Bulletin No. 282 - Pioneering in Western Agriculture

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Bulletin 282

A Resume of the First Half-Century of Research at the Utah Agricultural Experiment Station
PIONEERING IN WESTERN AGRICULTURE

A resume of the
FIRST HALF-CENTURY OF RESEARCH
1888 - 1938

at the
Utah Agricultural Experiment Station

including the
BIENNIAL REPORT
1936 - 1938

R. H. Walker, Director
Agricultural Experiment Station
Utah State Agricultural College
LOGAN, UTAH
President E. G. Peterson
Utah State Agricultural College
Logan, Utah

Dear Sir:

I have the honor to transmit herewith the report of the Utah Agricultural Experiment Station for the biennium ending June 30, 1938.

The Utah Agricultural Experiment Station was established fifty years ago as a result of the Federal Hatch Act becoming law in 1887 and the passage of a bill in the Utah Territorial Legislature in 1888. In commemoration of the first half-century of research at this Station, an attempt has been made to present in addition to the biennial report a review of the history of the Station and some of its major contributions to agricultural science during the fifty-year period. Owing to the desirability of publishing this resume of research, the usual biennial report of progress has been considerably shortened and confined largely to a list of the active projects and a report of administrative activities of the Station during the two-year period.

The limitations of space make it impossible to give a complete and comprehensive history of the Station since its inception. Owing to the large number of staff members who have made contributions during the fifty years, their names have not been tied in with the review of accomplishments but rather they have been listed as a group, accompanied by the positions held, in a separate section of the report.

This historical report of the first half-century of Experiment Station research has been prepared by the following committee: Dr. O. W. Israelsen, chairman, Professors Almeda Perry Brown, Aaron F. Bracken and David A. Burgoyne. These people have labored diligently and untiringly in their search through bulletins, reports and other published matter of this Station and through the archives of the College. They have been assisted in this work by the heads of the various departments and their associates. The painstaking efforts of all who have assisted in the preparation of this publication cannot be too highly commended. For the special service of the committee in the compilation of this report, the Experiment Station staff is sincerely grateful.

Respectfully submitted,

R. H. Walker
Director
The Utah Agricultural Experiment Station in reaching the fiftieth year of its history can look back upon a brilliant record of achievement covering the practical as well as the more fundamental problems of agriculture in this arid state. The difficulties encountered in conquering deserts down through human history have demonstrated the mastery of man's spirit over his physical environment. Man's destiny to multiply, subdue, and replenish the earth cannot be accomplished by enjoying the fruits of life unless that enjoyment is preceded by valiant and unselfish effort.

The pioneer forefathers crossed what was considered to be a trackless desert waste to establish themselves permanently under a new type of agriculture for Nordic peoples. With a wise and courageous leadership these mountain valleys were gradually but laboriously tilled and irrigated. However, the watering of desert lands, the cultivation of dry farms, the grazing of livestock on mountains and deserts, the introduction of various crops and crop varieties brought problems which were beyond the solution of individual farmers. Hence, the establishment of an experiment station as a division of the Utah State Agricultural College was the response to an urgent need. Now after a half century of progress a pause is made to review the accomplishments of this Station, many of which may be pointed to with pride. Experiments involving response of the major crops to varying amounts of water, movement of moisture in soils, alkali studies, drainage of water-logged land, and correlation of stream runoff with snow measurements, are of great practical as well as scientific value. Students from all important arid areas of the world have come to review the results of dry-farm experiments. Superior and disease-resistant cereals have been selected and distributed. Truck crops of better quality and higher yielding ability are now available. Feeding trials with livestock have pointed the way to larger profits. The work on better methods of hatching, brooding, and feeding of poultry has greatly aided and stimulated the poultry industry in this state. Fundamental discoveries in chemistry, bacteriology, and human nutrition are of outstanding importance. The study of alfalfa in relation to seed production, disease resistance, and varietal reaction has promise of important developments. The economic and social investigations have pointed the way to the solution of some of the most vital human needs. Investigations connected with control of insect pests and plant and animal diseases are of significant economic value. Indeed the accomplishments of the Utah Agricultural Experiment
Station have been so varied in plan and so far-reaching in scope that almost every farm family within the borders of the state has received benefit. Many of these benefits have been forgotten as to source but are imbedded in the background of usable experience to be employed in the development of a better agriculture and in the enjoyment of a richer and more satisfying rural life.

And now at the beginning of this second half-century the work of the Agricultural Experiment Station is dedicated to a greater and broader service to the people of Utah.

ELMER GEORGE PETERSON
President
## CONTENTS

### PART I

**A Resume of the First Half-Century of Research**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTRODUCTION</strong></td>
<td>9</td>
</tr>
<tr>
<td><strong>AGRICULTURAL ECONOMICS</strong></td>
<td>17</td>
</tr>
<tr>
<td>Early studies - Sheep and cattle studies - Apple studies - Dixie study - Price study - Family living costs - Cost of producing dry-land wheat - Poultry study - Millard County - Types of farming in Utah</td>
<td></td>
</tr>
<tr>
<td><strong>Studies Under Way</strong></td>
<td>24</td>
</tr>
<tr>
<td>Economic study in Uinta Basin - Economic study of Utah County - Economic study of Sanpete and Sevier Counties</td>
<td></td>
</tr>
<tr>
<td><strong>AGRonomy AND SOILS</strong></td>
<td>27</td>
</tr>
<tr>
<td>Soils Investigations</td>
<td>27</td>
</tr>
<tr>
<td>Fertilizer and rotation tests - Soil surveys - Technical studies on soils</td>
<td></td>
</tr>
<tr>
<td><strong>Crops and Crop Varieties</strong></td>
<td>32</td>
</tr>
<tr>
<td>Weed control</td>
<td></td>
</tr>
<tr>
<td><strong>Experimental Farms</strong></td>
<td>37</td>
</tr>
<tr>
<td>San Juan - Nephi - Sanpete County - Carbon County</td>
<td></td>
</tr>
<tr>
<td><strong>Alfalfa Seed</strong></td>
<td>40</td>
</tr>
<tr>
<td><strong>ANIMAL HUSBANDRY</strong></td>
<td>43</td>
</tr>
<tr>
<td>Basic advancements - Most needed information</td>
<td></td>
</tr>
<tr>
<td><strong>Animal Pathology</strong></td>
<td>44</td>
</tr>
<tr>
<td>Livestock disease service - Early investigations - Horse and sheep disease studies - Livestock and poultry disease spread - Pathology laboratory - Diagnostic service</td>
<td></td>
</tr>
<tr>
<td><strong>Dairying</strong></td>
<td>48</td>
</tr>
<tr>
<td>Milk skimming and cheese making - Feeding studies - Cow-testing associations - Dairy work expanded</td>
<td></td>
</tr>
<tr>
<td><strong>Dairy Experimental Farm</strong></td>
<td>51</td>
</tr>
<tr>
<td>Dairy herd - Beet pulp vs. corn silage - Home-grown rations - Breeding experience - Pasture studies - Disease control</td>
<td></td>
</tr>
<tr>
<td><strong>Poultry</strong></td>
<td>54</td>
</tr>
<tr>
<td>Objectives of early studies - Incubation studies extended - Incubator types - Egg production and flock selection - Breeding studies - Egg-laying contests - Feeding studies - Turkey feeding</td>
<td></td>
</tr>
<tr>
<td><strong>Sheep Studies</strong></td>
<td>58</td>
</tr>
<tr>
<td>Feeding and fattening lambs - Range forage and feeding - Economic aspects - Feeding farm ewes</td>
<td></td>
</tr>
<tr>
<td>Subject</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>BOTANY AND PLANT PATHOLOGY</td>
<td>61</td>
</tr>
<tr>
<td>Psyllid yellows of potatoes</td>
<td></td>
</tr>
<tr>
<td>- Virus diseases of the potato</td>
<td></td>
</tr>
<tr>
<td>- Tomato diseases</td>
<td></td>
</tr>
<tr>
<td>- Research activities continued</td>
<td></td>
</tr>
<tr>
<td>- Sugar-beet diseases</td>
<td></td>
</tr>
<tr>
<td>- Bacterial wilt of alfalfa</td>
<td></td>
</tr>
<tr>
<td>- Strawberry root rot</td>
<td></td>
</tr>
<tr>
<td>- Chlorosis</td>
<td></td>
</tr>
<tr>
<td>CHEMISTRY AND BACTERIOLOGY</td>
<td>69</td>
</tr>
<tr>
<td>Chemistry</td>
<td></td>
</tr>
<tr>
<td>- Forage crop studies</td>
<td></td>
</tr>
<tr>
<td>- Water studies</td>
<td></td>
</tr>
<tr>
<td>- Chemical content of irrigation water</td>
<td></td>
</tr>
<tr>
<td>- Alkali studies</td>
<td></td>
</tr>
<tr>
<td>- Soil studies</td>
<td></td>
</tr>
<tr>
<td>- Crop studies</td>
<td></td>
</tr>
<tr>
<td>- Smelter smoke research</td>
<td></td>
</tr>
<tr>
<td>- Miscellaneous studies</td>
<td></td>
</tr>
<tr>
<td>Bacteriology</td>
<td>72</td>
</tr>
<tr>
<td>Utah soils rich in Azotobacter</td>
<td></td>
</tr>
<tr>
<td>- Effect of legumes and other crops on nitric</td>
<td></td>
</tr>
<tr>
<td>nitrogen</td>
<td></td>
</tr>
<tr>
<td>- Maintenance of soil nitrogen</td>
<td></td>
</tr>
<tr>
<td>- Effect of water on bacteria</td>
<td></td>
</tr>
<tr>
<td>- Soluble salts and bacterial activity</td>
<td></td>
</tr>
<tr>
<td>ENTOMOLOGY</td>
<td>77</td>
</tr>
<tr>
<td>Orchard insects</td>
<td></td>
</tr>
<tr>
<td>- Codling moth studies</td>
<td></td>
</tr>
<tr>
<td>- Recommendations for control</td>
<td></td>
</tr>
<tr>
<td>Other orchard insects</td>
<td></td>
</tr>
<tr>
<td>- Forage crop insects</td>
<td></td>
</tr>
<tr>
<td>- Cereal crop insect studies</td>
<td></td>
</tr>
<tr>
<td>Truck crop insects</td>
<td></td>
</tr>
<tr>
<td>- Berry insects</td>
<td></td>
</tr>
<tr>
<td>- Insects affecting man and animals</td>
<td></td>
</tr>
<tr>
<td>- Grasshoppers and crickets</td>
<td></td>
</tr>
<tr>
<td>- Reptiles</td>
<td></td>
</tr>
<tr>
<td>- Insect collection</td>
<td></td>
</tr>
<tr>
<td>- Insect pest survey</td>
<td></td>
</tr>
<tr>
<td>GEOLOGY AND UNDERGROUND WATER</td>
<td>85</td>
</tr>
<tr>
<td>Water shortage</td>
<td></td>
</tr>
<tr>
<td>- The problem</td>
<td></td>
</tr>
<tr>
<td>- Methods</td>
<td></td>
</tr>
<tr>
<td>- Geological formations</td>
<td></td>
</tr>
<tr>
<td>- Iron County wells</td>
<td></td>
</tr>
<tr>
<td>- Beaver County measurements</td>
<td></td>
</tr>
<tr>
<td>- Millard County work</td>
<td></td>
</tr>
<tr>
<td>- Work in other localities</td>
<td></td>
</tr>
<tr>
<td>HOME ECONOMICS</td>
<td>89</td>
</tr>
<tr>
<td>Clothing investigations</td>
<td></td>
</tr>
<tr>
<td>- Family food studies</td>
<td></td>
</tr>
<tr>
<td>- Human nutrition</td>
<td></td>
</tr>
<tr>
<td>HORTICULTURE</td>
<td>93</td>
</tr>
<tr>
<td>Vegetable Crops</td>
<td></td>
</tr>
<tr>
<td>- Tomatoes</td>
<td></td>
</tr>
<tr>
<td>- Plant growing</td>
<td></td>
</tr>
<tr>
<td>- Onions</td>
<td></td>
</tr>
<tr>
<td>- Celery</td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td>97</td>
</tr>
<tr>
<td>Variety testing</td>
<td></td>
</tr>
<tr>
<td>- Cherry pollination and varietal problems</td>
<td></td>
</tr>
<tr>
<td>- Cherry varieties improved by breeding</td>
<td></td>
</tr>
<tr>
<td>- Pruning fruit trees</td>
<td></td>
</tr>
<tr>
<td>- Fruit harvesting</td>
<td></td>
</tr>
<tr>
<td>and maturity studies</td>
<td></td>
</tr>
<tr>
<td>- Orchard irrigation</td>
<td></td>
</tr>
<tr>
<td>- Small fruits</td>
<td></td>
</tr>
<tr>
<td>IRRIGATION</td>
<td>103</td>
</tr>
<tr>
<td>Irrigation science</td>
<td></td>
</tr>
<tr>
<td>- The pioneer work</td>
<td></td>
</tr>
<tr>
<td>- Intensive irrigation studies</td>
<td></td>
</tr>
<tr>
<td>- Water application and crop yield</td>
<td></td>
</tr>
<tr>
<td>- Irrigation methods</td>
<td></td>
</tr>
<tr>
<td>- Snow surveys and irrigation</td>
<td></td>
</tr>
<tr>
<td>- Future irrigation research</td>
<td></td>
</tr>
<tr>
<td>PHYSICS</td>
<td>109</td>
</tr>
<tr>
<td>Frost studies</td>
<td></td>
</tr>
<tr>
<td>- Soil-water problems</td>
<td></td>
</tr>
<tr>
<td>- Field studies guided by analysis</td>
<td></td>
</tr>
<tr>
<td>RANGE MANAGEMENT</td>
<td>111</td>
</tr>
<tr>
<td>Importance of range lands</td>
<td></td>
</tr>
<tr>
<td>- Early survey project</td>
<td></td>
</tr>
<tr>
<td>- Reseeding research</td>
<td></td>
</tr>
<tr>
<td>Active projects</td>
<td></td>
</tr>
<tr>
<td>- Flood prevention studies</td>
<td></td>
</tr>
<tr>
<td>- Cooperative feeding research</td>
<td></td>
</tr>
<tr>
<td>- Resources study</td>
<td></td>
</tr>
<tr>
<td>- Recent survey work</td>
<td></td>
</tr>
</tbody>
</table>
PART I

A Resume of the First Half-Century of Research
at the
UTAH AGRICULTURAL EXPERIMENT STATION
1888-1938
A Resume of the First Half-Century of Research at the Utah Agricultural Experiment Station

The first agricultural experiment in Utah was begun on July 23 and 24, 1847, when the advance group of Mormon pioneers under the urgent necessity for food, plowed and irrigated five acres of land near the center of what is now Salt Lake City. This they planted to potatoes, and again irrigated the soil with water diverted from City Creek. This marked the beginning of modern irrigation in America and is recognized as the first community effort by Nordic people to supplement natural precipitation with stream water. The success of this venture is indelibly marked by a network of canals covering the irrigable desert lands of western America.

The second agricultural experiment like the first was born of necessity. A group of Utah farmers found their farm lands, which had for years been irrigated with water from Malad Creek near Bear River City, so impregnated with alkali that growth of crops was impossible. In desperation they plowed and seeded the dry land above the canal. The ripened dry-farm grain which they harvested in the fall of 1863 was almost as much a gift of heaven to these transplanted, old-world Mormon converts as mana to the children of Israel. Thus, dry farming, which has since spread to all states in the arid west, had its beginning.

But with the extension of irrigation, dry farming and grazing in Utah, new and more complex problems developed. Accumulation of alkali salts, waterlogging of low lands, and leaching out of fertility, all of which have been credited with wrecking agricultural permanency in other arid lands, likewise began to threaten in this inland basin. With intensified culture of crop plants came insect pests, weeds, and plant diseases. Grazing without regulation of increasing numbers of livestock on mountain ranges in summer and on desert areas in winter upset the natural balance of plant and animal life. Recognition of the importance and increasing complexity of these problems soon led to concerted action in the form of publicly supported, organized research. In this effort, Utah, in common with other states and territories, took advantage of the provisions of the Hatch Act of 1887 and established the Utah Agricultural Experiment Station. Since that time research workers of the Station have diligently and intelligently devoted their talents and energy to approved projects designed to effect solutions of the more pressing agricultural problems confronting the state. In summarizing the accomplishments of this half-century, the staff of the Experiment Station is not unmindful of the support, cooperation, and encouragement exhibited by the people of Utah in whose behalf the research has been conducted.
The Utah Agricultural Experiment Station was established in 1888 when the territorial legislature passed a bill creating the Utah Agricultural College and the Utah Agricultural Experiment Station. Section 18 of the act reads: "In connection with the said College there shall be established an agricultural experiment station to conduct original researches... Said agricultural station shall be conducted in accordance with the provisions of an act passed by Congress, March 2, 1887."

To carry out the purposes of this act, the territorial legislature of 1888 appropriated $25,000 for the erection of a college building. Logan City and Cache County donated the 100 acres of land on which the college buildings are now located. In 1890 the legislature appropriated $5,000 for the erection of a chemical laboratory; $4,000 for a farm house; $1,200 for two laborers' cottages; and $2,500 for stock, tools, and miscellaneous purposes.

On April 1, 1890, J. W. Sanborn, who had been appointed director of the experiment Station as well as president of the College, found the Station in possession, outside of the ground occupied by the College and Station buildings, of 83 acres of upper-bench land.

In the first bulletin issued by the Utah Agricultural Experiment Station, President Sanborn writes:

"The demand for agricultural experiment stations is the direct outgrowth of the development of the natural sciences, which have shown the great truth that agriculture is broadly founded in the laws of nature. No other industry or profession is so deeply anchored in law and none is so complex in its ramifications."

"By rod, measure and scale in all the unverified fields of agricultural thought (which is practically the whole field), exact data are to be secured
in order to supplant conjecture by certainty, the rule of thumb process by the reign of law. Countless billions of farmers have pursued their industry previous to the middle age of the present generation, and left behind them no settled laws that any group of farmers previous to that date could have been found to be in accord upon, notwithstanding the fact that there is not a single operation on the farm that does not involve some mathematical, mechanical, physical, or natural law...

"The experiment stations, existing for investigation and not primarily as teaching adjuncts of college classrooms, are to sacredly devote their funds to this purpose of research."

This definition of responsibility and statement of purpose is clearly as applicable to the work of the Utah State Agricultural College and Experiment Station today as it was fifty years ago.

