scientists continued a broad spectrum of investigations directed at current economic problems. E. F. Jansen, Jr. became the department chairman.

O. B. Durgin joined the Department of Sociology in 1950. Besides teaching and research responsibilities he has held several administrative positions including that of University Registrar, Director of the Institute of Natural and Environmental Resources and Director of the Biometrics Laboratory. But over the years Durgin has been concerned with census data — a yardstick of change in the social characteristics of the country. Each decade he develops ways to make the tremendous amounts of data gathered in the census accessible and useful. As consultants to the N.H. Office of State Planning he and research assistant Anne Palmer, using the computer, analyze and interpret these data thus making the material available to organizations such as churches, town school boards, and county and state officials.

R. Tichenor, Jansen and J. Pickering did a case study of a recycling system of municipal waste in Nottingham, New Hampshire (1975). The potential for recycling was such that it was studied in a broader context in 1978. Seventy-five percent of the citizens contacted six months into the program favored recycling. Daily output was 1.18 pounds of recycled materials and 0.93 pounds of rubbish per person. Costs per ton of recycled material were $15.19. Net revenue is highly dependent on market price which at the time of the study was $16.83 per ton.

R. A. Andrews, and associates, during this time period published eight studies under the general title of *Marketing Agricultural Products in New Hampshire*. The first study treated livestock assembly costs and adjustments needed to improve regional livestock marketing. The research team then moved to look at marketing channels for select vegetables, potatoes and fruit. Andrews, G. M. Leighton and N. C. Latremore evaluated the market potential and prospects for New Hampshire produce and vegetables (1977). They interviewed vegetable producers, retail stores and wholesale produce operators in the State and predicted that "sales through roadside markets and wholesale to other retailers will likely expand at a rate three to five percent greater than the rate of population increase."

Responding to the oil crisis, M. M. Dalton, J. H. Herrington, O. B. Durgin and Andrews (1977) investigated fuelwood marketing. They pointed out that wood had been a major source of household fuel for New Hampshire residents prior to 1940. During the 19th century fuel wood was so scarce that it was imported from the maritime provinces of Canada. Until the oil crisis in 1973, the fuel wood marketing system had virtually disappeared. The shortage of oil and the increased costs of oil and electricity motivated consumers to seek fuel wood as a substitute. Fifty-two percent of the households sampled in the State "burned wood in a stove, fireplace, or both, and a few burned it in furnaces." "Wood appears to be an 'opportunity' fuel since many households cut all or part of their supplies on their own land."

Andrews and J. C. Dammann (1978) analyzed the fuel wood market-

ing system that evolved since 1973. They concluded that "15 percent of the wood passed through a middleman; direct sales from producers to consumers was the predominant market channel."

B. E. Lindsay and S. E. Martin (1977) established a land market transactions database for towns randomly sampled in New Hampshire, which represented the first attempt in this state to establish an informational base depicting land market movement. The intent was to determine the grantees and grantors, their motives for buying, and the specific characteristics of the parcels transacted. Non-New England residents purchased the smallest sized parcels. Frontage on an all-season road and access to a town within a 10 minute drive were the two most important attributes cited by buyers.

Lindsay and D. L. Dunn (1980) focused upon two existing tax exemptions in New Hampshire — current use and elderly — to isolate the influence of each upon property tax rates for selected New Hampshire municipalities. The impact of two exemptions upon property tax rates was shown to vary according to population size of the community. The effect of the current use tax exemption was greater than the elderly exemption on the property tax rate in towns with population under 4,000. The elderly exemption had a stronger impact on the property tax rate in towns over 10,000 than the current use exemption.

A statistical guide to agricultural land use changes, based on a description of such changes in the Northeast between 1949 and 1974, was developed by D. E. Morris (1977) as a handy reference for persons involved in land

O. B. Durgin (right) and A. Palmer analyze census data

use issues. J. B. Reed (1982) developed a computer program to evaluate current use assessment which enabled New Hampshire land owners to determine how long land had to be enrolled before savings would exceed penalty. A recent 14-year study by Morris, G. E. Frick, R. R. Weyrick and B. J. Hill has shown that in New Hampshire the Current Use Program was definitely attractive to landowners. This 1987 report addressed some of the important issues surrounding New Hampshire's Current Use Program, particularly those concerning the Program's conflicting goals. For example, the Program is intended to encourage preservation of open space through preferential assessment and with minimal disturbance of ad valorem taxation. But preferential assessment disrupts taxation of land according to value, and increasingly so as Program participation increases. In 1987, about 41 percent of the land in the State was enrolled in current use.