Dr. J. H. Paul, who succeeded J. W. Sanborn in 1894 as president of the College and director of the Agricultural Experiment Station, listed the following functions of the Station:

"To ascertain what is a balanced ration for man and animals, to classify the native plants, to deal with injurious insects, to investigate the amount of water necessary for successful agriculture, to maintain and extend the native forests, to discover the forage plants that could be grown with success on the more arid lands, and, by water surveys of all irrigation systems in the state, to establish by record the exact proportion of each stream which normally should go to each claimant under the law of water rights."

At the beginning of the fiscal year, July 1, 1896, the duties of the College president and Station director were separated. The extra demand on the president's time for the proper oversight and management of the Institution, as well as the constantly increasing importance and extension of the Experi-
ment Station investigations, made this division of duties necessary for the best interests of both College and Station. J. M. Tanner was appointed president and Luther Foster, director of the Station.

Dr. John A. Widtsoe succeeded Luther Foster as director in 1900. Under his guidance the Station made marked advancement. In a letter recently received from Dr. Widtsoe, he clearly indicated the history of the Station between 1900 and 1905.

"During my directorship it was decided that the Utah Station should concern itself primarily, without ignoring other desirable studies, with problems peculiar to the State.

"This policy included also the requirements, not stressed in the earlier years, that the Station staff must become acquainted first hand with the conditions of the state. The experimental fields and laboratories were to be testing places of facts gathered and ideas developed from direct contact with state conditions.

"Since water is the limiting agricultural factor in a semi-arid region, the study of the crop-producing power of water on Utah soils, under a low rainfall or with irrigation water, became the central project of the Station. Such an investigation required the services of the agronomists, horticulturists, soil and plant chemists, and engineers. Even the animal husbandry men took part in the studies, for it became necessary to contrast the feeding value of crops grown under irrigation or dry farming with those produced in humid regions.

"The investigators sought to discover, first of all, the water requirements of the plant, that is, the number of pounds of water required, through evaporation and transpiration, for the production of one pound of dry matter.
"It was soon found that the water requirements of the plants are such that crops should, theoretically at least, be produced on soils receiving only the average rainfall of the State of Utah. Thus, the studies in dry farming began. "The dry-farming investigations of the Station soon became well-known not only throughout our country but throughout the world. So important did this work seem to the state that authority was given to establish 6 experimental dry farms in various parts of the state. The Nephi station, then founded, has become known throughout the world.

"Paralleling the dry-farming studies were the irrigation investigations of the Station. Water was applied to a great variety of crops under various conditions and in various quantities and the effect of the irrigation water on soils and plants was carefully followed. The results of these experiments, continued through many years, now lie at the foundation of modern irrigation science.

Dr. P. A. Yoder, who followed Director John A. Widtsoe, was a well-trained chemist. During his administration, experiments in irrigation were extended to a number of localities in the state, using one or more crops in each locality.

Dr. E. D. Ball, who served as Director from 1907 to 1916, has the distinction of having occupied the position longer than any other director up to the present time.

Dr. Ball lists work done in irrigation, arid farming, and conservation as outstanding accomplishments of the Station under his direction. Codling moth and sugar-beet leafhopper studies outlined and carried on by Dr. Ball led to the development of: (1) the "driving spray" method for controlling codling moth, which revolutionized the handling of that pest throughout the western United States, and (2) the announcement that sugar-beet curly top was an insect-transmitted disease, carried by the sugar-beet leafhopper.

Dr. F. S. Harris, who became director of the Experiment Station in 1916, evaluates the work of the Station as follows:

"Probably the most noteworthy experiments were those centering around the use of water, and the increasing of production as a result of improved methods of irrigation. These same investigations have also aided the dry-farming industry. The treatment of the land in order to secure better microbiological activities, the better use of farm manures, improved methods of weed eradication, the control of diseases of plants and animals, the elimina-
tion of pests, the better methods of handling livestock and utilizing livestock products, the development of the foundation principles which later led to the establishment of a profitable poultry industry, the better utilization of foods in human nutrition, are but a few of the topics which are illuminated by the Experiment Station workers.

“All of the discoveries made have had a beneficial effect in making agriculture a more substantial and profitable industry, and also in improving living conditions for those who dwell on the land. The state and government have, without doubt, realized the return of many dollars for every dollar invested in agricultural experiment work in Utah. The stability of agriculture and the quality of country life have been improved as a result of these researches.”

Under the guidance of William Peterson who became director of the Station in 1921, the work expanded and new projects in agricultural economics, farm management, rural sociology, and home economics were added which were financed by federal funds made available by the Purnell Act passed in 1925.

During the period a farm for studying dairy production was established north of the College campus and through legislative enactment experimental farms were established in (1) Sanpete County to study the production of crops on muck soils, (2) Carbon County to investigate irrigation problems and production of crops on soils which are easily eroded, slow to absorb water, and low in organic matter, and (3) the Uinta Basin farm to study alfalfa-seed problems.

From 1924 to 1928 the activities of both the Experiment Station and the Extension Division were guided by Director Peterson. Because of the rapid growth of the work in each of these agencies during this period, it became essential in 1928 for each division to have the entire time and attention of a leader. William Peterson continued as director of the Extension Division, and P. V. Cardon was appointed director of the Experiment Station.

During Director Cardon’s administration several new cooperative projects with various bureaus of the United States Department of Agriculture were undertaken. Much research was temporarily discontinued in order that the Station might assist in numerous agricultural emergencies caused by the economic depression which began in 1929.
Three new field stations were established during this period: (1) in Millard County for further study of the alfalfa-seed problems, (2) in Washington County to investigate early fruit production, and (3) in Box Elder County to study orchard management with special emphasis on the production of peaches, apricots, and cherries. Decreased revenues, due to the continuation of the depression, made it necessary to abandon all of the experimental farms outside of Cache County with the exception of the dry-land station at Nephi and the horticultural farm at Farmington.

The broader objectives of the research conducted during Director Cardon’s administration as stated by him in a recent letter were modified by the “increasing recognition of the interrelationship of social and economic as well as physical and biological factors affecting agriculture in Utah. Researches were continued on problems involved in production practices on both irrigated and dry land, but these were supplemented by other researches which extended to the range lands and the importance of these lands as natural resources of common concern to all the people.

“This extension of research led to the farm communities themselves, their social structure, their economic status, their land use practices, the adequacy of water supply, and to water and soil conservation. Out of these studies came a clearer conception of the agricultural pattern of the state, the types of farming, and the interdependence of farm and range lands. Moreover, these studies helped to develop a clearer consciousness of the influence upon Utah agriculture of economic and social factors arising from regional and national, even international, human endeavors; and of the importance of adjusting land use in Utah to the impact of these factors.

“With state boundaries fixed, water supply limited, a major part of the land area in federal control, population increasing and overflowing the capacity of local communities, farm indebtedness ascending, the tax burden increasing, competitive markets becoming more exacting, and the status of rural community life being modified by wide-spread technological advancement in industry and commerce, Utah confronted the necessity of adjustment to conditions not anticipated by the Pioneers—a need which commanded knowledge of a type not readily available. To aid in the quest of such knowledge, the Utah Agricultural Experiment Station during the years 1929 to 1935 devoted much of its effort.”
Dr. Lowry Nelson was appointed director of the Station in 1936, being the first rural sociologist to hold such a position in the United States. Although he remained but one year, his congenial personality and clear vision of the agricultural problems of the state soon won for him the full cooperation of the Station staff. He did much to clarify the relationship between scientific investigations and improved rural life. He was appointed a member of the President’s committee on Farm Tenancy to investigate the status of farm labor in the United States. Dr. Nelson was a member of the subcommittee which drafted the report published by the federal government. During his term of office he was also appointed as one of the two United States representatives of the Permanent Agricultural Committee of the International Labor Organization at Geneva, Switzerland.

Dr. R. H. Walker, recently appointed director, comes to the Station from the Intermountain Forest and Range Experiment Station where he did outstanding work on soils in relation to artificial range revegetation problems in the intermountain area. With emphasis now being placed on soils and the conservation of our basic agricultural resources throughout the nation, Dr. Walker’s appointment as director of the Utah Agricultural Experiment Station should do much to maintain and advance the research standards of the Station and thus perpetuate its contributions to the solution of perplexing agricultural and rural-life problems in Utah, and in the West.
AGRICULTURAL ECONOMICS

During the early years of experimental work at the Station such problems as control of insects, feeding of livestock, irrigation investigations, crop varietal tests, soil treatment and other similar projects, mainly occupied the attention of the members of the staff. The work centered largely around questions of increased crop and animal production. As the agricultural problems became more clearly defined, however, it was discovered that costs of production, marketing facilities, and balance of the farm enterprise, were of importance to a well-rounded investigational program. Consequently, in the last few years, agricultural economics research has become one of the major activities of the Station, particularly since federal funds became available under the Purnell Act in 1926. The work of the department has now extended into researches organized in the fields of farm management, marketing, prices, commodity studies and economic analyses by agricultural areas.

Early Studies

The first farm-management field study, begun in 1914, consisted of analyzing 309 irrigated farms located in Beaver, Cache, Carbon, Emery, Millard, Salt Lake, and Sevier Counties. Farm capital and size of the farm unit were the principal measurements used in this study. The labor income for the farm operator as reported varied from $104 in Hinckley, Millard County, to $590 for the Monroe area in Sevier County.

The results from these early studies have been used by agriculturists in analyzing the organization and management on irrigated farms in Utah.

In 1915 the Office of Farm Management, United States Department of Agriculture, cooperating with the Utah Station, made a farm management study of the Utah County area and of the Great Salt Lake Valley. An analysis was made by type of irrigated farming. Measurements of farm efficiency used were distribution of capital, size of business, production from livestock and crops, receipts and expenses and correlation between income and education.

Sheep and Cattle Studies

The Utah Station, cooperating with the Bureau of Agricultural Economics, and the Bureau of Animal Industry, conducted an economic study of sheep and cattle ranching in Utah, and a farm management analysis of these enterprises based on records secured from livestock men for the year 1925. The details of this study are reported in the section on animal husbandry.

Apple Studies

A study was made of the apple industry in Utah in 1926-27, which showed that the trend in Utah was downward. Because of low yield and poor
quality, Utah apple growers were unable to compete with other producing areas where yields were higher and quality better.

While proper grading and packing constitutes one of the major problems confronting the apple growers of Utah, a problem of equal, if not greater importance, is that of producing higher yields of marketable apples possessing desired size and quality.

The average total income of all growers was $2,891, with a total expense, exclusive of operator's labor, of $1,959, leaving an average farm return of $932.

The average labor income, after allowing interest at 5 percent on the investment, was $253. Or allowing wages for the operator at the rate of $833 per year, there was a return on investment of .73 percent.

The general practice in Utah of paying practically a uniform price for apples irrespective of quality has been injurious to the apple industry. The packing and grading of apples by individual growers have also been a handicap to the Utah apple industry because of lack of uniformity of grading and packing, and quality of product.

Dixie Study

An economic survey of the Dixie section of Washington County was conducted in 1930. This study gave an analysis of the farming situation as it related to type of farm, trends of production, and marketing methods, including trade preferences for truck crops hauled from Washington County to the Salt Lake City market and trade territory. The competition from California truck crops on the intermountain markets was also determined. The study showed that, because of the small-sized units, there was an urgent need for intensifying production.

The average total cultivated acreage per farm was 21.8 acres. The acreage planted to field crops amounted to 71.6 percent, to fruit 22 percent, and to truck crops 6.4 percent.

The acre-yields and returns from field crops, as shown by this study, were low. The average acre-yield of alfalfa was 2.9 tons, with an average acre-yield of wheat of 23.3 bushels. When compared to the yield of field crops grown in that section, the acre-yields of truck crops were high.

The average total farm income was $1,254, while the average total farm expense was $766, leaving a net farm income of $488.

Low soil fertility is one of the outstanding problems confronting the farmers of Washington County. There is but a small amount of fertilizer available on the average farm, and the cost of importing fertilizer is high.

With a large percentage of the acreage planted to crops having low acre returns, it is indicated very strongly that one of the principal problems confronting these farmers is the reorganization of the farm business in such a way that the small number of acres now being cultivated can be made to yield high-acre returns.

If the system of farming cannot be changed so as to greatly increase the acre returns and thereby assure an adequate farm income, the size of the farm should be increased to provide a more economical farm unit.
Price Study

Prices of farm products in Utah have been studied since 1926. These investigations show the relationship of prices received for agricultural products in Utah to the prices received in the United States as a whole and to prices of industrial products.

Through use of index numbers, comparative prices showing relationships were presented in tabular and graphic forms for a period of twenty years, 1910-30. This service has been continued since 1930 by issuing monthly mimeographed releases.

An aggregate weighted index of Utah farm prices, composed of 22 agricultural commodities, was used. This price index was based on the period 1910-14 as representing 100.

During the war period, the prices paid for farm products in Utah averaged higher than did United States retail prices of goods purchased by farmers. The peak in Utah farm prices was reached in May 1920, when the average Utah price index of all commodities stood at 253 or 153 percent above pre-war. However, from May 1920 to September 1921, Utah farm prices declined from an index of 253 to 101, or a decrease of 60 percent. During this period, the purchasing power of the Utah farm dollar, based on United States retail prices of goods purchased by farmers, dropped to 65 cents. Following the low-price level of 1921-22, the trend was upward until January 1929, when the index reached 155, or equal to that of United States retail prices. From January 1929 to February 1933, farm prices dropped from an index of 155 to 60, or a percentage decrease of 61. There was an increase in farm prices from the low point in 1933 to April 1937, from an index of 60 to 133. From April 1937 to March 1938, prices dropped to an index of 106. The low purchasing power of the Utah farm dollar since 1921, especially from 1930 to 1936, has been a serious handicap particularly to agriculture.

Family Living Costs

A study of family living expenditures in Summit County, Utah, in 1930, included cost of living, the expenditure of the income, the relationship between the farm income and the family expenditures, the distribution and efficiency of the expenditures in relation to the various income groups, and a determination of whether or not the farm income was sufficient to provide a reasonable standard of living.

The information secured from the survey showed an average cash income of $2,520, with a cash expenditure for the farm of $1,391, leaving $1,129 cash available for family living. The family cash expenditures were $1,133, giving a balance of minus $4 as the average for all families reporting.

The total living cost for the farm family averaged $1,663, of which $1,133 was cash expenditure and $530 value of living supplied by the farm. This amount consisted of $258 for food and $272 for use of home and automobile.
The average total cash expenditure for food was $247, furnished by the farm valued at $258, or a total food cost of $505, for the year.

It was found that the cash expenditure for family living increased in proportion to increase in income. Certain items, such as food and household operation, remained fairly constant on the basis of the adult equivalent, while clothing showed a uniform increase with increased income. Expenditure for advancement, life insurance, and the use of the automobile showed a decided increase as income increased.

The families with low income spent their money for necessities and had little available to spend for education, life insurance, or automobiles. It was not until the income available reached $1,000 or more that the family requirements above necessities could be provided.

Cost of Producing Dry-land Wheat

In 1926-27 and in 1933-34, studies were conducted on cost of producing dry-farm wheat in the principal dry-farming sections of the state, Juab, Box Elder, and Cache Counties. In this study the cultural practices used to increase acre-yields of wheat, the more economical use of labor and equipment, and detailed production costs were analyzed. The average cost of producing a bushel of wheat on the dry farms in Utah in 1926-27 was 75.7 cents, while in 1933-34 the average cost was 68 cents per bushel.

Poultry Study

Economic factors affecting poultry production and marketing in Utah were analyzed for 1929, 1930, and 1931, the Division of Farm Management and Costs, United States Department of Agriculture, cooperating with the Utah Station on the production phases; the Division of Cooperative Marketing, and the Farm Credit Administration cooperating on the marketing of poultry products.

In this study it was found that the average capital investment per farm for the poultry enterprise alone was $3,888 or $3.90 per hen. The average income per hen was $3.43, with an average production cost of $3.18, leaving an income above all costs of 25 cents per hen.

The net cost of producing pullets up to the time they were placed in the laying pen was 90 cents.

With the same quantity of feed, an increase of 1 percent in the mash content of the feed increased the egg production per year 0.36 egg per hen in the mixed flocks and 0.79 egg per pullet in the pullet flocks. These data indicate that the old hens were more responsive to total quantities of feed but less to the percentage of mash in the feed than were pullets.

Flocks with relatively high fall egg production continued at a high-production rate during the rest of the year. The relationship between fall production and total yearly production was especially marked in the case of pullet flocks.
The growth of the poultry industry during the period 1920 to 1930 was due to a combination of factors: (1) Egg prices were relatively high because the consumer, especially in the large eastern cities to which most of Utah's eggs were shipped, had a high purchasing power; (2) Feed prices were relatively low in Utah as the result of the low-feed prices throughout the country and the surplus wheat produced in Utah and in southeastern Idaho; and (3) Due to the small acreage of the average irrigated farm in Utah, there was a surplus of family labor. The addition of a poultry unit to the other farm enterprises utilized this labor, thus increasing the farm income.

Millard County

An investigation, conducted as a cooperative study between the Departments of Irrigation, Soils, Sociology, and Agricultural Economics of the Station, was made of the economic aspects of the agricultural conditions in the Delta area of Millard County in 1929, 1930, and 1931. An economic analysis of the area was made to determine the ability of the farmers under conditions that existed in 1929 to 1931 to pay high taxes, meet capital indebtedness, pay farm expenses, and in addition support the farm family. The results showed (1) that acre-yields were low, (2) farm income was low, and (3) farm expenses were extremely high as a result of heavy taxes for special improvements. This situation made it practically impossible for the farmers in the district to become solvent. As a result of this study it was recognized that certain economic adjustments were needed to correct the major difficulties such as:

(1) Taking out of cultivation all large areas of land which normally do not produce sufficient to pay the costs of cultivation.
(2) Transfer of irrigation water from the less productive to the more productive lands of the area.
(3) Establishment of larger farm units.
(4) Livestock production as a major enterprise on the farms of the area.
(5) Capacity of the land to produce should be the basis for the reorganization program.

Types of Farming in Utah

In a type of farming study of the state the investigation took the following form:

(1) A general view of types of farming in the state as a whole, including a sketch of the historical background, a description of the principal physical and climatic features, and a series of maps showing land use and distribution of farms of various types, and

(2) The division of the state into type-of-farming areas and an analysis of the factors affecting type of farming within each area, together with a description of the farm organization of the important types of farms in each area.

The physiography, climate, and soils of Utah present frequent, sharp, and marked contrasts within small areas as well as between the major geo-
The state is divided into 4 major type-of-farming areas: diversified-irrigated, specialized dry-land wheat, diversified-irrigated farming and ranching, and specialized livestock ranching. Because of the heterogeneous character of Utah's agriculture, the small size and scattered nature of the irrigated and dry-land crop areas, and the close relation of crop-land to range use, the type of farming dominant in one area is also present in other areas. These areas merely indicate the dominant feature which distinguishes each from the other.
graphic divisions of the state. These natural differences, together with social and economic factors, have resulted in much diversity in agriculture. The most significant distinction is between irrigated lands (2.5 percent of the land area) and between mountain and desert-range lands which cover most of the state. Likewise, the greatest differences in farm organization are between the diversified-irrigated farms located on the irrigated land and the range-livestock ranches which, while usually having some irrigated land, obtain most of their income from cattle and sheep which graze the ranges throughout a large part or all of the year. Sales of livestock and livestock products are an important source of income on many other farms.