Dalton and Andrews (1979) used recording cash registers to tabulate daily sales of produce for several roadside markets. These data enabled them to construct daily, weekly and seasonal sales patterns. Using daily sales, "the operator can determine optimum operating hours." "Plotting a weekly sales pattern for a period of a month can help the operator schedule labor for the market and the field and determine the best day to close."

The department has a continuing interest in the welfare and demographic organization of the State's population. In 1978 N. LeRay (Sociologist, U.S.D.A.), A. E. Luloff and J. G. Campbell appraised the status of the older population of New Hampshire, and Jansen and LeRay updated this report in 1984. Luloff, G. W. Howe and S. G. Hutchins (1985) used U.S. Census information to develop trends and estimate future population growth and change.

The characteristics of hay, livestock products, and produce markets for small scale agriculture in southern New Hampshire were investigated by Andrews and Frick (1985). A total of 249 agricultural enterprises in southern New Hampshire were interviewed. "Typically, buyers and sellers lived within 15 miles of each other, learned about each other by word-of-mouth, and included small scale beef, sheep and goat operations as well as places with pleasure horses."

Lindsay and S. J. Graefe (1985) conducted an economic evaluation of alternative revenue sources for raising monetary funds for the New Hampshire Hazardous Waste Cleanup Fund. Their study contained a descriptive overview of industrial classification and geographic distribution of quantities of waste for New Hampshire hazardous waste generators. They concluded that the present flat fee system, in conjunction with the State General Fund and bonding, would provide the major funding sources for the New Hampshire Hazardous Waste Cleanup Fund.

Analytical Services

Since 1976 the Analytical Services Laboratory has been supervised by chemist S. C. Blanchard. His work involves routine testing of soil, fertilizer, and hay, grain and forage samples. State of the art technology, which includes instruments which allow greater automation of tests with increased accuracy, and computers which improve efficiency, translates

into improved service to persons outside the university and research scientists on campus.

Vocational/Technical Adult Education

Since the 1950s or earlier, Agricultural Education as a program offered both the B.S. and M.S. degrees. It became the Department of Occupational Education in 1971, with W. H. Annis as chairman, and the Vocational/Technical Adult Education department in 1987. Financial support comes from the University, the State Department of Education, and a small amount from the Station.

The O. J. Hubbard Fund

Between 1976 and 1983 O. J. Hubbard of Walpole, New Hampshire contributed a total of some $413,000 to the University of New Hampshire, the earned income from which shall be used by the Department of Animal Sciences. The purpose of the Fund is "to improve poultry and animal science education at both the undergraduate and graduate level at the University of New Hampshire, and for scholarship aid when desirable." In any fiscal year scholarship allotments are not to exceed twenty-five percent of the available income from the Fund. Mr. Hubbard is particularly interested in genetics, and it is his desire that, whenever practical, activity in this field be given priority. Income from the Fund has been and continues to be used for a variety of projects, including research, and supports activities which otherwise would not be feasible.

Crowley, John J. (ed.) 1986. Yearbook of Agriculture. *Research for Tomorrow.* U.S. Department of Agriculture, Washington, D.C.

Ernst, Ralph A. (ed.) *Poultry Science Newsletter*, a publication of the Poultry Science Association, Inc. Vol. 12, No. 2, April 1988, Champaign, IL.

Kerry, Norwood A. 1987. *The Legacy.* A Centennial History of the State Agricultural Experiment Stations 1887-1987. Missouri Agricultural Experiment Station, University of Missouri–Columbia, with Cooperative State Research Service. U.S. Department of Agriculture, Washington, D.C. 318 p.

Lane, David M. 1988a. *Index to New Hampshire Agricultural Experiment Station Researchers Covered in Research Highlights* From 1975 Through 1987. Biological Sciences Library, University of New Hampshire, Durham, NH 03824.

Lane, David M. 1988b. *Twenty-Seven Years of New Hampshire Agricultural Experiment Station Publications: Station Bulletins and Research Reports From 1960 Through 1987.* New Hampshire Agricultural Experiment Station, University of New Hampshire, Durham, NH 03824.

McGrath, William E. 1964. *Experiments and Experience.* A bibliography of the Research and Knowledge of the New Hampshire Agricultural Experiment Station; 1889-1963. [Durham, NH] New Hampshire Agricultural Experiment Station.

Parks, W. Robert. 1989. Personal Communication.

Sackett, Everett B. 1974. New *Hampshire University — the Story of a New England Land Grant College.* New Hampshire Publishing Co., Somersworth, NH.

Scientific Contributions of the New Hampshire Agricultural Experiment Station, 1908-1969. A listing of journal articles authored by members of the staff of the Experiment Station. Compiled by New Hampshire Agricultural Experiment Station and the University of New Hampshire Library.

Scientific Contributions of the New Hampshire Agricultural Experiment Station, 1908-1987. A file of available journal articles authored by members of the staff of the Experiment Station located in the Biological Sciences Library, University of New Hampshire, Durham, NH 03824.

Appendix 1

CHAPTER 74 (HJR1)
A JOINT RESOLUTION RELATIVE TO THE NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

Whereas, the Hatch Act of 1887 established the New Hampshire state agricultural experiment station; and

Whereas, for 100 years the New Hampshire state agricultural experiment station has been a vital instrument of education and research in the state of New Hampshire, and during this time the state agricultural experiment station has made citizens of the state aware of new opportunities in agriculture and has provided research and skills to utilize these new opportunities; and

Whereas, the New Hampshire agricultural experiment station has provided leadership to the agricultural and forestry industries of the state and the region; and

Whereas, through its nutritional studies the station has led the way to more competitive and efficient farm animal production, and through genetic selection it has developed and introduced many new and useful plant and vegetable varieties which are adapted specificially to northern climates; and

Whereas, the station has had a most important role in determining changes in land and resource management and future trends in land usage; and

Whereas, the citizens of New Hampshire directly benefit from its research on nutrition, metabolism, and consumer studies; and

Whereas, with the state agricultural experiment station's increased emphasis on biochemistry, molecular biology, and biotechnology, it shall continue to benefit New Hampshire in a significant and beneficial manner; now, therefore, be it

Resolved by the Senate and House of Representatives in General Court convened:

That in recognition of its role in bringing great economic benefit to the citizens of the state of New Hampshire and in anticipation of its bright future role as it commences its second century of service on behalf of the citizens of New Hampshire, the general court hereby proclaims 1987 to be the centennial year of the New Hampshire state agricultural experiment station; and

That a suitable copy of this resolution be presented to the New Hampshire state agricultural experiment station.

[Enacted in accordance with Article 44, part II of N.H. Constitution, without signature of Governor, April 30, 1987.]

Appendix 2

DIRECTORS OF THE NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION AND DEANS OF THE COLLEGE OF AGRICULTURE 1887-1987

Name	Title(s)	Period
Whitcher, G. H.	Director	1887-1894
Murkland, C.	Acting Director	1894-1901
Gibbs, W. D.	Director	1902-1902
Morse, F. W.	"In Charge"	1902-1903
Gibbs, W. D.	Director	1903-1907
Sanderson, E. D.	Director	1907-1910
Kendall, J. C.	Director	1910-1938
Eastman, M. G.	Dean of Agricultural Division	1911-1923
Eastman, M. G.	Dean of College of Agriculture	1924-1938
Eastman, M. G.	Director and Dean	1939-1947
Chandler, R. F., Jr.	Director and Dean	1947-1950
Grinnell, H. C.	Director and Dean	1950-1957
Grinnell, H. C.	Dean	1958-1961
Keener, H. A.	Director	1958-1961
Keener, H. A.	Director and Dean	1961-1978
Peirce, L. C.	Interim Director and Dean	1978-1979
Feltner, K. C.	Director and Dean	1979-1983
Fairchild, T. P.	Interim Director and Dean	1983-1983
Kleinschuster, S. J.	Director and Dean	1983-1985
Fairchild, T. P.	Director and Dean	1985-

Appendix 3

VICE, ASSOCIATE, ASSISTANT DIRECTORS OF THE NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION, ASSISTANTS TO THE DIRECTOR, AND ASSOCIATE DEANS OF THE COLLEGE, 1889-1987

Name	Title(s)	Period
Morse, F. W.	Vice Director	1896-1909
Stone, C. W.	Vice Director	1910-1914
Eastman, M. G.	Vice Director	1938-1939
MacLeod, A. G.	Assistant to the Director	1939-1940
Erikson, A. L.	Assistant to the Director	1940-1942
Grinnell, H. C.	Assistant Director and Assistant to the Dean	1942-1947
Grinnell, H. C.	Associate Director and Associate Dean	1947-1950
Richards, M. C.	Associate Dean and Associate Director	1950-1958
Richards, M. C.	Associate Dean	1958-1972
Urban, W. E., Jr.	Assistant Director	1972-1980
Rich, A. E.	Associate Dean	1972-1982
Urban, W. E., Jr.	Associate Director	1980-1986
Booska, E. P.	Assistant to the Director and Dean	1971-1984
Blanchard, R. O.	Associate Dean	1982-
Booska, E. P.	Business Manager	1984-
Stewart, J. A.	Associate Dean for Research and Agricultural Experiment Station	1986-