Acreage of cropland harvested, income, and investment, averaged larger for ranches than diversified-irrigated farms. However, the variation in size of ranches is great, many being small, while a few are fairly large. Although some ranchers run both cattle and sheep there is a marked tendency to specialize in one or the other. Nearly all sheep in Utah are on ranches, but many operators of diversified-irrigated farms have a range-cattle enterprise. Except in size, cattle and sheep ranches present greater uniformity in organization and practice than other types of farms, with the possible exception of the specialized dry-land wheat farms.

The diversified-irrigated farms present a great variety of enterprise combinations. In many, one enterprise is sufficiently stressed so that, in the 1930 Census classification, the farm was listed as a dairy, poultry, crop-specialty, fruit, or truck farm. Where no single enterprise was dominant, it was classed as a general farm. The emphasis given to a particular enterprise is conditioned by natural factors such as climate, soil, water supply and by economic forces.

The present utilization of land and farm organization has grown out of the natural conditions and economic and social developments. Although in a broad, general way, the agricultural use of land is adapted to the present conditions, many serious maladjustments exist. In some localities dry farming has been extended into areas having insufficient precipitation or too poor soil for successful dry farming; in others, maladjustments in use of water supply exist. Serious deterioration of forage resources on some ranges has resulted from improper grazing practice. Farms are frequently too small and sometimes consist of small, noncontiguous tracts.

One of the most difficult problems confronting many Utah communities is their limited resources in relation to population. Under normal conditions, most of the ranches and a majority of the diversified-irrigated farms provide a reasonably satisfactory income for the farm family. There are, however, many diversified-irrigated farms and some ranches, particularly in the southern and eastern parts of the state, which are so small that only a meager farm income can be obtained even under favorable conditions. Agricultural income in some localities may be increased by providing more adequate water-storage facilities, by practicing better irrigation methods, by extending the more intensive crop and livestock enterprises, and by better combination of enterprises. In many localities, however, these possibilities are not sufficient to
provide reasonably satisfactory incomes for even the present farm population, much less to provide for normal increase. The lack of agricultural resources is offset, in some localities, by the presence of mining or manufacturing which furnishes part-time employment to farmers, thereby supplementing the farm income.

Many of the agricultural resources of Utah can be used most advantageously by groups of people working together. Problems in the use of these resources can only be solved by the group rather than by individual action. This is particularly true with regard to the use of ranges and irrigation water. Cooperation played an important role in the early development of Utah. The further extension and development of its principles in agriculture and industry appear desirable. The development of lines of employment other than agriculture is also a group problem; a new source of employment tends to benefit everyone in the community.

Studies Under Way

The studies now being conducted include an analysis of the economic phases of the available agricultural resources and their utilization. The work is being done in cooperation with the Departments of Agronomy and Soils, Irrigation, and Range Management of the Utah Agricultural Experiment Station. The Uinta Basin, and Utah, Sanpete, and Sevier Counties are included.
in the present studies. Problems involving farm mortgage, land values and taxation, causes of bank difficulties in Utah, dairy farming in the Ogden milk shed, and labor requirements for farm production are also being studied.

**Economic Study in Uinta Basin**

The economic analysis of the Uinta Basin area is nearing completion. The results show that most of the farms are classed as "general farms"; the specialized livestock farms were the most profitable, however. The average family incomes for the general, dairy, and part-time farms were too small to provide a reasonable standard of living.

**Economic Study of Utah County**

In addition to the economic investigation of the available agricultural resources of Utah County, data on the ability and willingness of the farmers to pay mortgage indebtedness were secured. In order to determine the ability of the farmers to support the farm family and pay indebtedness, it was necessary to add to the study an analysis of the present potential resources of the county and determine their best utilization.

The analysis was made (1) by areas, (2) by type of farming, and (3) by mortgage-debt delinquency status. Information on the operator's experience and attitude toward debt payment was secured. A historical study of crop yields and the acreage of various crops grown on lands under the Strawberry Valley Reclamation Project, which covers a large portion of the land in the south half of Utah County, was also made. The trends in yields and acreage were compared with trends for the state as a whole.

**Economic Study of Sanpete and Sevier Counties**

In addition to studying the general economic problems which affect farming in the Sanpete-Sevier area, a detailed analysis was made of each type of farming. The farm-survey records secured in these counties, for the 1936 crop year, were classified according to the following farm types: general irrigated farms, crop and livestock farms, sheep ranches, lamb-feeding enterprises, and part-time farms.

A wide range was indicated in the farm income from different types of farming in this area. The total income for part-time farms was only about one-half that received by farmers operating full-time irrigated farms and livestock ranches and only about one-seventh that received by sheepmen.

The following studies are now under way and will be completed in the near future: Farm mortgage, land value, and tax delinquency study; causes of country bank difficulties in Utah; and labor requirements for producing crops and care of livestock.

1 The study is being conducted through the cooperation of Soil Conservation Service, Bureau of Agricultural Economics, and the Grazing Division of the Department of Interior.

2 This study is being conducted in cooperation with the Federal Land Bank of Berkeley.

3 This study is being conducted in cooperation with the Bureau of Agricultural Economics and the Agricultural Adjustment Administration.
Utah has a limited acreage of tillable land ranging from areas with adequate irrigation-water supplies to dry farms dependent upon the natural rainfall. The soils vary from rich alluvial loams to heavy clays, some of which are impregnated with alkali. With these varying conditions, combined with lack of exact information as to tillage practices, cropping arrangement, and adaptability of crops to this situation, it became clear that experiments of an agronomic character should be among the first started with the establishment of the Station. A solution of problems involving such fundamental and complex relationships was and still is primary to the efficient utilization of our natural yet limited agricultural resources.

The initial agronomic experiments started in 1890 consisted of irrigation tests, study of plant diseases, crop varietal tests, and included feeding trials with livestock. It was not until 1901, however, that an agronomist became a member of the Station staff. With a greater degree of specialization, the work of the department became definitely limited to more specific problems involving crops and soils.

The first agronomic tests were conducted on the College farm located immediately east of the Administration building. The 83 acres of bench land covered by sagebrush was broken up, cleared, and made ready for irrigation in 1890. Of the 83 acres, 12 were used for horticultural plantings, 20 were seeded to various pasture grasses, 24 were devoted to crop rotations, and the remaining land was divided into plots for experimental purposes. Comparisons in yield between different crops and crop varieties, tillage tests, and many experiments of partly agronomic character were conducted. Of all the tests started, however, those involving the duty of water for various crops were probably of most historic interest since they were among the first established in America. These, however, are reported under the section on irrigation.

Soil Investigations

The soil which is the fundamental basis of agriculture is associated with many diverse complexities in Utah. In age, our soils, as indicated by profile development, vary from those which are classed as infantile to those which are mature. The soluble-salt content ranges from very small amounts to concentrations so high as to preclude the growth of even alkali-resistant plants. Lands near the centers of many valleys are waterlogged while the valley margins are usually well-drained. And now after approximately 90 years of cropping, farms not well supplied with fertilizers are showing definite reduction in crop yield. Investigations involving many of these problems have been conducted by Experiment Station workers.

Fertilizer and Rotation Tests

Beginning in 1910 the rotation and manuring studies were gradually expanded to become the main feature of the Greenville farm. The following
The table shows the response of various crops to application of manure in differing amounts:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Amount of manure in tons</th>
<th>Increased yield of crop for each ton of manure applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beets</td>
<td>5</td>
<td>2 tons per acre</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1 ton &quot; &quot;</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>0.4 &quot; &quot;</td>
</tr>
<tr>
<td>Potatoes</td>
<td>5</td>
<td>13 bushels per acre</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>4.3 &quot; &quot;</td>
</tr>
<tr>
<td>Wheat</td>
<td>5</td>
<td>2.0 bushels per acre</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>1.13 &quot; &quot;</td>
</tr>
<tr>
<td>Oats</td>
<td>5</td>
<td>1.65 bushels per acre</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>1.21 &quot; &quot;</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>0.36 &quot; &quot;</td>
</tr>
<tr>
<td>Corn</td>
<td>5</td>
<td>3.83 bushels per acre</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>1.61 &quot; &quot;</td>
</tr>
</tbody>
</table>

The following conclusions can be drawn from the many years of experimental results on manuring and rotation:

1. Manure is essential to the maintenance of soil productivity producing greatest returns when applied to beets, potatoes, and corn.
2. Corn and small grains are more exhaustive to soil fertility than potatoes or sugar beets.
3. When the supply is limited, the returns per ton of manure is greater in light rather than in heavy applications.
4. Manured beets are more resistant to blight.
5. Beet nematode can be controlled by rotation.
6. Organic matter and nitrogen of soil can be built up or maintained by rotation with one-third of farm in alfalfa and returning the manure to the land from feeding alfalfa to livestock.
7. Manure may greatly increase availability of phosphorus.

In 1928 the first regular experiments with commercial fertilizers were started on the Greenville farm. These experiments, together with some cooperative tests throughout the state, have shown that:

1. The Greenville soil is somewhat responsive to phosphate and to nitrogen as well as to manure.
2. Manure with phosphate gave the highest yield increase for any crop.
3. Manure alone gave a higher yield increase of the crops tested than phosphorus alone.
4. The most effective commercial combination for any crop was nitrogen and phosphorus.
5. Phosphorus was the most effective single material for beets, alfalfa, and peas.
6. Nitrogen was the most effective single material for grain.
7. Raw rock phosphate was of no value on this soil, only available (citrate soluble) phosphate seems to be of use here.
The average yields of sugar beets with no fertilizer, with phosphate alone, with manure alone, and with phosphate and manure together, were 10.4 tons, 14.5 tons, 17.0 tons, and 18.7 tons per acre, respectively.

In cooperation with the adjacent Dairy experiment farm recent tests have shown that phosphate fertilizer not only increases the clover content and the total yield of forage in pastures, but also considerably increases the phosphorus content of the herbage and thus enhances its feeding value.

**Soil Surveys**

The Utah Agricultural Experiment Station, in cooperation with the Bureau of Soils, began soil survey work in Utah in 1899. This work continued with some interruption until 1904. Between 1904 and 1919 there was no cooperative work under way. During the years 1912 and 1913, however, the Bureau of Soils without the formal cooperation of the Agricultural Experiment Station made a soil survey of the Cache Valley area. Cooperative work with the Bureau was again undertaken and continued during the years 1919, 1920, and 1921. During this time, the Delta area in Millard County, Ashley Valley and Uinta River Valley in Uintah County were surveyed. Since 1934 the field work has been completed on the Price River section, Carbon County; Virgin River area, Washington County; and Jordan River Valley, Salt Lake County. A portion of the field work has been done in the Uinta Basin, in Utah County, and in the Beryl district of Iron County. None of these reports have been published; however, land classification maps have been prepared and made available to various agencies.
Under the present system soil surveying as conducted in Utah, 3 maps are made of each area; namely, a soil-type map, an alkali map, and a land-classification map. In the land-classification map, the land is divided into 6 classes. Classes 1 to 3 are considered arable and 4 to 6, non-arable. In the arable, class 1 is the most desirable, with 2 and 3 being respectively less desirable. In the soil classification map, soil texture, structure, depth of soil, drainage, alkali, position, and slope are all used as a basis of classification.

In addition to the field studies associated with the work of land classification various technical, physical, and chemical tests are made in the laboratory. Laboratory researches together with the field work including alkali tests have been of distinct value in explaining the slow action of the drainage system in the Delta area in removing alkali salts. Apparently the slow response to drainage is due to: (1) the high percentage of fine textured soil; (2) high ratio of sodium to calcium in the soil alkali and drainage water, resulting in low permeability to water, especially with the lower concentration of alkali; and (3) upward moving waters which increase the alkali content of the surface-soil layers.

The maps and results of laboratory studies obtained from the soil survey have a wide variety of uses both scientific and economic. This work is of special value in formulating soil-management and fertilizer practices, in planning cropping programs, in studying relationship between climate and soil formation, and in following changes in alkali and drainage conditions over a period of years. The land-classification maps serve as a basis of determining values for taxing purposes, loans, and land purchase. With the use of such maps, intelligent land and water-adjustment programs and reclamation enterprises can be safely inaugurated and successfully consumated. While the completion of the soil survey will require a number of years, yet when finished, it will give a complete and accurate inventory of our land resources.

Technical Studies on Soils

Since alkali is encountered in many of the Utah soils effort has been directed toward a solution of the practical phases of the alkali problem as well as to get a better understanding of the more fundamental relationships concerned between the various salts and the soil.

In working with the various salts as related to effect on plant growth, when added to a fertile soil, it has been found that 1,000 ppm\(^4\) or less of chlorides, 2,000 ppm or less of carbonates, and 3,000 ppm or less of sulfates generally stimulated growth. Higher quantities depressed yield and when the amount added reached 4,000 ppm for chlorides, 8,000 ppm for carbonates, and 12,000 ppm for sulfates the concentrations were too high for satisfactory growth. In sand the toxic limits for wheat were as follows when the salts were added: sodium chloride with 12 percent moisture, 2,900 ppm; with 18 percent, 5,700 ppm; sodium carbonate with 12 percent water, 2,700 ppm; and 21 percent, 3,300 ppm; sodium sulfate with 12 percent water,

\(^4\) Parts per million.
8,000 ppm; with 24 percent, 16,000 ppm. The differences between the fertile loam and sand can be accounted for in the greater degree of absorption of salts by the loam. Work has also been done in the field to establish the toxic limits to plant growth for the various salts. From the results accumulated it is difficult to set definite limits because of the variation with moisture percentage, soil textures, and organic-matter content. Essentially, however, the toxic limit for the chlorides ranges between 2,000 to 3,000 ppm, carbonates under 2,000 ppm and sulfates 4,000 ppm and above. Under field conditions the toxicity of the chlorides and carbonates are very definitely the reverse of the relationship found when the salts were added to the soil, that is, the carbonates have a higher degree of toxicity than the chlorides. In the field it must be recognized, however, that the alkali salts are usually found occurring as mixtures. Under such conditions the toxic limit for plant growth varies between 2,000 and 3,000 ppm of soil.

Different crops and varieties within the same crop were found to show varying degrees of sensitivity toward alkali. Of the cereals, rye and barley were more resistant than oats, corn and wheat. The cereals generally were more resistant than the pasture grasses tested. Sweet clover could stand higher concentrations of salts than alfalfa.

The more fundamental work on soil alkali has been connected with base-exchange relationships. It has been found that the vapor pressure of soil is greatly influenced by the nature of the replaceable base in the mineral complex. In dry soil the calcium-treated material has the greatest water-absorbing power but in wet soils the sodium-treated material has the greatest absorbing power. Soils containing replaceable calcium are more friable and permeable to water than when the soil contains replaceable sodium.

Much research has been done concerning the replacement of one base by another. It has been demonstrated from chemical equilibrium studies that any cation may be used to replace another, but that some are more readily replaced than others. According to ease of replacement, they fall in the order Na, K, Ca. Whenever a soil comes in contact with a solution containing more than one cation, all cations present enter into base exchange. Chemical equilibrium studies indicate that the law of mass activity, if not vigorous, is a close approximation of base-exchange reactions. According to theories concerning the nature of base-exchange materials, the cations present are partially ionized. The Soils Division has done considerable technical research in developing a method to measure the activity, i.e., effective concentration, of these ions.

The relationship existing between physical properties of soils and base-exchange compounds, and the chemical reactions occurring when soluble salts come in contact with these compounds, are inseparable from the alkali and drainage problems occurring in farming or potential farming areas. The Soils Division is correlating the studies of base exchange and alkali, as well as similar studies from other institutions, with the studies conducted by the Physics and Irrigation and Drainage Departments concerning the movement of water through soils.
The upward movement of water through the soil by artesian pressure results in the accumulation of alkali or soluble salts. The presence of these soluble salts affects the physical and chemical properties of soil colloids. The physical properties of soil colloids have a decided effect upon the reclamation of land by drainage. The presence of sodium results in water moving through the soil with difficulty. The primary cause of the failure of many drainage systems is a lack of understanding of the physical laws concerning the movement of water through the soil. For successful planning of a drainage system, it is necessary to know the composition of the irrigation water as well as the soluble salts present. Indications are that the most effective drainage may be accomplished by pumping water from lower levels and irrigating with this water which contains a relatively large amount of calcium.

Another achievement of the Soils Division worthy of mention is a statistical study of the distribution of soil material in the United States according to size of its particles. In this study, soils from the 13 soil divisions of the United States, as well as soils developed from specified parent material, were considered. It was found that the ratio of the area of separate 5 to the total area is approximately constant, in the 13 divisions. It was also shown (1) that quartz-bearing igneous rocks tend to give soils low in silt and high in sand and clay, (2) soils whose parent rocks are mixtures of sandstone and shale approximate the average texture, and (3) limestone, slate, shale, and loessial material tend to give soils of high silt and low sand content.

One of the most outstanding developments attributed to the Soils Division in cooperation with the Physics Department is the pipette method for mechanical analysis of soils. This method was developed independently at about the same time at not fewer than three laboratories—at Dresden, Germany; at Bangor, Wales; and at the Utah Station. Introduction of this method revolutionized the field of mechanical analysis.

Crops and Crop Varieties

Tests to compare different crops and crop varieties were started as soon as the Station was established. Beets and corn were tried and determined to be adaptable to Utah conditions. Alfalfa was found to yield almost three times as much hay as timothy. Varieties of barley, oats, potatoes, winter and spring wheat were tested. While different varieties have been recommended as time has gone on, these tests have resulted in the almost universal growing of Trebi barley, Swedish Select and Markton oats, Dicklow and Federation spring wheat on the irrigated farms and Utah Kanred and Relief winter wheat on the dry farms. There is a possibility now, however, that Erect spring wheat, a new oat not yet named, and Velvon barley—all new hybrid strains—will replace the older established varieties.

Alfalfa, which was introduced into Utah in the late 1850's from California, has become the major crop of the state, occupying approximately 45 percent of the cultivated land. It is important for both seed and forage
production. The crop, however, suffers from attacks of weevil, nematode, bacterial wilt, and other diseases. In 1932, under a cooperative arrangement with the Botany and Plant Pathology Department, a large number of varieties and strains of alfalfa were seeded on wilt-infected land in Salt Lake County. Significant varietal differences in reaction to weevil, nematode, and bacterial wilt were measured. A Turkestan variety, no. 19304, was highly resistant to both the nematode and bacterial wilt. But the forage yield of this variety is low which necessitates crossing to secure a more desirable type. Many selections have been made from the more promising varieties. High forage yield, favorable seed production, resistance to disease and insects, together with good palatability are the characters necessary in an alfalfa variety to meet the present needs.