Appendix 4

BOOKS AND MONOGRAPHS
Published by New Hampshire Agricultural Experiment Station Scientists Between 1895 and 1987, Listed Alphabetically by Author

(Includes those books and monographs listed by W. A. McGrath, 1964, in *Experiments and Experience.* A bibliography of the Research and Knowledge of the Agricultural Experiment Station; 1889-1963. Updated to 1987 by W. M. Collins.)

Benedict, F. G. and E. G. Ritzman *(1923).* Undernutrition in Steers; Its Relation to Metabolism, Digestion and Subsequent Realimentation. Washington, Carnegie Institution of Washington, 333 p. (Publ. Carnegie Inst., Washington No. 324)

_____ *(1927).* The Metabolism of the Fasting Steer. Washington, Carnegie Institution of Washington, 246 p. (Publ. Carnegie Inst., Washington No. 377)

Blanchard, R. O. and T. A. Tatter *(1981).* Field and Laboratory Guide to Tree Pathology. New York, Academic Press, 285 p.

Bowring, J. R., H. M. Southworth and F. V. Waugh *(1960).* Marketing Policies for Agriculture. Englewood Cliffs, NJ, Prentice-Hall, 276 p.

Bruns, P. E. *(1955).* Applied Forest Management. Ann Arbor, MI, Edward Brothers, Inc., 383 p.

_____ *(1969).* A New Hampshire Everlasting and Unfallen: An Illustrated History. Concord, N.H., Society for the Protection of N.H. Forests, 95 p.

_____ *(1969).* Birch Symposium, Durham, N.H. 1969. *Proceedings*, Bruns, P.E. (ed.) sponsored by the Dept. of Forest Resources, University of N.H., and others, 103 p.

Charles, T. B. and H. O. Stuart *(1934).* Commercial Poultry Farming. Danville, IL, Interstate Printing Co., 436 p. (7th ed. 1949)

Crow, G. E. *(1982).* New England's Rare, Threatened and Endangered Plants. In collaboration with the New England Botanical Club Endangered Species Committee, prepared for the U.S. Dept. of Interior, Fish & Wildlife Service, Northeast Region, in cooperation with the N.H. Agricultural Experiment Station.

Dingman, S. L. *(1984).* Fluvial Hydrology. New York, W.H. Freeman and Co., 383 p.

Donahue, R. L. *(1955).* Our Soils and Their Environment. Danville, IL, Interstate Printers and Publishers, 446 p.

_____, E. F. Evans and L. I. Jones *(1956).* The Range and Pasture Book. Englewood Cliffs, NJ, Prentice-Hall, Inc., 406 p.

Dunn, S. *(1949).* A Laboratory Manual to Accompany the Text Elementary Plant Physiology. Cambridge, MA, Addison-Wesley Press, 50 p.

_____ *(1949).* Elementary Plant Physiology. Cambridge, MA, Addison-Wesley Press, 164 p.

_____ *(1972).* Lighting for Plant Growth. By E. D. Bickford and S. Dunn, 1st ed., Kent, OH, Kent State U. Press, 221 p.

Forste, R. H. *(1971).* New England Conference on River Diversions, Orono, Maine. *Proceedings* (R. H. Forste, ed.), Water Resources Center, UNH, Durham, NH (162 p.). "Sponsored by the New England Council of Water Center Directors and the New England Governors Conference."

Gourley, J. H. *(1922).* Textbook of Pomology. New York, Macmillan Co., 380 p.

Harter, R. D. *(1986).* Adsorption Phenomena. R. D. Harter (ed.). New York, Van Nostrand Reinhold Co., 379 p.

Hocker, H. W., Jr. *(1979).* Introduction to Forest Biology. New York, John Wiley and Sons, 467 p.

Husch, B. *(1963).* Forest Mensuration and Statistics. New York, Ronald Press, 474 p.

Judkins, H. F. and H. A. Keener *(1960).* Milk Production and Processing. New York, John Wiley and Sons, 452 p.

_____ *(1962).* Milk Production and Processing. New York, John Wiley and Sons, Published in Spanish, 498 p.

Kolega, J. J. (ed.) *(1963).* Farm Electrification Research. Fourth Edition of Research Activities and Special Studies in Farm Electrification Conducted in the United States (Jan. 1956-Dec. 1961). New York [Edison Electric Institute] 110, 12, 22 p.