Strawberry clover (Tri folium fragifernum), a new legume introduced from Australia, gives promise of being well adapted to the low-lying, wet
ALKALI SOILS OF UTAH. From the several plantings made over the state, the results are encouraging.

Approximately 85 percent of Utah's land area is usable only for grazing purposes, and since it is recognized that this part of our state has been more or less injured by drought, and erosion, intensified by unregulated grazing, the problem of revegetation naturally arises. In an attempt to meet this situation a cooperative agreement, now in its second year, has been entered into by the Utah Agricultural Experiment Station, the Division of Forage Crops and Diseases of the United States Department of Agriculture, and the Intermountain Forest and Range Experiment Station with the objective of grass improvement, particularly range grasses. Emphasis thus far has been given to the wheat, brome, and ryegrasses and Indian ricegrass with many other native as well as introduced species.

Since the water and fertility relationships of plants grown under such extremes of environmental conditions constitute a very important aspect of the problem, the breeding program is being reinforced by a closely related physiological program.

The cereal improvement program has been in progress at the Station for many years. Hybridization as a means of improvement had its beginning about 1918 or 1919. During the first 10 or 12 years the work was devoted largely to genetic studies of morphological characters in wheat. Later varietal tests of oats, barley, corn, flax and grain sorghums were added to the program. Still more recently barley breeding was undertaken. During the past 12 years the small grain-breeding program has had one dominating objective; namely, the breeding of varieties resistant to certain devastating disease, at the same time maintaining or improving the other desirable characters, such as quality, acre-yield, straw strength, winter hardiness, and nonshattering. This work, since 1930, has been conducted in cooperation with the Office of Cereal Crops and Diseases, United States Department of Agriculture.

The plant-breeding program has yielded new improved varieties of small grains, including Relief and Erect wheat, Velvon barley, and a new oat C. I. 3141 (not yet named).

Relief, a hard red winter wheat highly resistant to the principal smuts in this area, was released for commercial production in 1931. In 1937 this new variety constituted about 80 percent of the winter wheat of Box Elder County, the greatest wheat-producing county in Utah. Other winter-wheat selections now under trial show even greater promise than Relief.

Erect is a new white-kerneled, spring, irrigated wheat of high yield with strong straw. This new variety was released for commercial production in 1937.

Velvon, a new high-yielding barley, which is smooth awned and covered-smut resistant, was also released for planting in 1937.

C. I. 3141, a new high-yielding white-kerneled oat, resistant to both loose and covered smuts, was released for commercial growing in 1938.

New high-yielding double crosses of corn have been tested and proved superior for Utah conditions for both grain and silage. Of the standard
varieties Minnesota 13 and Improved Leaming have been found adaptable to Utah conditions.

Flax-varietal trials indicate that under present price conditions this crop cannot be profitably grown in Utah.

Some of the grain sorghums have given satisfactory yields but do not appear superior to corn.

In addition to these more practical aspects of the breeding and testing work, a series of detailed studies have been made on the number and distribution of the races of smut in this section and on behavior of wheat varieties toward the races of smut. Genetic studies on the nature of inheritance of resistance to smuts and on the morphological characters of plants have also been made. These studies furnish a foundation for the breeding program.

Significant accomplishments have been made in the breeding project but no doubt varieties superior to these new ones will eventually be produced.

**EXPERIMENTAL PLOTS ON WEED CONTROL**

Various tillage, cropping and chemical treatments have been made to determine most effective and economical methods of control. Here the first data became available to show that alternate weekly cultivation at greatly reduced cost was as effective in eradication as the generally recommended weekly cultivations. The foreground shows alternate weekly cultivation; at the right is Canada thistle, the untreated plot, and in the background are sweet corn and potatoes, growing on plots where the weed growth had been eradicated.

**Weed Control**

In a report by the Agricultural Service Department Commission, United States Chamber of Commerce, Washington, D. C., for 1930, the annual loss from weeds in the United States was estimated to be 12 times that occurring from animal disease, 1$\frac{2}{3}$ times the losses from plant diseases, and 3 times the losses from insect pests of plants. In monetary value the annual
loss is estimated at 3 billion dollars. Utah undoubtedly contributes her share to this tremendous loss.

Experimental work on weed eradication covering a period of several years shows the following results to date:

1. Tillage consisting of fall or spring plowing followed by alternate weekly cultivations over a period of 2 years proved an effective measure of control for such weeds as white top, Russian knapweed, morning glory, and Canada thistle.

2. In one study the cost of tillage ranged from $7.50 for alternate weekly cultivation to $27.00 for alternate weekly plowing per acre per season with no difference in effectiveness of control. The cost of treating with chlorates ranged between $32 and $120 per acre.

3. Several different types of chemicals have been used in weed eradication studies. Of those tested, sodium chlorate and calcium chlorate appear to be most effective.

4. Chemicals generally were not as effective in control as tillage.

5. As a result of the experimental work, however, it is suggested that in a weed-eradication program both cultivation and chemicals be used, cultivation on the larger areas with chemicals applied on roadways, ditch banks, and other places where tillage is difficult or impossible.

6. Additional experimental work is under way which should lead to further reductions in costs as well as to effectiveness of control measures. The present work is conducted on 6 farms located in different sections of the state and more technical work at the central station at Logan.
Experimental Farms

In addition to the experimental work conducted at the main Station farm and to cooperative tests carried on with farmers in various parts of the state, several experimental farms have been established by special legislative appropriation, in most cases, to meet a local demand for reliable results on a specific or general farm problem.

The first farms, 6 in number, established in 1903 to test the feasibility of dry farming in different parts of the state, were located as follows:

Iron County farm, 4 miles west of Parowan, later changed to near Cedar City.
Juab County farm, 6 miles south of Nephi.
San Juan County farm, 6 miles south of Monticello, and relocated in 1925, 11 miles east of Monticello.
Sevier County farm, in Grass Valley, 18 miles southeast of Richfield.
Tooele County farm, 14 miles south of Grantsville.
Washington County farm, near Enterprise.
Dry-farm stations were later established at Kanab, Kane County; Widtsoe, Garfield County; in Cedar Valley, Utah County; and at Ajax, Tooele County.

The results secured from the farms at Parowan, Cedar City, Widtsoe, and Ajax indicated that these areas were not well adapted to dry farming. The crop yields recorded from the farms at Kanab, Enterprise, Grantsville, and Grass Valley showed a moderate degree of success with yields approaching failure in dry seasons. On the other hand the San Juan section and Juab Valley proved to be successful areas for dry farming.

San Juan

The San Juan farm established in 1903, south of Monticello, continued until 1916. In 1925, it was reestablished by a special act of the State Legislature but was again discontinued in 1933. The results show that winter wheat is the most successful crop for this area with other cereals, forages, and row crops making a combination which would add permanency to a farm enterprise. The following average yields show the possibilities of this section: Turkey winter wheat, 28.0 bushels an acre; Early Baart spring wheat, 13.4 bushels; Swedish Select oats, 28.3 bushels; Australian white flint corn, 5,498 pounds of dry fodder per acre; beans, 115 to 800 pounds per acre, with Mexican Red and Mexican Pinto leading; potatoes yielded from 56 to 144 bushels an acre, with the Bliss variety favored; field peas produced acre-yields varying from 4 to 21 bushels. Sorghums were tried with a fair degree of success. Root crops such as mangels, beets, and carrots produced yields which varied from 4 or 5 tons up to 16 tons per acre. Rate of seeding trials with wheat favored 3 to 4 pecks per acre. Winter wheat produced approximately the same yield following the row crops as after a clean summer fallow. The data give ample evidence that dry farming in San Juan County can be successful where soil conditions are favorable.
Nephi

The Nephi dry-land substation, established in 1903, has continued to the present with an unbroken accumulation of yearly results. The original farm of 40 acres was later increased to 103 acres. From 1907 to 1920 inclusive, the Cereal Office of the United States Department of Agriculture cooperated with the Utah Agricultural Experiment Station in the operation of the farm. Numerous experiments involving practical as well as fundamental problems of dry-land agriculture have been included in the projects given consideration over this 35-year period. The following represent some of the important practical contributions:

SUMMER FALLOW FOR DRY-FARM WINTER WHEAT
A weedy fallow not only reduces the subsequent wheat yield but increases preparation-of-seedbed costs.

(1) No measurable difference has been found between fall and spring plowing but significant progressive decreases in yield have occurred from delayed spring plowing.

(2) The furrow drill has given no higher yields than the ordinary drill.

(3) A rough untitled but weedless fallow has produced as high yields and allowed for accumulation of as much moisture as a well-tilled fallow. A rough fallow saves water as well as soil during periods of torrential showers.

(4) No difference has been found between the use of the mold-board plow as compared to the large one-way disk plow.

(5) Green manuring with either peas or wheat has produced no increase in wheat yields.

(6) Continuous burning of stubble is showing reductions in wheat yields.

(7) Application of barn-yard manure in amounts varying from 5 to 10 tons per acre has increased yields 23 percent and quality of wheat 17 percent.
The highest yields of winter wheat in a rate-and-date seeding test have come from sowing 5 to 6 pecks on October 1, with later seeding favored in dry falls and earlier in wet falls.

Alternate cropping has produced a greater total amount of wheat since 1904 than continuous cropping and at much less cost.

Wheat alternating with fallow has produced an average of 23.4 bushels, while wheat following row crops has produced approximately 20 bushels.

Of the many winter-wheat varieties tested, Utah Kanred and Turkey 26, both selections produced at Nephi, are highest in yield, but Relief is favored in smut-infested areas.

Forage tests seem to favor alfalfa and yellow sweet clover over the grasses. Crested wheatgrass is by far the best grass of the several tested.

The following conclusions are drawn from the more technical studies:

1. Of the total amount of precipitation falling over a fallow cycle from the end of one crop season to the beginning of another, 32.5 percent remains in the upper 10 feet of soil for plant use.

2. For each inch of rainfall, 0.93 of a bushel of wheat was produced.

3. The average water cost of dry matter under field conditions varied from 406 to 1,247 pounds, with 709 pounds as an average.

4. Average losses from the "combine" harvester amount to 0.82 percent and from the header and stationary thresher, 5.02 percent.

5. Even though wheat loses weight per bushel and bleaches following storm no loss in quality occurs.

6. Nitrate accumulation shows a direct relationship to time of plowing.

7. Utah dry farms in Juab Valley as well as in Cache Valley have lost approximately 20 percent of the nitrogen and organic matter as compared to virgin land. Growing alfalfa for approximately four years or more apparently reduces this loss to 8 percent.

Sanpete County

The Sanpete County farm, established in 1927 and discontinued in 1933, was located 3 miles west of Ephraim on a peat or muck soil. The more difficult problems encountered were alkali accumulation, high spring water table, frost, and looseness of soil.

In seed-bed preparation fall plowing was found to give best results, followed by packing the soil with a heavy roller in spring after seeding peas, oats, barley, and wheat.

Manure and phosphorus both singly or in combination gave favorable results. For continued high production this soil must be fertilized.

A number of crops and crop varieties were tried. The average yield of Trebi barley, the highest yielding variety, ranged from 50 to 75 bushels per acre; Dicklow wheat from 62 to 78 bushels; Markton oats did well; the Cobbler potato produced an average yield of 185 bushels per acre; alfalfa produced favorable yields; and canning peas gave high yields as well as a
product of extra quality. Vegetable crops such as celery, cabbage, cauliflower, carrots, and parsnips all produced profitable yields, and, like peas, the quality was exceptional.

Carbon County

The Carbon County farm, located approximately two miles west of Price, was continued from 1927 to 1933. The problems of this area involve cropping and tilling a heavy soil which is easily eroded, waterlogs in certain sections, and contains high concentrations of soluble salts.

Several crops and crop varieties were tested on this farm. Brown Beauty potatoes produced the highest average acre-yield of 339.7 bushels. The yield of Golden King corn was 81.4 bushels; Dicklow wheat, 60.6 bushels; Trebi barley, 91.7 bushels; Swedish Select oats, 94.5 bushels; Mexican Pinto beans, 2,076 pounds per acre; and alfalfa produced from 2 to 4 tons to an acre.

In the fertilizer trials 125 pounds of treble superphosphate to an acre increased the yield of alfalfa 50 percent, and beets approximately 40 percent.

The results covering a period of seven years secured from this farm clearly indicate that the Price area will produce profitable yields of crops on the better soils under efficient management.

Alfalfa Seed

In 1925 approximately 22 million pounds of alfalfa seed were produced in Utah but by 1929 only 3 million pounds were grown with no appreciable recovery up to and including 1937. Detailed studies were inaugurated in 1925 with the establishment of the Uinta Basin alfalfa seed farm and in 1927, in general field tests conducted in the Millard County seed area, to determine the factors responsible for successful seed setting and the causes for failure. Both of these studies were discontinued in 1933, but beginning in 1936 a cooperative project with the Division of Forage Crops and Diseases, United States Department of Agriculture, was established to continue the investigation of the alfalfa-seed problem.

The following conclusions are drawn from the work to date:

1. Soils of medium texture are more consistent in seed production than heavier or lighter types.

2. Thin stands usually set seed more abundantly than thick stands.

3. Row and hill-spaced plots on the average gave from 30 to 76 percent more seed than those drilled in the usual way.

4. Clipping and pasturing-off the early summer growth to approximately May 15 has resulted in increased seed yields in many cases.

5. There is definitely a mid-season period for poor pod-setting in which the buds and flowers of alfalfa are apt to be damaged by insects, particularly Lygus and related species.
(6) Seed setting is more successful very early in the summer or early in the fall.

(7) Irrigation water should be used sparingly to avoid rank growth. After flowers have set seed, more liberal use of water may be necessary to insure full development of the pod.

(8) Effective fertilization of the alfalfa flower is not dependent upon tripping but pollination is increased 2 to 3 times by tripping of the blossom.

(9) Seed-crop failures of major proportions in recent years have been characterized by occurrence of bud damage and excessive stripping of the flowers which is partly attributable to insects such as the Lygus bug.

(10) Low yields of seed, however, are without question associated with many factors including climate, soil, and insect damage.
ANIMAL HUSBANDRY

It is the duty of an agricultural experiment station to develop as rapidly as possible a substantial experimental foundation for each recommended farm practice. This can be done in either of two ways: by original research or by adapting the results of experiments done elsewhere to local conditions through suitable demonstrations.

Basic Advancements

Two outstanding lines of research and demonstration that were undertaken early at the Utah Agricultural Experiment Station dealt with horse feeding and with the value of alfalfa as a forage plant for livestock.

During the first 10 years, 1890-1900, a number of management practices with horses were studied, such as, the effect of watering horses immediately before or after they had been fed grain, mingling the hay and grain rather than feeding them separately.

The value of alfalfa as a horse feed was established and its diuretic effect was proved to be associated with its protein content rather than with any kidney damage that could be attributed to its use. The desirability of limiting the intake of alfalfa hay to about half the amount that would be consumed voluntarily was shown. Approximately half the hay was saved under a system of limited feeding with no loss of weight by the horses. Better still, colic in the horses was eliminated and the drivers found they no longer needed whips, as the horses drove more willingly.

Early observations indicated that alfalfa is by far the best hay crop that can be grown in the state. Observations were made on the effect of season and the stage of development of the plant on its total yield and feeding value, and on the chemical life history, on the effect of the season and the age of maturity on its feeding value for beef cattle, and finally, on the relative values of first, second, and third crop alfalfa hay for milk production. These have laid a firm foundation for the practices that have developed relative to raising and feeding alfalfa hay.

The utilization in livestock rations of the by-products of the beet-sugar factory received early attention at this Station (1903) and recommendations made for the use of these by-products as a result of this work have been followed with profit by feeders in this area. Recent findings (1936) have shown that rations composed largely of beet by-products are improved materially for fattening beef cattle by the addition of small amounts of bone meal, and will, if followed, result in a large saving of feed.

Smaller findings and miscellaneous demonstrations too numerous to mention here have contributed much to the foundations of good farm practice in this region.

Most Needed Information

New feeds and new methods of management will constantly need the attention of the research worker. The most important problems that confront
the livestock industry of the state, however, are larger problems than these. Inasmuch as the livestock industry of Utah is so largely a range industry, the most needed information is an accurate inventory of range resources. Not only is it desirable to know the kind and amount of vegetation produced, but its composition and digestibility as well.

A complete soil survey of the ranges of the state is needed to locate the areas that produce deficient vegetation. Suggestions have come from several sources that indicate a phosphorus deficiency in at least certain soils of the state. Effective supplementation of the forage grown can be accomplished only if its deficiency is accurately determined.

The management problem that appears to be of greatest importance is that connected with breeding herds. Factors affecting the size of the calf and lamb crops need to be located, and practical means of improving the management of the flocks and herds at this point should be developed. As long as summer feed is cheaper than winter feed effective methods of carrying the breeding herds over the winter without impairing their breeding capacity are needed for greatest economy of production.

Research in these two general fields appear to be most necessary at the present time.

**Animal Pathology**

**Livestock Disease Service**

Veterinary service was established early in the history of the Station. The consulting veterinarian answered general inquiries related to livestock diseases, made special investigations of unusual losses, and gave advice regarding their control. For a number of years the state employed no veterinarian to make investigations of livestock diseases and inaugurate regulatory control measures. Therefore some of this work was attempted by the consulting Station veterinarian.

**Early Investigations**

Early investigations were made regarding the control of bovine tuberculosis and it was demonstrated that the disease could be definitely eradicated through the use of tuberculin as a diagnostic agent. At that time it was believed that much of the tuberculosis of humans was contracted from the milk of diseased cows. A concerted effort was therefore made to control this disease among cattle. As a monument to this early work, Utah today is designated by the United States Bureau of Animal Industry as "modified accredited free from tuberculosis."

At an early period the following livestock diseases were found common in the state: tuberculosis, glanders, anthrax, blackleg, sheep scab, lumpy jaw, and hog cholera. Tests conducted at the close of the first decade in the history of the Station showed that practically 100 percent protection against blackleg could be obtained by the use of vaccine.
Horse and Sheep Disease Studies

In addition to the livestock diseases already mentioned, the following horse diseases were also found to be prevalent in this area: cerebro-spinal meningitis, influenza and strangles (distemper). It is of interest here to note that cerebro-spinal meningitis was in all probability the same disease which is now called equine encephalomyelitis (brain fever).

Investigations as to the cause of “bighead” in sheep were inaugurated. This disease, characterized usually by an edematous swelling about the head, was found more prevalent in certain areas and especially so when a few hours of brilliant sunshine followed a storm. Several range plants were investigated but the cause of the disease was not definitely determined. It could not be transmitted from one sheep to another. More recent work conducted by the United States Bureau of Animal Industry has shown the disease is caused by eating a species of Tetradyamia.

Experiments begun in 1925 and terminated in 1933 indicated that sugar beet by-products contain no poison capable of sickening or causing death of animals as was commonly believed by some livestock feeders. Beet-top silage was found not toxic for sheep and cattle but it may contain harmful substances (probably botulinus toxins) that will sicken horses. Certain spoilage which takes place in beet by-products may favor the development of Bacillus botulinus growth and result in death-producing toxins.

BANG'S DISEASE
The calf of this cow, affected with Bang’s disease, has been born dead.

Livestock and Poultry Disease Spread

The extensive spread of Bang’s abortion disease and the increased prevalence of poultry diseases influenced the 1929-30 State Legislature to provide
funds for building, equipping, and maintaining an animal disease laboratory to be used for diagnosis and research in connection with diseases of livestock. Prior to this time research and diagnostic service had been laboring under the handicap of no laboratory facilities and insufficient staff and funds to carry on this type of work. Since the opening of this laboratory so much of the time has been spent in diagnostic work that the character and scope of research work has suffered. The diagnostic service, however, has proved itself of definite value to the livestock interests.

BENT-LEG OF SHEEP
A disease of rapidly-growing rams which is believed to be the result of certain nutritional factors.

Pathology Laboratory

The results of laboratory tests and field observations suggest that animals having skin lesions with no internal lesions and yet which react to the tuberculin diagnostic test, may not be affected with true tuberculosis.

Observations on a herd of 22 dairy cows affected with Bang's abortion disease showed that none of the animals exhibited any tendency to recover as judged by their blood serum agglutination titer over a period of 1 to 5 years. That cows infected with the disease are unprofitable is demonstrated by the fact that at the end of 5 years all of the 22 animals had been eliminated because of abortions, mastitis, sterility and arthritis.

Since herds of dairy cattle mingle together enroute to and from pasture in many villages in the state a study was undertaken to determine the effect of such contact on transmission of Bang’s disease. From this study it appeared that there was not a great amount of spread as a result of contact with infected herds. Neither could drainage from infected pastures into clean pastures be shown to be a common means of spread. Introducing untested
animals which later proved to be infected into a herd was by far the most common means of establishing infection in a previously clean herd.

Since 2 species of mosquitoes native to Utah were found capable of transmitting the virus of equine encephalomyelitis (brain fever of horses) to guinea pigs it is highly probable that insect vectors are largely responsible for the spread of this disease among horses. This finding suggests that efforts be made to control or eliminate mosquito-breeding swamps and to protect horses as much as possible during an epidemic by placing them in darkened stables and by blanketing them during the period of the day when insect vectors are especially abundant.

Iritis of chickens is generally considered to be one syndrome of the disease known as fowl paralysis (Leucosis lymphomatosis). To test the ability of hens so affected to transmit the virus of this disease or to transmit a susceptibility to this disease to their offspring, eggs were pedigreed and incubated from 53 hens showing iritis. The results of the study show that iritis-affected hens are not necessarily progenitors of lymphomatosis in their progeny.

Sinusitis (roup) of turkeys annually causes economic loss, not through mortality but because of the decreased gains in growth and lower grading at market time. Experiments have shown that the injections of 4 percent silver-nitrate solution (1 cc.) directly into the swollen sinus brings about recovery in approximately 90 percent of the trials. Before injecting the solution, the mucus accumulated in the sinus should be removed. A low level of vitamin A appears to enhance the development of this disease. The disease was transmitted by sinus exudate but not by Berkefeld filtrates prepared from the exudate. This investigation is being continued.

Parturient hemoglobinemia (red water disease) affects dairy cows a few weeks following calving. It is characterized by bloody urine, extreme and rapid loss of flesh. Chemical analysis of the blood and urine of 20 cases suggest that the disease results from a disturbance in metabolism. The blood plasma is always extremely low in inorganic phosphorus. The disease usually occurs when rations are fed which are low in phosphorus content, such as alfalfa hay, beet pulp and beet syrup. This experiment is planned over a long period and investigations will be continued.

Progress has been made in the control of mastitis in the Agricultural Experiment Station dairy herd. This was accomplished by disposing of the badly affected cows, and adopting a program of stable sanitation which includes washing the teats and udders with a chlorine solution prior to each milking. All cows are tested each month (Hotis test) to determine their degree of infection. They are arranged in their stalls according to degree of infection, those which are disease free always being milked first, suspicious cases next, and the definitely infected cases last. Milking tubes are sterilized in hot water twice daily. Twelve months of this procedure has definitely checked the spread of this disease to newly added heifers.
Diagnostic Service

This service was first available February 1930. The 28,915 consignments received at the laboratory, resulted in examination of 326,861 specimens, a diagnostic service rendered to approximately 20,000 farmers, representing every county in the state.

Dairying

Dairying has always been fundamental to the livelihood of Utah people. For this reason a definite program of experimental dairying was begun at the Station as early as 1894.

Milk Skimming and Cheese Making

One of the earliest problems investigated was a comparison of the various methods of skimming milk. Results of the study showed that a separator was a wise investment for farmers with a dairy herd of 10 cows or more. The extra butter obtained by its use, if valued at 20 cents per pound, would pay 20 percent on the money invested in a separator when compared with the results of the shallow-pan system, and 50 percent when compared with the deep-setting system.

Under ordinary conditions, separator cream testing 30 percent butterfat was found to churn at a lower temperature, and more thoroughly than did thinner cream.
Good milk proved to be a most important factor in the production of good cheese. The degree of temperature at which cheese was cured was found to be important in relation to the quality and condition of the cheese.

After being ripened and cured for 1 month in a room at 60° to 65° and then put into cold storage, cheese retained its flavor for several months, and even improved in flavor. When held at low temperatures, cheese cured perfectly if sufficient time were allowed, showing that changes are taking place in the cheese even at temperatures at which bacterial life is practically inactive.

Experiments on the canning of cheese were carried on during the year of 1904-05. It was shown that canned cheese after 90 days curing compared well in quality with paraffined and unparaffined cheese. From the canned cheese there was no loss due to evaporation, while in the case of paraffined and unparaffined cheese losses amounted to 5.5 and 8.6 percent, respectively.

Feeding Studies

Alfalfa hay proved to be the best type of roughage for milk production. This feed combined with a limited amount of grain, (6 pounds per day) was found to be an economical ration for dairy cows, returning a two-dollar value in dairy products for each dollar invested in feed.

Increasing the concentrate portion of the ration was not found to increase the percent of fat in the milk of a cow that was in a normal physical condition. A study of the relative value of the 3 crops of alfalfa hay, as measured by milk production, showed them to be about equal. However, the second crop was less palatable as shown by the reluctance with which cows consumed second-crop hay.

A study was made of the comparative value measured in dairy products, of the soiling system of feeding dairy cows and of pasture feeding. The
results showed that one acre of soiling crops supplied feed for 2 cows for 108 days, produced 3,145 pounds of milk, and 147.9 pounds of butterfat. Two cows fed on 1 acre of pasture for 102 days, and produced 4,047 pounds of milk, and 189.8 pounds of butterfat.

An early study of rations for calves showed that gradual replacement of a large proportion of whole milk with skim milk resulted in satisfactory growth.

Cow-Testing Associations

The first cow-testing association in Utah, which was organized under the leadership of the Agricultural Experiment Station, was operated during the year 1910-11. Results of the testing showed a range in annual butterfat production between the lowest and the highest producers of 40.7 pounds to 324.7 pounds.

Forty-eight of the best cows in the association would be more profitable to a farmer than 189 of the poorest. Other observations on dairy cows suggest that cows freshening during the early winter months produce more milk and butterfat than do those freshening in the spring.
Cows should, on the average, be dry more than one month, but a rest period longer than two months appears to be of no advantage.

Selection of dairy sires upon the basis of their records as breeders is more sure to result in dairy-herd improvement than is selection either by pedigree or by information.

**Dairy Work Expanded**

Although the Dairy Department was organized very soon after the Station was created, its early contributions were restricted because of lack of facilities for large-scale research work in dairy production. Larger and better research programs were begun early in 1924 when a long-time lease on a suitable farm was completed, making possible the systematic study of dairy industry problems pertaining to breeding, feeding (including types of feed to be grown, and proper combination of feeds), housing, costs of production, and use of pasture land.

**Dairy Experimental Farm**

The dairy experimental farm consists of 86 acres of irrigated land with farm buildings and equipment to care for 30 head of milking cows and their offspring.

**Dairy Herd**

The original farm herd of Holstein cattle came from three sources; 14 cows were lent by the Bureau of Dairy Industry, 4 by the Utah Agricultural College, and the remainder, mostly grades, came from the Cache County Herd. In January 1938, the grades were replaced by 17 pure-bred cows from the Bureau of Dairy Industry herd at Huntley, Montana. These cows are the result of from two to four crosses of proved sires which have been used in a breeding project intended to develop dairy cattle pure for a high production of milk and butterfat. In addition to these pure-bred cows, the Bureau of Dairy Industry has furnished the Utah Station with 4 proved herd sires.

**Beet Pulp vs. Corn Silage**

From 1926 to 1929 a study was conducted on the relative value of wet beet pulp and of corn silage in the dairy ration. During the four winters over which the study extended it was observed that cows on the wet beet-pulp ration produced slightly more milk and butterfat than did those on the corn-silage ration. However, the latter exhibited a higher breeding efficiency. Cows on the beet-pulp ration developed weakness in the hind legs which seemed to cause discomfort when the animals moved about. They developed a habit also of licking fences and chewing sticks, which fact suggested possible mineral deficiency thought to be lack of phosphorus.
Home-Grown Rations

Another feeding study had for its objective determination of the relative value, measured by milk production, of three different home-grown rations: (1) alfalfa hay and pasture; (2) alfalfa hay and pasture, plus corn silage; (3) alfalfa hay and pasture, plus chopped barley.

Snow-Fence Silo
Corn silage can be stored successfully in a temporary snow-fence silo.

The highest production of butterfat resulted from ration 3, in which chopped barley was added to alfalfa hay and pasture. Giving this ration a rating of 100, rations 1 and 2 rated 79 and 84 respectively.

Breeding Experience

Experience in breeding has shown that continuous use of proved sires has resulted in an inheritance for high milk and butterfat production.

Pasture Studies

Study of possible pasture improvement through fertilization was started in 1932, in cooperation with the Agronomy and Soils Department. Small strips of irrigated natural-grass pasture were treated with various commercial fertilizers, and with barnyard manure. In all experimental plots an increase in pasture forage resulted, the greatest response following the application of treble superphosphate. In addition to increase in amount of forage produced, chemical analysis showed a significantly higher percentage of phosphorus than was found in forage harvested from plots receiving no phosphorus-
containing fertilizer. Growth of clovers was stimulated to a marked degree by the application of treble superphosphate. As results of these studies, the main pastures at the farm have since been treated with this fertilizer in addition to barnyard manure. This procedure has doubled the carrying capacity of pastures so treated. Studies of pasture fertilization will be continued.

WHEAT CHOPPED COARSE FOR DAIRY COWS
Wheat, when low in price, is an excellent feed for dairy cows. This cow, in addition to a liberal allowance of alfalfa hay and pasture, consumed 2,892 pounds of chopped wheat and produced 14,039 pounds of milk containing 429 pounds of butterfat in a lactation period of 343 days.

Disease Control

From the time the dairy herd was assembled its maintenance proved difficult because of the frequency with which abortions occurred due to the prevalence of Bang's disease. In 1930 the affected animals were detected through cooperation with the veterinary division of the college, and eliminated from the herd. The result has been an improvement in breeding efficiency and in the production of milk and butterfat, due to more nearly normal gestation periods.

Cooperation of the veterinary division has been secured in a study of procedures intended to free the dairy herd of mastitis, which is recognized as one of the great barriers to profitable dairy production, and in certain instances, is a menace to public health.
The first research work in poultry husbandry at the Station was started in November 1896. It was declared by the director of the projects to be the first research work on poultry set up in any state experiment station.

Objectives of Early Studies

Although facilities for research were meager, the scope of the early studies was extensive. This fact is illustrated by the multiplicity of objectives listed for study involving a flock of only 37 chickens. As possible factors affecting egg production it was proposed to investigate the relative value of old hens and pullets; of early-hatched and of late-hatched pullets; the relative value of different breeds; the effect of cross breeding; the effect of exercise.

Cost studies were to include investigation of yearly cost of feed per hen, and feed cost of eggs per dozen. Other objectives included average yearly egg production per hen, relative weight of eggs as affected by breed; relative fertility of fresh and of old eggs; the effect of different treatments on egg fertility and finally, the merits of various incubators.

Some of the results of this study indicate that at the prices of feeds and eggs prevailing at the time, there was little profit in keeping hens 3 and 4 years old; the profit from pullets hatched in April was one and one-half times greater than that from pullets hatched in May; exercise, that is, scratching for grain in a litter of straw, resulted in the production of 26 eggs per fowl more than when hens were given their feed in troughs. No advantage was discovered in crossing Leghorn chickens with Brahmas.

Incubation Studies Extended

During the ensuing ten years, studies of incubation problems were continued and extended, the main object being the investigation of factors causing the death of chicks in the shell, and the failure of fully developed chicks to hatch. It was generally believed at the time that chicks became so weakened by impure air in the incubator that they were unable to break the shells. This theory was exploded by the discovery, made through chemical analysis of air drawn from incubators at various times and from under setting hens, that the incubator air had a much lower carbon dioxide content than did that surrounding the eggs under a setting hen. A series of experiments followed this discovery in which the incubator atmosphere was modified by addition of various quantities of carbon dioxide. The data from these studies indicated that this procedure has an injurious effect upon artificial incubation. Further modification of the atmosphere within the incubator led to the conclusion that development of chicks could not take place without proper conditions of humidity. It was observed further that addition of moisture to the air in the incubator together with proper ventilation reduced loss in weight of eggs during incubation and increased hatchability. Subsequent investigations substantiated these conclusions.
Incubator Types

During the succeeding period 1908-12 poultry investigations centered around the development of a large cabinet type of incubator. By means of electric fans a uniform temperature was maintained by a forced rapid circulation of air through the cabinet. Ten years elapsed after this experiment before the cabinet type of incubator, with forced circulation, came into use commercially but it has now (1938) replaced almost entirely all other types in commercial hatcheries.

Egg Production and Flock Selection

Studies of factors affecting egg production extending over a period of years (1910-17) resulted in the following conclusions:

(1) Egg production of unselected white Leghorns was influenced from year to year by environment, but averaged about 130 eggs per hen the first year, 120 for the second, and 110 for the third.

(2) The average egg production of white Leghorns was found to be decidedly above the average of the general purpose breeds.

(3) Selection of high layers in a flock having a high production for their first year resulted in material improvement of the later production of the flock.

(4) Environmental factors influenced egg records more in the pullet year than later.

(5) Low-producing flocks were influenced more by environmental factors than were high-producing flocks.

(6) Low producers fell off in the latter part of the season faster than did high producers.

Winter egg production varied more than did annual production. Environment was an influencing factor.

(7) Late maturing pullets were always among the poorer producers.

These observations and others made possible by individual trap-nest records undoubtedly led to present practices of "culling" or "flock selection" for egg production, and for the selection of hens for breeder flocks for hatcheries in the National Poultry Improvement Plan.

S. C. WHITE LEGHORN HEN
This hen just completed her fourth year of production with a total record of 886 eggs.
Breeding Studies

Experimental work on breeding has continued to the present time (1938). The average first-year egg production of S. C. White Leghorns in the Station flock is now well over 200. Size of egg and weight of bird have been given special consideration in the selection of breeders, resulting in an average egg-weight increase of 2.6 ounces per dozen eggs, and an average increase in weight of hens amounting to approximately one-half pound.

Egg-Laying Contests

A series of egg-laying contests were conducted at the Station over a period of seven years. The purposes were to stimulate interest in breeding better poultry in the state; to give the beginning poultry raiser an opportunity to secure individual egg records on his pullets, and to check their producing ability with that of other pullets under the same conditions of management. The average yearly production for Utah birds was 202 eggs, while the average for all birds entered in the contest was 204.4 eggs. The records of this series of contests showed conclusively that the spring peak in egg production, as well as the fall period of low production, can be leveled out by proper breeding, good feeding, and management.

Feeding Studies

A series of poultry-feeding studies started in 1920 have resulted in some valuable information for poultry raisers. Some of the findings are enumerated as follows:

Protein.—Inclusion in the laying mash of approximately 20 percent of good meat meal and dried milk increased the egg production for the year by about six times over rations containing no animal protein. Milk in liquid form was equally effective. Five percent dried milk and 15 percent meat meal in the mash were as effective as when larger proportions of dried milk replaced proportionate amounts of meat meal.

Calcium.—Natural deposits of limestone, providing there was little or no magnesium present, could replace grit and as sources of calcium the more expensive oyster shell which poultry raisers had been purchasing at a cost of $1.50 to $2.50 per hundred weight. Measured in terms of number of eggs produced, whiteness and breaking strength of shell, as well as in percentage of mortality, these limestones proved to be as effective as were oyster shells.

Since these studies were made, two large plants and several small ones in Utah have been crushing, grading, and marketing limestone for the poultry industry.

Attempts to replace limestone with granite as grit were unsuccessful, resulting in a reduction of 18 percent in egg production, and a three-fold increase in mortality.

Grain.—Barley, supplemented with 5 to 10 percent of good alfalfa meal, was found to be equal to yellow corn in the starting, the growing, or the laying ration of Leghorn chickens. Measured by egg production, soft white spring
wheat and hard red fall wheat appeared equally effective as part of the ration for Leghorn hens.

Coarse and medium coarse grinding of grain gave marked decrease in mortality, and slight increase in egg production over finer grinds.

A RANDOM SAMPLE OF DRESSED TURKEYS FROM THE LOW PROTEIN (17 TO 20%) BARLEY AND WHEAT RATION AND FROM THE HIGH PROTEIN (25 to 28%) CORN AND WHEAT RATION

These carcasses represented the average of the better and poorer individuals in each pen. There was no apparent advantage in finish as evidenced by fleshing, fatness, or pinfeather condition of the birds produced on these two rations, while feed cost and mortality were higher for the birds fed the high protein ration.
Turkey Feeding

In 1935 turkey-feeding studies were initiated to test the validity of the current belief that turkeys required a relatively expensive, high-protein diet (25 to 35 percent) and that corn was an essential part of the grain and mash mixture fed to turkeys. Data obtained over a period of three years show quite conclusively that a high protein diet gives no better results either in weight or finish of turkeys up to 29 weeks of age than does a lower protein (17 to 20 percent) diet. A marked increase in mortality resulted from the higher protein feeding. The study showed also that barley is equal in every way to yellow corn in the starting, growing or finishing ration of turkeys.