Kulhavy, D. L. and P. C. Johnson *(1983).* Southern Pine Beetle: Annotated Bibliography, 1868-1982. Nacogdoches, Texas: Center for Applied Studies, School of Forestry, Stephen F. Austin State University, 95 p.

O'Brien, M. J. and A. E. Rich *(1976).* Potato Diseases. U.S. Dept. of Agriculture, Agricultural Research Service. Agriculture Handbook No. 474.

O'Kane, W. C. *(1916). Injurious Insects; How to Recognize and Control Them.* New York, Macmillan Co., 414 p.

Peirce, L. C. *(1987).* Vegetables: Characteristics, Production and Marketing. New York, Wiley, 433 p.

Prince, F. S. *(1956).* Grassland Farming in the Humid Northeast. Princeton, NJ, Van Nostrand, 441 p.

_____ *(1959).* Fertilizers and Soil Fertility. Rev. ed., Durham, NH, 187 p.

Rich, A. E. *(1983).* Potato Diseases. New York, Academic Press, 238 p.

Routley, D. G., 1975-, (ed.) Research Highlights. New Hampshire Agricultural Experiment Station, Durham.

Slanetz, L. W. *(1962)* (ed., with others) Microbiological Quality of Foods; Proceedings of a conference held at Franconia, NH, August 27, 28, 29, 1962. New York, Academic Press, 274 p.

Standon, A. *(1943).* Insect Invaders. Boston, Houghton Mifflin Co., 228 p.

Swain, L. C. *(1940).* Forestry. Boston, MA, Bellman Publishing Co., Inc. (Vocational and Professional Monographs, No. 8)

Weed, C. M. *(1895).* The Cultivation of Specimens for Biological Study. Concord, NH, The Republican Press Assn., 22 p.

_____ *(1895).* Ten New England Blossoms and Their Insect Visitors. Boston and New York, Houghton Mifflin and Co., 142 p.

_____ *(1896).* Fungi and Fungicides; A Practical Manual Concerning the Fungus Diseases of Cultivated Plants and the Means of Predicting Their Ravages. New York, Orange Judd Co., 228 p.

_____ *(1897).* Stories of Insect Life. Boston and London, Ginn and Co. Publishers, The Athanaeum Press, 54 p.

_____ *(1897).* Life Histories of American Insects. New York, Macmillan Co., 272 p.

_____ *(1898).* Seed Travelers. Studies of the Methods of Dispersal of Various Common Seeds. Boston, Ginn and Co., 53 p.

_____ *(1899).* Insect World; A Reading Book of Entomology. New York, D. Appleton and Co., 210 p.

_____ *(1901).* Nature Biographies; The Lives of Some Everyday Butterflies, Moths, Grasshoppers and Flies. New York, Doubleday, Page and Co., 164 p.

_____ *(1903).* The Flower Beautiful. Boston and New York, Houghton Mifflin and Co., 138 p.

_____ *(1903).* Spraying Crops; Why, When and How. 4th ed., revised, rewritten and greatly enlarged. New York, Orange Judd and Co., 136 p. (1st ed. 1892)

_____ and C. W. Crossman *(1902).* Laboratory Guide for Beginners in Zoology. Boston, D. C. Heath, 105 p.

_____ and N. Dearborn *(1903).* Birds in Their Relations to Man. Philadelphia and London, J. B. Lippincott Co., 380 p.

Woodward, K. W. *(1921).* The Valuation of American Timberlands. New York, John Wiley and Sons, Inc., 246 p.