Sheep Studies

Feeding and Fattening Lambs

Various investigations for the establishment of desirable practices in the feeding and fattening of lambs have been conducted at the Station. A very early study on the relation of shelter and temperature to growth of sheep and to their food consumption showed that sheltered lambs made greater weight gains with less feed than did those held in the open corral.

Experiments in which range lambs were fed surplus farm products and by-products of sugar factories resulted in fair weight gains at low cost. Barley and alfalfa constitute an excellent basal ration for fattening lambs; however, supplemental feeds increased gains and reduced costs.

For lamb-fattening purposes no significant differences were noted in the feeding value of any of the three cuttings of alfalfa which were grown under comparable conditions and cut at the same stage of maturity. The finer stemmed, more leafy crops, however, gave best results.

Ground barley showed a lower feeding value than did whole barley. Replacing barley in the basal ration, the following relative fattening values were found: rating corn, which was found to have the highest value, as 100, wheat had a relative value of 88.4, and barley 84.4.

The addition of cotton-seed meal to a barley-alfalfa ration increased gain and finish, thereby enhancing the selling price of the lambs. Gains made by the wrinkly lambs were equal to those made by the so-called smooth-bodied Rambouillet lambs.

Range Forage and Feeding

Because of the general practice in Utah of grazing sheep throughout the year, the nutritive value of range-forage plants and the desirability of supplementary feeding are important to sheep operators. To determine whether it would be advantageous to supplement range feeding, an experiment was set up in the Trout Creek area of Juab County. Three bands of 120 sheep were each weighed and tagged. Supplementing the usual range forage, one band received shelled corn, a second received an equivalent amount of cotton-seed
cake, and a third band was wintered with no supplement. Results of the study showed that range sheep receiving adequate range forage do not require supplementary feeding.

Analysis of 16 dominant range plants in the region showed a fairly satisfactory nutritive ratio, with a tendency toward an unbalanced mineral content due to low phosphorus.

**Economic Aspects**

Because of the importance of sheep ranching in Utah, a study was initiated for the purpose of investigating management practices, economic status, and outlook of typical sheep ranches in the state. Information was obtained by means of personal interviews with 54 ranch operators, who owned about 5 percent of the sheep in the state. Size of ranch was measured by its number of breeding ewes. Some of the findings of the study follow:

As the size of the ranch increased:

1. The area of owned land increased (however, the highest percentage investment in land was found in the smaller ranches where sheep were run in connection with irrigated land of high value).
2. The percentage of investment in improvements, equipment, and other livestock decreased.
3. Paid labor increased.
4. Total ranch receipts increased.
5. Profits were found to increase as proportion of investment in sheep increased.
6. A large investment in land tended to decrease profits.

A comparison of two ranches with equal numbers of sheep showed a larger net income from fine-wool sheep than from those cross-bred.
Feeding Farm Ewes

To relieve overcrowded winter ranges, a practice was established in Utah of feeding ewes intended for summer market and for lamb production on the farm. In this way many permanent farm flocks were established.

Wool from range sheep brought higher prices than did the wool from farm ewes. In response to requests from operators of both farm and range herds, a comparative study of quality of wool from both types of herds was undertaken. Some of the findings are here enumerated:

1. Farm-fed ewes produced on the average heavier grease-weight fleeces than did range-fed ewes.
2. The shrinkage of range fleeces was appreciably greater.
3. Length of staple appeared to be slightly greater for farm-fed ewes.
With the intensification of agriculture in Utah, plant diseases have rapidly increased in number and in severity. They now constitute one of the major sources of economic waste in crop production. Fire blight is a serious menace in pear production. The sugar-beet industry is slowly recovering from the scourge of curly-top. The tomato, an important cash crop, is at present threatened by disease. Each year the farmers of this state suffer losses totaling 1 to 2 million dollars from bacterial wilt of alfalfa. These are only examples of the 250 plant diseases attacking the major agricultural crops of Utah.

The effectiveness of the work of the Botany and Plant Pathology Department has been greatly increased by cooperation with the United States Department of Agriculture.

Psyllid Yellows of Potatoes

In 1927, Utah potato fields were swept by a disease unknown to the farmer or to science. In rate of spread and degree of destructiveness, the disease has scarcely a parallel in the history of agriculture. In one year it extended itself from Arizona on the south to central Idaho and Montana on the north, covering the states of Utah, Colorado, Arizona, Nevada, and California. The early potato crop in Utah was practically a failure. In the late crop the decrease in yield amounted to 25 percent and the potatoes that were harvested were reduced in market value.

This disease has persisted in its severity in local areas and is especially severe in certain parts of Colorado, Arizona, and California. In 1927, the year of its sudden appearance, the Department of Botany and Plant Pathology discovered that this dreaded disease was caused by the injection into the potato of a toxic substance by a minute insect (the tomato psyllid) while feeding on the plant.

Subsequent studies have further clarified the nature of this disease in connection with the insect causing it. Such facts have provided the basis for perfecting effective control measures, the details of which have been worked out by other agencies.

Virus Diseases of the Potato

It was definitely known more than twenty-five years ago that potatoes shipped in and grown under Utah conditions would completely “run out” in three years and become worthless for seed. Potato growers were forced, therefore, to procure their seed annually from outside districts if a good yield were to be maintained. A possible answer to this perplexing problem appeared in the discovery of virus diseases in potatoes about 1915. Since that time the major virus and virus-like diseases of the potato have been differentiated and described for Utah and effective control measures perfected.
PSYLLID YELLOWS OF THE POTATO

Potato stem showing late stage in the development of the psyllid yellows disease. When plants are fed upon by the insect which causes the disease the buds in the axis of the leaves commence growth and produce aerial potatoes. Underground the same response results in numerous "little" potatoes and germination and growth of the older tubers. The solons frequently do not terminate in tubes but continue growth, thereby producing a daughter plant directly. Such effects may result in a second crop. Under severe disease conditions the crop may be an entire failure.
All these diseases spread rapidly in the field, are transmitted through the tuber from generation to generation, and become accumulative in the seed stock and thus caused the "running out," so named before the recognition of the true cause. Utah loses on the average of 21 percent of its potato crop annually through disease, and virus diseases are by far the greatest contributors to this loss.

The cooperative research work has shown that effective seed stock can be maintained and good crops produced if clean seed is planted in seed plots critically selected and isolated, and if in these plots the various diseases are recognized and removed or rogued at a period sufficiently early to prevent field spread. With proper attention given to these factors Utah can produce her own seed potatoes and greatly increase the average state yield.

Tomato Diseases

Research work on tomato diseases in Utah was initiated in 1923, because of the increasing importance of several tomato diseases—fusarium wilt, western yellow blight and mosaic. The work was directed along 4 major lines—survey of tomato diseases, variety tests, selection for resistance, and differentiation of the diseases and their causal agents. Considerable data of value, especially with respect to desirable varieties to use in combating the tomato wilt, were accumulated. In the meantime, the discovery of Verticillium wilt, the spread of bacterial canker, and the establishment of the connection between western yellow blight of tomato and curly top of sugar beets had multiplied the disease problems of the tomato.

Through the effective cooperation of the Agricultural Experiment Station, the College administration, and the canners of the state, a direct Congressional appropriation of $20,000 was made for work on the curly top problem. On July 1, 1931, a cooperative agreement among the Bureau of Plant Industry, Division of Horticultural Crops and Diseases, of the United States Department of Agriculture and the Agricultural Experiment Station made possible a considerable expansion of the tomato-disease program. Investigations on certain biochemical phases of curly top were also made possible by the new agreement.

The investigation of bacterial canker was intensified and in 1934 an important contribution to the control of the disease was announced. By a fermentation process of seed extraction, coupled with strict sanitary methods in the production and handling of young tomato plants, it was found possible to eliminate bacterial canker almost completely.

The work on tomato curly top expanded rapidly. Experimental plots were established at Hurricane, where varietal trials and selection for resistance could be projected on a large scale and under conditions of severe infestation with the curly top vector. As a result of these trials a few promising strains have been developed, though nothing showing complete resistance. Since some of the wild types seemed to be somewhat resistant to curly top a search for additional material was thought desirable. Accordingly, a member of the staff spent the winter of 1937-38 in an intensive hunt for native tomato plants.
along the west coast of South America. From the material thus obtained it is hoped a strain of tomatoes having resistance to curly top and possessing desirable commercial qualities may eventually be developed.

![Bacterial Canker in a Tomato Field in Utah County](image)

**BACTERIAL CANKER IN A TOMATO FIELD IN UTAH COUNTY**
Such destruction might have been prevented by application of recently recommended control measures.

**Research Activities Continued**

The following lines of research are being carried on at present:

1. Resistance studies on curly top of tomato. Attention is also being given to the development of means for reducing losses by the disease.
2. Curly top of bean. Strains of beans resistant to curly top and having characteristics required by the market are being sought.
3. Resistance studies on Verticillium wilt of tomato. The purpose of these studies is to develop, if possible, strains of commercial tomatoes having resistance to wilt.
4. Bacterial canker of tomato. Studies are being directed toward an improvement in methods of seed treatment and sanitation which may bring this disease still further under control. Resistance is being sought and attempts made to determine the host range of the causal organism.
5. Tomato mosaic studies. It is hoped to develop means by which the losses from mosaic may be reduced.

**Sugar-Beet Diseases**

Utah farmers suffer heavy annual losses from various root rot and seedling diseases of the sugar beet. In recognition of this fact a project was outlined on sugar-beet diseases in 1921 and has continued since 1925 in cooperation with the United States Department of Agriculture.
The early research work resulted in a segregation and definition of several serious disease problems of the sugar beet, most prominent of which are the late blight, wet-root rot, dry-rot canker, and black root of seedlings.

Studies have shown that late blight is induced during years of low rainfall on soil lacking in fertility particularly in phosphorus. This can be prevented in part by proper fertilization and cultivation of the soil.

Wet-root-rot research, particularly that conducted in cooperation with the United States Department of Agriculture, has also shown that the wet-root rot of sugar beets is induced by a fungus *Phytophthora drechsleri*, and occurs in severe form only in water-logged soils or where water is allowed to pond in low places in the field. The studies further show that with intelligent selection of soils and proper distribution and use of irrigation water, this disease can be effectively controlled.

**DRY ROT CANKER**
Sugar beets showing various stages of dry rot caused by *Rhizoctonia solani*. This serious disease can be controlled only by crop rotation. Potatoes should not follow beets in infected fields as the same fungus produces disease on both crops.

Dry-rot canker, the nature and cause of which was discovered by the Utah Station workers has been described. For this there appears no definite control except a proper rotation of crops.
Bacterial Wilt of Alfalfa

In 1925, Utah grew 1,528,000 tons of alfalfa on 588,000 acres. In 1932 the same acreage produced 1,176,000 tons, or 352,000 tons less than in 1925. At $7 per ton this decrease represents a loss of approximately $2,464,000. Since 1925 the acreage has increased in the state by 98,000 acres, yet with this increased acreage, the total yield for 1932 was below that of 1925 by upwards of 90,000 tons. Drought, decreased soil fertility, and possibly other factors have functioned in this loss, yet it is significant that this progressively decreasing yield is coincident with the development and spread of bacterial wilt in Utah. Surveys and field studies are conclusive in showing that this disease is a major factor in this decrease.

Since 1931, studies have been organized in cooperation with the Department of Agronomy and Soils with the purpose of understanding more definitely the factors influencing the severity, the length of time a stand might be maintained in various parts of the state, the relation of the disease to crop rotation systems, and finally to discover resistant strains of plants from which resistant varieties might be developed. Some sixty strains, both of local origin and introduced, and numerous selections have been tested. As a result of these studies, some practical results worthy of the growers attention are:

1. The dry farmer need not fear bacterial wilt, and in irrigated areas, where rotation can be reduced to 3 years, common varieties can be grown with little loss.

2. In areas where diversification of crops does not permit such a rotation a resistant variety of Turkestan may soon be increased in yield to meet the needs.

3. Resistance and quality have been found to justify the hope that the disease will ultimately be brought under effective control or reduced to a degree of minor importance in crop production.

Strawberry Root Rot

A survey of farms in the principle strawberry-growing areas in Utah shows clearly that the root rot of this plant has become a limiting factor in production. Many growers in the state have been forced out of the business.

Research work on this project, begun in 1934, has already shown that the trouble is a complex of root rots caused by a number of organisms and possibly intensified by various factors in the soil, such as water content and soil fertility. Three specific organisms have been isolated which are capable of destroying strawberry roots, and 2 obligate parasites incapable of destroying strawberry roots and 2 obligate parasites incapable of growing in pure culture, are found constantly in the tissue of the roots in quantities which greatly damage the plant. Solution of the problem is not immediate, although work is being pushed toward a better understanding of the various factors influencing severity, and toward the development of varieties resistant to the disease.
Chlorosis

In 1928, investigation of the cause and nature of chlorosis was started. An extensive series of experiments on the treatment of the disease by application of minerals directly to the plant soon demonstrated that chlorosis in Utah is an iron deficiency disease induced largely by high lime content of soils.

EFFECT OF INJECTION OF IRON ON CHLOROSIS IN PEACH

The tree illustrated here was uniformly yellow (chlorotic) in the spring of 1931. At that time powdered iron phosphate was introduced into a small hole bored into the branch on the left side of the tree. When this photograph was taken in midsummer the treated branch showed almost complete recovery from chlorosis, while the branch on the right remained severely chlorotic. The injected iron was carried up to the leaves resulting in the production of new green color. Similar results have been obtained with apples, pears, apricots, grapes and many ornamental shade trees.

Attempts to control the disease by soil treatments have thus far proved unsuccessful, but attention is still being given to this phase of the work.

While the results of the injection experiments seem to point definitely to an iron deficiency as the cause of chlorosis, chemical studies of normal and chlorotic tissue do not reveal the expected differences in iron content. Differences in other mineral constituents, however, particularly potassium and calcium, do occur, and the solution of the problem may involve a proper mineral balance of elements other than iron. Moreover, the mobility of iron in the plant may be as important a factor in production of chlorosis as its
entrance into the root. These aspects of the problem require further study before the causes of chlorosis can be fully explained.

Other promising studies are concerned with the search for varieties resistant to chlorosis. Already it has been possible to produce green Concord grapes by drafting onto vinifera, whereas Concord rooted on its own stocks and roots is chlorotic in the same test soil. Similarly favorable stock for some of the fruit trees may be found by trial in soils known to be chlorotic.
CHEMISTRY AND BACTERIOLOGY

Chemistry

Without the aid of chemistry, the dynamic changes in soil, the growth of plants, the soil-plant relationships, the feeding and nutrition of animals, and many other similar problems would still remain unsolved. With the appreciation that the agricultural problems of Utah could not be intelligently solved and understood without the aid of this science, a chemist was appointed as a member of the first Station staff.

The department has not only worked on problems logically belonging to it, but has cooperated with almost every other division of the Station in providing a service essential to working out various details of projects where chemistry was involved.

Forage Crop Studies

With approximately 85 percent of Utah’s land surface usable only for range purposes, and with a limited supply of forage to supplement grazing, it is natural that the Station should attempt to solve certain of the problems connected with the efficient utilization of range forage and livestock feeds. In this work, chemists have made numerous tests on variation of nutritive plant elements and cooperative studies in feeding trials. A study of alfalfa, the chief forage crop of Utah, shows the following results:

1. Leaves make up only one-fourth the dry matter of the plant but contain three times as much protein as the stems.
2. Protein content of the plant increases up to the first week of full bloom, then decreases.
3. Digestibility of the crop, particularly the proteins and fats, decreases as plants pass bloom stage and become more mature.
4. Greatest gain of dry matter occurs between bud and medium bloom.
5. Alfalfa leaves as compared to stems are much richer in protein and fat.
6. Considering protein, alfalfa should not be cut before early bloom and not later than full bloom.
7. Alfalfa does not lose any beef-producing properties as plants pass from bud stage to full flower.

Perhaps one of the most fundamental projects attempted by the Division of Chemistry was the recent cooperative experiment on the sufficiency of desert forage for sheep, reported under the Animal Husbandry section. Chemical analyses showed that the several species of desert forage differ widely in the various nutritive elements and also showed marked variations within the same species at different seasons of the year.

In a cooperative study of phosphorus deficiency it was found that the addition of steamed bone meal, cotton seed cake, or mill-run bran eliminated pica, improved the appetite, increased gains in steers and reduced feed costs.
Water Studies

During the early years of the Station a stream survey of Utah was made to determine the amount of salts carried in solution. The following results represent an average composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Amount (ppm by weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime</td>
<td>73.08</td>
</tr>
<tr>
<td>Potassium</td>
<td>3.89</td>
</tr>
<tr>
<td>Magnesium</td>
<td>17.65</td>
</tr>
<tr>
<td>Chlorine</td>
<td>5.70</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.11</td>
</tr>
</tbody>
</table>

In connection with nitrogen it was found that each acre-foot of irrigation water added amounts of this important element to the soil ranging from a trace up to 66 pounds per acre-foot of water. On the average, 11.4 pounds of nitrogen were added to the soil for each acre-foot of water used.

In the survey 58 streams, the water of which was used mostly for irrigation, were studied. The soluble salts ranged from 84 to 1,250 ppm. In most cases streams at the source were ideal for irrigation but through drainage some carried large amounts of salt at the mouth.

It was advised to flush lands in the spring with high water which was much lower in salt content in order to wash alkali out of the soil surface. Water containing 500 ppm. sodium carbonate, 1,000 ppm. of sodium chloride, and 4,000 ppm. sodium sulfate proved very harmful to crops after two to three years. It was found that soils treated with sodium carbonate leached very slowly and developed poor physical condition. Sodium chloride treated soils leached more readily but still slowly. More rapid leaching was observed with sodium sulfate.

Chemical Content of Irrigation Water

A study of the irrigation streams of the state clearly show that the influence of water upon the soil may be fourfold: (1) It may increase or decrease the available plant food of the soil without changing the total quantity of plant food; (2) It may carry plant food from a soil, thus leaving it intrinsically less productive; (3) It may carry to a soil small amounts of phosphorus, potassium, and nitrogen, therefore tending to slightly increase its total plant food; and (4) Water may carry to and deposit in a soil "alkali" salts which in time will render it barren. It is, therefore, evident that irrigation water may be used to make the desert blossom like the rose, or it may transform the most productive field into a barren waste. A knowledge of the composition of the irrigation water and the soil, linked with a judicious use of the water, is essential to a continued high state of soil productivity.

Alkali Studies

In a study of the origin of alkali, marked variations were found in amount of salt contained in the rock. The highest concentrations occurred in the shales and sandstones of the Cretaceous and Tertiary formations in Utah.
In certain local areas salts became concentrated by movement of underground water to the surface. In case of shales highly impregnated with salt the movement of water from lower depth to the surface is responsible for the high concentrations. The "niter spots" in eastern Utah were also studied and found to be the direct result of leaching of nitrates out of pre-existing deposits in country rock, mainly cretaceous shales, and concentration by seepage in local areas.

Soil Studies

Considerable work has been done on the chemical analysis of Utah soils. In general the results showed that these soils formed in an arid climate were high in all ash elements but characteristically low in nitrogen. In some cooperative tests it was found that by applying manure in rotations, where alfalfa was a part, the nitrogen could be slightly increased.

In a study of nitrate nitrogen it was found that crops varied considerably in closeness of feeding on nitrates. Nitrates were always found to be low on alfalfa land. In winter, as a result of downward leaching, nitrates moved eight or ten feet below the surface and with heavy applications of irrigation water the nitrates were carried out of the soil in drainage water.

Crop Studies

The chemical composition of various crops as affected by different quantities of irrigation water has been studied.

The following results are for wheat:

<table>
<thead>
<tr>
<th></th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated wheat 25 in. water</td>
<td>12.63</td>
</tr>
<tr>
<td>&quot; &quot; 15 &quot; &quot;</td>
<td>12.92</td>
</tr>
<tr>
<td>&quot; &quot; one irrigation</td>
<td>13.62</td>
</tr>
<tr>
<td>Winter wheat, dry farm</td>
<td>14.64</td>
</tr>
</tbody>
</table>

For corn the results show the same as wheat, a decreased nitrogen content with increased water, but the ash elements for corn increased with heavier applications of water. Oats and barley showed the same relationship.

During the early period of experimental work it was considered that Utah could not produce wheat of a quality to meet the demands of the baking trade. Milling trials and chemical analysis showed that the bad reputation of Utah wheat was due to the growing of inferior varieties. Through cooperative effort this difficulty was corrected. It was also thought that to produce good quality wheat the seed should come from areas outside the state. This impression was likewise corrected by analyses of home-grown seed and comparisons with that introduced.

The Division of Chemistry did considerable work with sugar beets. The yield, sugar content, and percentage purity of the sugar were found to be uniformly high, thus indicating that beets were well adapted to Utah conditions.
Smelter Smoke Research

At a time when there was considerable speculation as to the effect of smelter smoke on crops, a study was made to determine the nature of the damage. It was found that crops differ in degree of sensitivity toward the gas fumes, that injury is limited to areas where the smoke settles, that the smoke does not injure the fertility of the soil, and that the smoke does not materially affect the feeding value of crops.

Miscellaneous Studies

A test on wheat flour showed that highly-milled flour can be stored in dry rooms free from odors for at least four years without suffering deterioration. Poor grades of flour, however, were found to deteriorate more rapidly. Aging in storage tended to increase the water-absorbing qualities of the flour, as well as the soluble carbohydrates. No change in protein content occurred.

In addition to the technical work conducted by the Division of Chemistry, studies were extended into more practical fields. The pioneer investigational dry-land work was under the direct leadership of this department of the Station. Irrigation trials were also conducted in which duty of water, water requirements, and moisture movement were all studied. The most outstanding results coming from this particular work were in the water loss of dry matter study. With an abundant water supply the average of 6 years' results follow:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Water required to produce one pound of dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1,048 pounds</td>
</tr>
<tr>
<td>Corn</td>
<td>589 pounds</td>
</tr>
<tr>
<td>Peas</td>
<td>1,118 pounds</td>
</tr>
<tr>
<td>Sugar beets</td>
<td>630 pounds</td>
</tr>
</tbody>
</table>

The average of all results indicated that under such conditions as obtained at Logan, Utah, the average water loss of dry matter for all crops amounts to 750 pounds. Such conditions as differences in soil type, fertility, and crops were found to influence the amount of water required.

Bacteriology

The activity, number, and species of bacteria in soil as related to such factors as moisture, fertility treatment, and tillage operations have come to be major fields of soil investigations. The availability of the mineral elements of the soil to plants and the availability as well as the accumulation of nitrogen are all more or less dependent on the countless numbers of soil organisms.

Utah Soils Rich in Azotobacter

The first investigational work to be accomplished in the field of soil microbiology was in demonstrating that Utah calcareous soils are rich in
Azotobacter. Later work has shown these organisms to be widely distributed in the first, second, and third foot sections of our arid soils.

A systematic analysis of the dry-farm soils of Utah reveals the fact that the nitrogen fixing powers vary from 0 to 25 pounds per acre, depending upon the treatment received. It has been discovered that the factors which govern the rate of fixation are moisture, aeration, and sufficient organic matter for the necessary energy of the lower forms which take part in the fixation.

**Effect of Legumes and Other Crops on Nitric Nitrogen**

Experiments conducted at the Utah Agricultural Experiment Station during 12 years have demonstrated that even on soils poor in nitrogen, the legume first feeds upon the combined nitrogen of the soil. The plant residues and other complex nitrogen compounds found in the soil are transformed by bacteria into ammonia, and this in turn by other bacteria into nitric nitrogen which is the type of nitrogen upon which most plants feed.

Legumes remove nitric nitrogen from the soil equally as fast as non-legumes. This occurs in spite of the fact that the soil was well inoculated with the symbiotic bacteria, which undoubtedly assists alfalfa in obtaining free nitrogen from the air when needed, but not until the soluble nitrogen had been used up as shown by the fact that alfalfa soil never contains more nitric nitrogen than oat and corn land and is poor as compared with potato and fallow land.

**Maintenance of Soil Nitrogen**

In a study made of the influence of a 7-year rotation consisting of oats, beets, beets, oats, and alfalfa for 3 years on the nitrogen, phosphorus, and organic material on an irrigated silt loam, it was found that oats removed more nitrogen than sugar-beets when the crowns of beets were returned to the soil. When the crowns were also removed, the 2 crops depleted the soil nitrogen to approximately the same extent. Properly inoculated alfalfa feeds first on the combined nitrogen of the soil; when this is insufficient the plants draw on the nitrogen of the air. With rotations in which alfalfa is removed from land, the nitrogen of the soil apparently cannot be maintained. However, as evidenced by experimental results there are 2 practical methods of maintaining this important element. (1) by adoption of a rotation which includes legumes with the legume being plowed under and allowed to decay, thus furnishing nitrogen to the succeeding crops; or (2) by practicing a combined system of crop rotation and livestock farming, the legume being fed to livestock and the manure returned to the soil.

The rotations investigated showed a loss of 83 pounds of nitrogen from each acre to a depth of 3 feet. Thirty-nine pounds of this was removed by beets and oats. The balance was either removed by the alfalfa or leached below the third-foot level by drainage water.

Alfalfa removes twice as much phosphorus from the soil as does either oats or sugarbeets. During the life of this experiment (18 years) analyses
showed that of a loss of 720 pounds of phosphorus from each acre of soil, only 491 pounds were removed by the crops, the balance may have been held in the undecomposed plant residues or was carried below the third-foot level by irrigation water.

Effect of Water on Bacteria of Soil

Water is the limiting factor in crop production in Utah. Optimum moisture, therefore, for maximum crop production is a vital problem. Studies indicate that for bacteria the greatest activity is obtained when the moisture content is maintained between 60 and 70 percent of the water-holding capacity of the soil, and although not absolute it is quite certain that this is not far from the point most favorable for the higher plants.

The intelligent use of water also has another economic phase. When used in excessive amounts, drainage water may at times carry away from the soil as much as 30 pounds of nitrogen to an acre. This only tells part of the story, for excessive irrigation also carries other soluble plant food beyond the feeding range of plant roots.

Soluble Salt and Bacterial Activity

There are millions of acres of land in the arid west which contain varying amounts of soluble salts. Some of these soils contain such large quantities of the so-called "alkalies" that no vegetative growth is possible. Such soils can be reclaimed only by the leaching out of the soluble salts. But actual experience shows that in some soils the salts are very difficult to wash out; hence, we must know more about the underlying processes of leaching. Some of the work now in progress has this goal as its aim.

The results which so far have been obtained show that the toxicity of the alkali salts towards bacteria and probably to the higher plants is due (1) to a physiological effect upon the protoplasm, and (2) an injurious osmotic pressure. Laboratory work indicates that insofar as the bacteria are concerned the first effect can in some cases be mainly overcome by the use of certain salts, thus creating an antagonistic action in the soil. Results have already accumulated sufficient to indicate that alkali salts in some concentrations may injure the plants only indirectly through action on the bacteria. Remove this ill effect and the injury to the higher plants may disappear.

Since one of the main toxic effects of alkali salts to plants is due to osmotic pressure, it is evident that this can be overcome by either of 2 methods: (1) the removal of the salts which produce the osmotic effect, or (2) the formation of complex molecular aggregates which would have a corresponding lower osmotic pressure. It is well-known that organic compounds possess the power of combining with the common alkali salts. The work so far has indicated that the application of 15 tons of barnyard manure to some alkali soils which are partly barren, will produce fair crops.

It has been found, moreover, that many alkali soils are non-productive for a number of years after the soluble salts have been removed. The results indicate that this is due to (1) a poor physical condition, (2) a small quan-
tity of certain available plant-food elements, and (3) the absence of the normal bacterial flora. All 3 of these may be corrected by a liberal use of barnyard manure. Hence, it seems that livestock farming combined with rotation of crops is essential not only for the maintaining of the nitrogen content of the soil but may help in the reclaiming of alkali lands.

It is also quite possible that having learned the action of the various alkali salts upon the bacterial flora of the soil, we may in time come to use bacteria as a measure of the soil's productive power. A close correlation has been found between the soil microflora and the higher flora. Others have found that the Azotobacter can be used as a very sensitive test for available phosphorus. Then why not use the reaction of these organisms as an indicator of the alkali content? Time and systematic work are required to answer this question.
ENTOMOLOGY

With the inception of investigational work at the Utah Agricultural Experiment Station, entomology was considered to be one of the special fields in which research was needed. The first entomological work conducted was the publication of information, largely based upon experimental results and source material obtained elsewhere, which it was thought could be adapted to conditions in Utah and be of practical use to the fruit growers in aiding in the solution of insect-pest problems.

Orchard Insects

One of the first insect pests of orchard fruits to demand the attention of the Station entomologist was the codling moth. In the report for 1893, it was declared that this insect was one of the most troublesome and destructive orchard pests in Utah. It is noteworthy that at this time essential information was provided for growers concerning descriptions of various developmental stages of the codling moth, its biology and methods of control.

In October 1902, an entomologist was appointed to the staff of the Station. Prior to this time the work in horticulture and entomology had been performed by one man. The first concern of the entomologist was the discovery of those lines of entomological investigation that would be of greatest practical service to the farmers of Utah. This concern resulted in the early determination that among the most injurious species of insects then infesting the orchards of the state were the following, named in order of their relative importance: codling moth, tent caterpillar, and San Jose scale.

Codling Moth Studies

The first experiments consisted of tests to determine the relative value of early, late and successive sprayings for the control of the codling moth. In connection with the execution of these experiments a basic study was made in 1903 of the life history and habits of this insect. Results of investigations pointed definitely to the annual occurrence in Utah of 2 broods of codling moths.

Recommendations for Control

The following is a brief summary of recommendations made in 1903 for codling moth prevention and control: (1) The placing of burlap bands on tree trunks and then, at 9-day intervals, destroying all first-brood larvae which cocoon under the bands. Second-brood larvae could all be killed at one time, after the picking season was over. (2) The practice of good orchard husbandry and sanitation including cultivation, pruning, scraping dead bark scales off trees, destruction of wind-fallen fruit, and screening of all buildings where apples and pears were stored. (3) Spraying with an arsenical suspended in water just after the bloom falls and before the calyx cups close and again after 2 weeks. The spray should be rather coarse and driven
with great force into the calyx cups leaving within them a good deposit of the insecticide. This spray program was found to give 90 percent worm-free fruit. (4) Protection and encouragement of natural enemies, particularly birds.

Despite years of world-wide scientific and practical efforts to control the codling moth, this insect still persists as the most serious limiting factor in apple and pear production wherever these fruits are grown. At the present time there is need for further experimental work in this state having for its basic purpose the more effective and economical control of the destructive apple worm.

Other Orchard Insects

Other insect pests of economic importance occurring in Utah orchards which have been investigated by the Department of Entomology during the past decade are the following: fruit-tree leaf roller, pear-leaf blister mite, treehoppers, bud moth and lesser bud moth. At present, research is in progress with respect to the biologies of the green soldier bug and the peach twig borer. Among the most injurious insects, not already mentioned above, which now infest the orchards of Utah, are the green, rosy, and woolly apple aphid, black cherry aphid, black peach aphid, green peach aphid, peach-tree borer, flat-headed and round-headed tree borer, fruit-tree bark beetle, apple leafhopper, brown mite, European red mite, common red spider, pear and cherry slug, San Jose scale, and treehopper.

Forage Crop Insects

The alfalfa weevil was found to be one of the most destructive insect pests of forage crops in the state. The earliest record obtainable of its presence in Utah dates back to the spring of 1904 when it was found for the first time in the United States on a farm on the east side of Salt Lake City. Following the discovery of this serious pest, it was identified, the details of its life history worked out, and methods for its practical control established.

Investigation of the seed chalcid-fly indicated that alfalfa-seed growers of this state during the 10-year period, 1926 to 1935 inclusive, sustained an annual average loss of 13 percent of their crop. Results of investigations for prevention and control of this pest in alfalfa seed indicate the desirability of all growers within a district following a uniform practice with respect to the selections of the crop that is to be left for seed production, whether it be first or second crop. If part of the alfalfa left to produce seed is first crop and part is second crop, a generation of chalcid flies develops in the first-crop seed and upon emergence as adults they either migrate to second-crop alfalfa, or remain in the first crop, where in either event a new brood of "flies" is produced in the newly forming seeds. Seed production from either all first-crop or all second-crop alfalfa in an entire district greatly reduces the chalcid-fly infestation.

Beginning in 1930 and continuing to 1934, entomological investigations of the Station showed that intense populations of Lygus bugs in all alfalfa-
seed fields of the state constituted a serious limiting factor in alfalfa-seed production. A study of the feeding activities of these insects indicated that the vegetative growth of alfalfa was retarded, serious “blasting” of buds induced, and the incidence of flower-drop and shrivelled seed was considerably increased.

The superb plant bug was found to cause similar but more severe damage in alfalfa-seed fields when intensity of infestation was comparable with that of Lygus bugs.

The following insects constitute other pests of forage crops occurring in Utah which might profitably receive some investigation for the development of control measures: aphid, alfalfa caterpillar, blister beetle, clover root borer, leafhopper, Say’s plant bug, thrips, and webworm.

Cereal Crop Insect Studies

Insects of cereal crops have received relatively minor investigation. The wheat jointworm and the wheat strawworm have been given periodic attention with respect to distribution and intensity of infestation. The same is also true regarding the pale western cutworm. Periodic incidence of the latter pest in dry-land grains has been known to entomologists of the Utah Station during the past quarter century. Perhaps the most serious outbreak in this state occurred in Cedar Valley, Utah County, during the early spring of 1934. An investigation of this problem was initiated in the spring of 1936. These studies are still in progress. Cereal crops in Utah are also damaged by aphids, crickets, grasshoppers, Say’s plant bugs, wireworms, and false wireworms.
LYGUS BUG STUDIES, UINTA BASIN ALFALFA-SEED EXPERIMENTAL FARM, 1933

Of all insect inhabitants of alfalfa-seed fields, Lygus bugs were found to be most numerous. For the purpose of ascertaining the effects of their feeding and their life history in alfalfa, investigational work was performed in the field. Rearing cages were necessary so that the intensity of infestation could be controlled and the time required for individual development of various stages in the life history of the insect determined.

**Truck Crop Insects**

The cabbage aphid and flea beetle attacking tomatoes, beans, and potatoes, received attention in the early years of the Station; control recommendations for these being published in 1892. Since that time, other pests of truck and garden crops have been studied. In 1906 attention was called
to the occurrence of large numbers of beet leafhoppers which seriously
damaged sugar-beet fields of Utah in 1905. It was found that punctures of
this insect seem to cause a sort of thickening of the veins of the leaf and an unhealthy condition
called “curly leaf” or “blight.” This pest of beets received attention until 1917 and later from 1923
to the present. Other truck-crop insects which have been studied include the sugar-beet webworm, sugar-beet root maggot, sugar-beet crown borer, sugar-beet root aphid, blister beetle, cutworm, corn earworm, false chinch bug, squash bug, potato tuber moth, Colorado potato beetle, imported cabbage worm, and the potato psyllid. At present the biology and control of the pea aphid on canning peas is being studied, cube and derris, used as dusts and sprays seeming to give promise as control materials. The relationship of local and long-distance movements of the beet leafhopper to “blight” injury in Utah, and possible methods of control are under investigation, together with experiments on tomato-fruitworm control. Natural or synthetic cryolite, diluted with an equal quantity of talc, has given good control results against the tomato fruitworm in recent tests. The tomato-insect work is being done in cooperation with the United States Bureau of Entomology and Plant Quarantine.

Berry Insects

Several pests of berry crops have received attention, including the gooseberry fruitworm, grape leafhopper, strawberry-root weevil, and strawberry-leaf roller. Work now underway concerns the control of the oblique-banded leaf roller as a pest of dewberries, and aphids affecting raspberries, currants, and gooseberries. Early spring pruning, with removal and burning of pruned canes and litter from under bushes usually results in noticeably decreased infestation of dewberry fruits by the oblique-banded leafroller.

Insects Affecting Man and Animals

A serious outbreak of equine encephalomyelitis, resulting in the loss of several hundred horses, led to a study of blood-sucking insects as possible transmitters of this disease. Work carried on in cooperation with the Animal Husbandry Department showed that two local mosquitoes, *Aedes nigromaculatus* and *A. dorsalis*, are capable of transmitting this malady from diseased to healthy guinea pigs under experimental conditions. During the winter of 1933-34 the Station cooperated with the United States Bureau of Entomology and Plant Quarantine in putting 1,019 men to work on the Federal Civic
Works Administration Pest Mosquito Control Project, draining many mosquito-breeding areas near cities and towns. Other studies conducted have dealt with the control of box-elder bugs, house ants, horseflies, mosquitoes, houseflies, black widow spiders, cockroaches and bedbugs.