Appendix 5

STATION CHRONOLOGY

Year	
1887	Hatch Act passed by Congress established federal Agricultural Experiment Stations.
1887	The Agricultural Experiment Station became part of New Hampshire College of Agricultural and Mechanic Arts, at Hanover.
1887	Director Whitcher talked on fertilizer, crop rotation, restoring worn out pastures.
1893	The New Hampshire Agricultural Experiment Station moved to Durham.
1895	C. M. Weed, Entomologist, was first D.Sc. on the Experiment Station staff.
1895-1900	Early Experiment Station staff were generalists.
1897	The Experiment Station cooperated with the State Board of Agriculture "on exposure of sales of oleomargerine."
1900	C. W. Burkett, Agriculturist, was first Ph.D. on Experiment Station staff.
1900	First Station report on analysis of poultry feeds.
1901	First Technical bulletin published.
1903	E. M. Davis, Purchasing Agent; M. E. Townsend, Stenographer — first women on Experiment Station staff.
1903	First nursery inspection law enacted; Station Entomologist appointed inspector.
1906	Adams Act enacted by Congress; provided funds to permit more extensive planning and conduct of agricultural research.
1907	The Station was investigating the "practicality" of milking cows by machine (Bulletin No. 129).
1908	Cucumber variety 'Granite State' nearly ready for release to public.
1912	C. A. Black, first woman Ph.D. and first woman scientist on Station staff.
1914-1918	Impact of WW I on the Agricultural Experiment Station.
1916	Poultry Department established.
1921	First appropriation by N.H. Legislature in support of agricultural research by the Experiment Station.
1923	N.H. College of Agriculture and Mechanic Arts became the University of New Hampshire.

1923	Home Economics Department established.
1925	Purnell Act passed by Congress; provided funds for research in Agricultural Economics, Rural Sociology and Home Economics.
1925	Millage formula adopted by Legislature.
1925	Rural Electrification project began in the Experiment Station.
1928	Research in Human Nutrition initiated.
1932	First research report by Station scientist in which statistics was applied to experimental data.
1932	The Depression impacts on Agricultural Experiment Station research. Civil Works Administration (CWA) requests the Station to organize and conduct several studies involving groups of office and white collar workers.
1933	Consolidation of retail milk routes in Laconia was recommended by the Station.
1935	Specialization of Station workers underlined the need for cooperative research projects.
1935-1937	Director Kendall underscored significance of soil survey work in New Hampshire. Soil survey began in Grafton County in 1935.
1935-1937	Federal agricultural programs (Soil Conservation Program, Agricultural Conservation Program, Agricultural Adjustment Act) impact on the Experiment Station research.
1936	Sixty-five percent of New Hampshire farms had electricity — highest of any state in the U.S.
1936	Bankhead-Jones Act enacted by Congress to support regional and cooperative research by state Stations and U.S.D.A.
1936	First mention of replicated plots in field experiments.
1937	Experiment Station studied decline of agriculture in Dorchester, N.H.
1939	Kendall completed 28 years as Station Director.
1940	Experiment Station recommended reorganization of milk truck routes to reduce travel.
1941	Importance of soil loss from erosion, and value of cover crops to reduce the loss is recognized (Bulletin No. 330).
1941	Ritzman Laboratory summarized 25 years of research in animal breeding and nutrition (Bulletin No. 331).
1942-1946	World War II impacts on research programs of the Experiment Station.
1944	Use of statistics in Station research was increasing.
1945	Cobalt deficiency discovered in soils in Carroll county.

1945	Re-routing in transportation of fluid milk from farm to processor, and every-other-day retail delivery of milk saved mileage and vehicles during the emergency period.
1945	Use of calculating machines by Station personnel speeded and simplified statistical analysis of research data.
1945	Radioactive isotopes being used in Experiment Station research.
1946	Flannigan-Hope Act passed; amended Bankhead-Jones Act to increase appropriation to Stations.
1951	Station began sponsorship of the New Hampshire Broiler Test conducted by Poultry Department. Test discontinued in 1963.
1954	Station studied efficiencies of delivering of animal and poultry feeds in bulk, and tank truck assembly of milk in New Hampshire.
1955	Station began publication of "Progress Reports," April 1955; discontinued them in 1963.
1955	Boron and magnesium found deficient in New Hampshire soils.
1955	Microbiological method for determination of protein developed.
1956	First determination of land-use trends from aerial photographs.
1956	Station Director Grinnell recognized financial grants from industry in support of research projects as expressions of confidence in Experiment Station staff.
1956	Station research program is augmented by assignment of five cooperative agents from U.S.D.A.
1958	H. A. Keener named Director of the N.H. Agricultural Experiment Station.
1958	Color of germinating peach seed found directly associated with flesh color of mature fruit.
1959	Station began sponsorship of the New Hampshire Egg Production Test which continues to this day.
1961	Niacin requirement of the laying hen determined.
1963	Female mice fed legumes had reduced fertility and increased reproductive anomalies.
1964	Maple decline along U.S. Route 4 attributed to severe salt injury.
1965	Five new vegetable varieties introduced this year.
1965	*Eimeria acervulina* (coccidiosis) successfully cultivated *in vitro*.
1969	Recommendations made for recreational use of the 13 mile woods section along the Androscoggin River.
1970	Tissue culture technique used to study single gene resistance of tomato to *Phytopythora infestans*.
1970	Gene dosage influences monogenic resistance to northern corn leaf blight.

1974	First detailed study of New Hampshire tidal marsh soils.
1975	Station began publication of "Research Highlights."
1975	Analysis of sewage sludges from a sample of New Hampshire towns showed one-half contained potentially toxic elements, especially lead.
1976-1986	"Remote sensing" provides detailed changes to foresters and land-use changes to other groups.
1977	Defect in cell chemistry implicated in smooth muscle cells from aortas of atherosclerotic susceptible pigeons.
1977	Station published summary of Granite State weather data based on observations covering some 75 years.
1978	One hundred new varieties of plants introduced by the Station since 1938.
1978	H. A. Keener retires at completion of 20 years as Station Director.
1979	Timber sales aid in reducing costs of recreational and other activities of town forests.
1980	Four hundred vascular flora of New Hampshire are rare and need habitat protection.
1980-1985	Forest geneticists suggest isozyme analysis technique as tool for selection of forest trees and studying effects of air pollution on conifers.
1981	Computer control of temperature and moisture improves kiln drying process for New Hampshire hardwoods.
1982	Research on experimental sanitary landfill showed leachate from garbage appeared in nearby water sources early.
1982	New green-stemmed asparagus cultivar, 'Emerald', introduced.
1982	Scanning electron microscopy improves clarity of detail of pollen grain structure and aids in correcting morphological discrepancies in the literature.
1982	Role of iron in transport of blood oxygen is clarified by determination of its three-dimensional shape.
1983	No-till method for sod seeding of legumes has advantages over conventional plowing.
1983	Hydroxamic acid found to be a factor both in resistance to northern corn leaf blight and the corn leaf aphid.
1983	Working model developed for forecasting apple scab discharge in commercial orchards provides basis for determining time and rate of fungicide application.
1984	Tissue culture technique used in research by reproductive physiologist is aimed at regulating the length of the cow's estrous cycle to give better control of time of breeding and increase reproductive efficiency.

1984	Genetic engineering technique used to study gene function in bacteria.
1984	Apple aphid is a pest suited to biological control.
1985	Bioassay developed for measuring small quantities of toxin produced by red tide algae found in coastal waters and which can produce paralytic shellfish poisoning.
1985	Stored fat found to have a role in survival of white-tailed deer.
1985	Methionine shown to be the first limiting amino acid for the dairy calf.
1986	Recombinant DNA technology applied to study of genetic control of enzymes in yeast during growth has tie to cancer.
1986	"A synopsis of New Hampshire seaweeds," a treatise on the state's algal flora, based on 18 years of research.
1986	Management plan is developed for multiple use of town forests.
1987	The genetics of the soybean has been significantly advanced by research using the isozyme technique.
1987	A model 80 year white pine rotation using "prescribed burning" was developed.
1987	Experiment Station celebrates 100 years of research.

Appendix 6

NEW HAMPSHIRE PLANT INTRODUCTIONS, A CHRONOLOGICAL LISTING FROM 1939 TO 1987 (This List Prepared by D. G. Routley, Extends That Which Covered the Years 1939 to 1978 and Appeared in Research Highlights, Spring 1978)

1939	New Hampshire Eggplant
	Merrimack Wonder Pepper
1945	Anne Tighe Lilac
1946	Brilliant Bean
	Flash Bean
1949	Early Chatham Tomato
	Orange King Tomato
	Orange Chatham Tomato
	New Hampshire Victor Tomato
	Windowbox Tomato
	High C Tomato
	Tiny Tim Tomato
	Popinjay Popcorn
	Tiny Green Bean
	Bush Buttercup Squash
	Korean Long Eggplant
	Granite State Muskmelon
	New Hampshire Midget Watermelon
1950	Carnival Popcorn
	Dixville Tomato
	Baby Blue Squash
	Durham Raspberry
	Great Bay Strawberry
1951	Korean Mint
	Korean Golden Sweet Melon
	Colebrook Watermelon
	White Mountain Watermelon
1952	Shelleasy Bean
	Pando Soybean
	Cocheco Sweet Corn
1953	New Hampshire Red Pickler Tomato
	Shirokubi Winter Radish
	Granite Pink Monarda
	Blaze Strawberry
1954	Doublerich Tomato
	Greencrop Bean
	Scarlet Beauty Bean
	Miss Kim Lilac
	Strafford Strawberry
1955	Merrimack Potato
	New Hampshire Red Raspberry
	Sunapee Peach
	Granite State Chrysanthemums (12 varieties)
	Purple Heart Geranium
	White Mountain Geranium
1956	Success Raspberry
1957	Red Shellout Bean
	Royalty Bean
	New Hampshire Surecrop Tomato
	Pinnochio Pepper
	Korean Chestnuts
1958	Sweetheart Beet
	Baby Butternut Squash
	Anna Amhoff Lilac
	Maybelle Farnum Lilac
	Durham Pillar Rose
	White Mountains Rose
	Grafton Pillar Rose

1959	Nectar Melon
	Golden Midget Watermelon
	Orange Buttercup Squash (Golden Turban)
	James MacFarlane Lilac
1960	Sweetnut Naked-Seed Squash
	Market Midget Watermelon
	Butterball Naked-Seed Squash
1961	Sungold Casaba Melon
	Nellie Bean Lilac
1962	Rockingham Tomato
1963	Goldpack Squash
1964	Reliance Peach
	Fall Red Raspberry
1965	Permagreen Pepper
	Sweet Chocolate Pepper
	Nosegay Pepper
	Applegreen Eggplant
	Eat-all Squash
	Market Master Watermelon
	Meredith Peach*
1966	Colbaga
	Sweet Granite Muskmelon
	Redgold Squash
1967	Tiny Dill Cucumber
1968	Fall Gold Raspberry
1969	Tricky Jack Pumpkin
	Fireside Popcorn
	Sunset Tomato
	Purple Heart Plum
1970	Agnes Smith Lilac
1971	Meader Blueberry
	Mericrest Nectarine
	Hybrid Cultivated Elderberry
1972	Korean Mountain Ash
1973	Meader Persimmon
	August Red Raspberry
1975	Jesse Hepler Lilac
1976	Red Chief Rutabaga
1977	Cocheco Plum
	Envy Soybean
	Phillips American Highbush Cranberry
	Summer Red Coleus
1978	Midnight Snack Sweet Corn
1979	Prestige Raspberry
1982	Autumn Pride Squash
	Sunapee Ornamental Corn
	Emerald Asparagus
1983	Fiesta Ornamental Corn
	Helen Champlin Lilac
	Green Gram Mung Bean
1986	Earligold Muskmelon
	Merrimax Soybean
	Surecrop Pea

*Bred in New Jersey — named at the request of New Hampshire.

Appendix 7

I. CENTENNIAL SYMPOSIUM — NOVEMBER 18, 1987
TOPIC: CHANGING OPPORTUNITIES IN NEW HAMPSHIRE AGRICULTURE AND BIOLOGICAL INDUSTRIES

Speakers and Topics

David Smith, Professor of Agricultural History, University of Maine, Orono. Historical Adjustments to Changes in New England Natural Resources.

Robert W. Long, Acting Assistant Secretary, Science and Education, U.S.D.A. Current and Future Effects of Biotechnology on New Hampshire Agriculture.

Richard Taylor, Manager, Applied Biotechnology Unit, Arthur D. Little, Inc. New Hampshire as a Center for Biotechnology Industries.

Berrien Moore III, Director, Institute for the Study of Earth, Ocean and Space, University of New Hampshire. New Hampshire and Global Change: The Challenge.

Bob H. Robinson, Associate Administrator, Economic Research Service, U.S.D.A. World, National and Regional Economic Issues Affecting New Hampshire Agriculture.

Lewis Mix, Agway, Inc., Member of the "Toward 2005" Committee. Task Force 2 Report: Issues and Opportunities for Northeast Agriculture, Food and Forestry.

II. CENTENNIAL WORKSHOP, DECEMBER 1, 1987
TOPIC: NEW DIRECTION IN AGRICULTURAL AND NATURAL RESOURCES RESEARCH

A. **Panel Members on Issues in Agricultural Research**

Stephen Taylor, New Hampshire Commissioner of Agriculture
Stephen Barba, President, The Balsams
Erick Leadbeater, Orchardist, Contoocook, NH
Jim McLaughlin, Senior Planner, NH Office of State Planning

B. **Panel Members on Issues in Natural Resources Research**

Jack Sargent, Director, NH Division of Forests and Lands
Brad Wyman, Forest Manager, James River Corp.
Denver Burns, Director, Northeast Forest Experiment Station, U.S. Forest Service
Ned Therrien, Public Relations, White Mountain National Forest

Appendix 8

INDEX OF AUTHORS AND OTHERS CITED

*(*INDICATES THE PERSON WAS NOT AN AUTHOR OF RESEARCH PUBLICATION CITED)*

Appendix 9

SUBJECT INDEX