Grasshoppers and Crickets

Grasshoppers and crickets have been important agricultural pests in Utah since crops were first planted by the pioneers. Grasshopper control has been necessary in parts of the state almost every year, and in nearly all agricultural districts in some years. Agricultural Experiment Station workers have aided the farmers in meeting this serious problem. Station publications have been issued dealing with the ecology and control of grasshoppers and crickets. Beginning in 1934, entomologists of the Station have cooperated with the United States Department of Agriculture in making surveys of the fall abundance of grasshoppers and their eggs, and have acted as control leaders in the Federal-State cooperative program of control. Poisoned bait is the chief method of control employed during recent years.

Since 1934 Mormon crickets have annually increased in several counties of the state inflicting considerable damage to farm crops and range forage, particularly in Juab, Millard, Sanpete, Tooele, and Uintah Counties. The Station has aided in control campaigns against these destructive insects. An investigation of the biology, ecology, habits, and control of the Mormon cricket in Utah is now being made by the Station.
Reptiles

For a number of years the reptiles of Utah were studied as to distribution and food habits. It was found that insectivorous lizards were helpful in reducing insect abundance on range land and helped to reduce beet-leafhopper populations in desert breeding areas.

Insect Collection

The insect collection has been built up primarily from the standpoint of its usefulness. Identified material of injurious and beneficial species is available for ready comparison. Much background information has been secured as to species occurring in Utah, distribution of injurious insects, and occurrence of species which aid in controlling insect and plant pests. Information has also been accumulated as to the seasonal occurrence of many little-known forms. The excellent collections of Orthoptera, and aphids are worthy of note.

Insect Pest Survey

Agricultural Experiment Station entomologists have cooperated with the United States Department of Agriculture publication, Insect Pest Survey, by reporting upon insect outbreaks which have occurred in Utah. Such published data are especially useful to workers needing information as to time and areas affected by various insect outbreaks.
GEOLOGY AND UNDERGROUND WATER

Some underground water for culinary purposes was developed in the State of Utah almost as soon as settlement began. It was soon discovered that artesian water was available, and surface wells were used to supply culinary water in many places.

Water Shortage

The shortage of irrigation water during the period 1912 to 1917 led to development of underground water for irrigation. An ample supply of good water was found in several sections and this stimulated rapid development of underground water without adequate knowledge as to the amounts available, or the dependability of water supplies. Controversies arose in several localities and prompted research in underground-water supplies.

The Problem

The problem to be solved was: What amount of water could safely be developed in any basin for a continuous supply for culinary use, irrigation, watering of stock or for combined uses. Coincident with the need for solving this problem, several wells were dried up by the development of others. This
led to controversy and law suits, and impeded growth. Therefore, for the progress of underground-water development in the state, it was essential to find definitely the available and dependable sources of supplies.

Methods

The methods of attacking the problem were: (1) to determine the static head of flowing wells and the level of the water in wells which were pumped; (2) to keep record in sufficient detail to show whether the effective heads in the underground reservoir were maintained, increased or decreased during the season; (3) to measure all the water taken from wells in a particular basin; (4) to make measurements at frequent intervals to determine the seasonal water yields; and, (5) to determine whether or not the supply was greater at one particular part of the season than at another. A log of wells drilled was recorded and measurements were made to determine the water available from the different water-bearing strata.

Geological Formations

The major area studied was within the limits of old Lake Bonneville, and therefore included in the lake-deposited sands, clays, and gravels. The history of the development of the underground artesian basin was shown to be geologically similar in each locality. Previous to Lake Bonneville, drainages into the basin were established about as at present. The streams flowing from the canyons extended far out into the valleys and much gravel, sand, and coarse debris were deposited along their meandering courses. With the approach of the glacial epoch these streams were swollen and the amounts of water flowing into the basin greatly enlarged. The basin began to fill with water, and the coarse debris in the river was deposited at the edge of the lake as the water rose, which in many cases extended into the canyons. The lake remained long enough to accumulate from 100 to more than 300 feet of sands and clays over the entire lacustrine basin. With the disappearance of the lake, the streams again established drainage in the valley, but the old fans and deltas from the earlier deposition were buried under the Bonneville material. The porous gravels and sands of the earlier period were completely buried with the nearly impervious clays deposited in the lake waters.

Wells bored through these clay and sand deposits and into the old deltas and stream deposition of the earlier period, give the physical condition for the production of artesian water in the larger part of the lake basin. Some valleys had had independent lakes not connected with Lake Bonneville. It was often found that each gravel layer was influenced by different sources of ground water and that the static head and the flow of water from each gravel was different.

Iron County Wells

Many new wells were developed in Iron County. Logs were collected on each of these wells. The static head was not sufficiently high to produce
arterian water, but all water was measured and correlated with the water table, which dropped almost at a constant rate from the time pumping began in the spring until the end of the irrigation period.

**Beaver County Measurements**

Similar measurements were made in Beaver County over a series of years and it was noted that the water table fell approximately 5 feet during the pumping period, and built up 4 feet during the non-pumping period. At the end of 7 years the water table was $8\frac{1}{2}$ feet lower than at the time of beginning, indicating that the water pumped was in excess of the normal annual recharge.

**Millard County Work**

In the Flowell district of Millard County, where 80 wells yielded an artesian flow, the water was of an especially good quality and flowed freely.

![Typical Millard County Artesian Well](Typical%20Millard%20County%20Artesian%20Well.png)

As much as 7 second-feet flowed from 1 eight-inch diameter well. These wells afforded such splendid irrigation supply that the promoters resented the suggestion that the supply had any limit. In 3 years the static head dropped from 70 feet to 14 feet, and men were convinced they should close their wells during the non-irrigation period. When the wells were opened in the spring, the total flow measured as high as 55 second-feet from an area of scarcely 4 square miles. This flow was reduced approximately 50 per-
cent during the irrigation season. By actual measurement the effective head in the south part of the Flowell basin dropped 56 feet and many wells have ceased flowing. The water is now being handled carefully as a result of the investigational work.

Work in Other Localities

The low seasonal water supply showed the static head in parts of Cache County to go down 15 feet in a single year, and still much persuasion was necessary to get users to close their wells during the winter.

Recharge of underground water supply was tried in 2 localities. At Brigham City, the effective water level was raised 18 feet by digging holes through the impervious clay and allowing 5 second-feet of water to run into the ground for a period of 200 days.

The work was also extended to include direct assistance in the development of stock water and culinary-water supply over a period of years. The work on underground water resulted in legislation which is now giving effective protection to underground water. The owners of present underground-water rights in the state make a dependable and economic use of more than 80,000 acre-feet annually. Large new developments may yet be made.
HOME ECONOMICS

From its beginning the investigational work of the Agricultural Experiment Station has influenced, directly or indirectly, family living in the farm homes of the state. Improved practices in cultivation, efficient use of irrigation water, the building up of high class dairy herds and poultry flocks, have not only augmented the family income, but have contributed directly to the family food supply. Horticultural investigations have resulted not only in better fruits for market, but also in better nutritional opportunities for the farm family. Larger yields and better crops of all kinds for sale made possible better housing, extension of electrical facilities, accompanied by acquirement of electric washers and of other labor-saving equipment in many farm homes. And increasingly large numbers of farm boys and girls have been able to go away for college educations.

It was not until 1925, however, that government aid was made available for investigation of farm-home living. In this year the passing of the Purnell Act, which includes provision for research in Home Economics, was a recognition of the need for greater understanding of the manner in which farm-home living was keeping pace with other phases of farm activities. Although the amount of money allocated to home economics research has been relatively small, and facilities for pursuing research somewhat meager, progress has been made.

Immediately after funds became available for home studies, two lines of investigation were begun, one concerned with clothing problems, and the other with problems of family nutrition in farm homes.

Clothing Investigations

Investigations of the degree to which ultraviolet rays penetrate various clothing materials were begun at the Station in 1926. This problem is of particular interest in this region of bright sunlight, since ultraviolet radiations constitute that part of sunlight which prevents development of bowlegs and knock-knees (rickets) in children and it is important to know the type of fabric which will allow maximum penetration of these rays.

Results of the investigation showed that kind of fiber, looseness of weave, and weight of fabric all influenced the penetrability of ultraviolet rays. The fabrics which were tested are listed below in the order of their capacity to transmit the rays:

(1) Rayon, light weight, loosely woven.
(2) Rayon, heavier weight, more closely woven.
(3) Cotton, light weight and loosely woven.
(4) Rayon and wool combinations.
(5) Cotton and wool combinations.

Heavy, closely-woven cotton, silk, and wool fabrics allowed very little if any of the ultraviolet radiation to penetrate. It would appear, therefore,
that light weight, loosely woven rayon is the most desirable fabric for making children’s summer clothing, with loosely woven cotton as second choice. One of the inferences which may be drawn from this study is that the starching of children’s clothing is not a desirable practice since it tends to close the spaces between threads in the weave, thus shutting out ultraviolet rays.

**Family Food Studies**

A series of investigations involving the problems of farm family nutrition, which were inaugurated in 1926, are still in progress.

A study of farm family food practices conducted in 7 counties and continuing over a period of a year showed, among other things, the following conditions:

1. Of those foods that can be supplied by the farm an average of only seven-tenths were so furnished.
2. Lack of an adequate supply of irrigation water appeared to be the limiting factor in producing vegetables and fruits for home use.
3. Use of fruits and vegetables was below standard requirements established by nutrition specialists. This led to the assumption that the average farm home diet may be deficient in vitamins and minerals, particularly in iron.

Analysis of approximately one thousand dietaries of rural school children strengthened the assumption of low iron and vitamin content of farm family diet, as did also a study of number and variety of pot herbs used in Utah farm homes. Bioassay of a synthetic diet patterned, according to varieties and quantities, upon the average school child’s diet indicated low intake of all vitamins, more particularly of vitamin C.

Following up the possibility of vitamin-C deficiency, 250 grade school children were given capillary resistance tests to determine whether a deficiency existed great enough to affect the strength of the blood vessels. Few cases of drastic deficiency were encountered, though indications of mild deficiency were frequently found. Children tested in the fall and again in the spring showed at the second test a tendency to greater capillary fragility, suggesting a diet less rich in vitamin-C-containing foods during the winter. Dietary records supplied by the children bore out this suggestion.

Study of factors in the history of 2 groups of children, 1 classed as healthy on the basis of examination by a physician, the other as less healthy, indicated that in addition to quality of nutrition, health of children is probably affected by such factors as diet of mother during pregnancy, breast feeding, communicable diseases experienced in early childhood, and emotional atmosphere in the home.

A survey of heights and weights of 12,193 rural children, and 13,871 children in Utah cities of 10,000 or more population, showed a decided tendency for city children to be taller than rural children, and to weigh more for height and age. Measurements of musculature, subcutaneous tissue, and weight are now (1937-38) being made on groups of rural and city children in an effort to learn whether the differences in size can be attributed to differences in nutrition.
Other work now in progress (1938) includes a study by chemical procedures of the relationship between intake and urinary output of vitamin C (ascorbic acid). The object of the study is an investigation of human needs for vitamin C, together with a study of factors influencing those needs.

Investigation of vitamin-C content of common foods is also going forward by chemical procedures, and will be supplemented by bioassays as soon as laboratory facilities permit.

The canning properties of various fruits under test on College farms are being studied in cooperation with the Department of Horticulture. This work will probably be enlarged and extended as will the work in connection with vitamin-C content of foods.

**Human Nutrition**

Early in the history of the Agricultural Experiment Station, the role of proper feeding in the production of fine livestock was recognized. Numerous animal-feeding experiments were set up which resulted in the adoption by stock feeders of improved feeding practices. Later it was realized that nutrition of man might be bound up with his growth, state of health, and general well-being. Accordingly, in 1919, a project was established for the investigation of such problems.

An inquiry concerning the value of the height-weight-age relationship as an indication of nutritional status was included in the early studies. An investigation of growth phenomena in relation to quality of nutrition was also initiated. However, from the beginning, the main work was directed toward the development of a test for determining suitability of milks from various sources for use of infants and invalids. Great variability was found in toughness or hardness of curd from different cows. An achievement of the Station was the development of a "curd-o-meter" for measuring the degree of curd hardness.

A direct relationship was established between softness of curd and digestibility of milk. As a result of this work it is now possible to obtain the more easily digestible soft-curd milk in cities throughout the country for use of babies and invalids. Efforts to determine cause showed softness of curd to be associated with (1) low casein content, (2) low fat content, and (3) low total solids. Research at the Station corroborated by work done elsewhere, shows that sub-clinical mastitis is often associated with soft-curd milk. However, soft-curd milk may be produced from cows entirely free from subclinical mastitis. This study is still in progress.

In cooperation with the Dairy Department a test of the cheese-making properties of soft-curd milk was made. A soft-bodied, quick-ripening cheese resulted from use of such milk. This work is being continued.
HORTICULTURE

Horticulture in Utah developed from a need of fruits and vegetables by a people who had established settlement a thousand miles or more from areas of diversified production. Fortunately the climate, soil, and supply of water for irrigation, were all well adapted to high yields of good quality fruits. With such favorable natural conditions it is not surprising that by 1890, fruits as well as vegetables were grown in every settled valley of the state. Finding the most adaptable varieties, the best methods of irrigation, control of pests, and solving many other problems, however, were the cause of considerable concern to those interested in the industry. Thus the appointment of a horticulturist as a member of the first Station staff was a natural consequence of a vital need to establish fruit and vegetable growing in this state on a more secure basis.

Vegetable Crops

Although there were some vegetable varietal tests conducted during the early years of the Station, almost all of the vegetable studies have been carried on since the establishment of the Farmington farm in 1920 with the exception of a study of tomato varieties about 1917. The vegetable research thus far conducted involves studies of tomatoes, onions, celery, and numerous preliminary studies of a minor nature.

Tomatoes

The first studies made with tomatoes consisted of a varietal test in which observations were made on a few plants of all varieties obtainable. These trials, which confirmed the value of most of the varieties then in use as either market garden or canning varieties, were closed in 1924 and a new series involving only varieties of canning tomatoes was started in 1925. During the period of 1925 to 1929 approximately 600 individual plant and mass selections were made in an attempt to develop improved strains. Between 1931 and the present (1938) many of these strains have been tested. As a result of these tests the Station now possesses promising new strains of Livingston Stone and Stone tomatoes. Variety no. 316 is outstanding as a canning tomato. Several selections from Livingston Stone show good yield and fine quality but are not ready for distribution.

Plant Growing

Because of the large number of vegetable plants needed in Utah, a study of plant-growing methods was undertaken in 1932. Up to the present time these investigations have largely involved a study of sources of heat for hotbeds. Plants have been grown in hotbeds heated by fermenting manure, electricity, and hot water. Records have been kept indicating quality of plants and the cost of heating. No consistent difference in quality has been found between plants grown with the several sources of heat. These studies
indicate, however, that electricity affords the safest source. If sufficient plants are grown in a well-constructed hotbed, it has been found that electric heat is cheaper than manure.

Onions

The onion work involves three major and several minor objectives. The major objectives are to develop strain improvement, better storage qualities, and to find causes underlying the production of multiple onions. The varietal trials of 1920-22 established the superiority of the sweet Spanish onion for culture in Utah. After this fact was established it was considered necessary to organize an improvement project to produce a strain better suited to Utah conditions than the Riverside sweet Spanish as it then existed. As a result of this project, the Station has developed what is considered by leading onion authorities the outstanding strain of sweet Spanish in the United States. A white strain of sweet Spanish onion of unusual merit has also been developed. The keeping quality of the Utah strains is superior to the original strains. Extensive studies, conducted to determine the factors influencing the storage value, have led to the following conclusions:

1. High relative humidity is conducive to excessive storage decay, regardless of temperature. The situation is aggravated, however, if temperature and relative humidity are both high.
2. Onions harvested slightly immature will keep better than those allowed to remain in the field until the tops have fallen.
3. Onions which are irrigated until harvesting time do not keep as
well as those in which irrigation is discontinued at least 10 days before harvesting.

(4) While neckrot is a common source of storage losses, it is often of less importance than decay originating in bruises.

Doubles and scallions in onions increase as the distance of thinning is increased

Twenty-five bulbs were pulled in consecutive order from a representative area in each thinning treatment. Upper: No thinning, which shows no doubles or scallions. Lower: Four-inch spacing, which shows considerable doubling of onion bulbs. As the rate of spacing is increased to 6, 8, and 10 inches, multiple bulbs increase in proportion.

(5) Frequent sorting during the storage period has always resulted in greater losses.

(6) There is no indication that curing in the windrow either before or after topping improves the storage quality. Bulbs pulled, topped, and crated the same day keep as well as those cured in the field for a week or ten days.
It frequently happens that an otherwise profitable crop of onions is rendered unprofitable by the presence of a large number of double, split, or multiple bulbs. It was found that this condition is always associated with a thin stand, regardless of the state of soil fertility or of the moisture conditions. Attempts to associate this with high nitrogen content of the soil have not been successful.

Minor onion studies have included seed production, varietal trials, and the development of a non-bolting strain of sweet Spanish onion. The one outstanding discovery in these studies has been that materially larger seed yields are obtainable from mother bulbs that have been split through the neck to about half way down the bulb. In some cases the seed yield has been doubled by this treatment.

Celery

Celery studies have consisted largely of, (1) varietal trials which established the superiority of the so-called Utah variety, and (2) strain tests to
determine which of the many strains of Utah celery is best from the standpoint of quality, yield, and marketability. It was found that a wide range of difference exists with respect to each of these characteristics. The work has not yet progressed far enough to warrant recommendation of any strain, although several promising strains have been isolated.

Fruits

Introducing and testing varieties of apples, peaches, cherries, pears, and apricots to find those best adapted to Utah conditions, was started by the Station's first horticulturist. The first varietal test orchard was planted in 1890 on the College campus. It included over 300 varieties of hardy tree fruits, and laid the foundation for the Utah fruit industry which had its major development shortly after, in the decade from 1900 to 1910.

Varietal Testing

A new varietal testing orchard was planted on the experimental farm at Farmington in 1927 and was devoted exclusively to stone fruits, including over 100 varieties of peaches, 45 plums, 30 cherries, and 20 apricots.

As a result of this work, thousands of trees of superior new varieties are being planted for trial by Utah fruit growers. The early yellow peach varieties are especially popular for local market purposes. Of the new peaches introduced by the Station, the Golden Jubilee, Halehaven, South Haven, July Elberta, Ideal, Sunbeam, and Goldfinch, appear most promising.

A number of new plum and prune varieties likewise promise to be of value to Utah orchardists, and to consumers. The President, long keeping late plum; Pacific, a large, high quality prune which ripens three weeks before the Italian prune; Yakima, a large, early, red eating plum; and Sugar, an enormously productive, early, sweet, eating prune, are being tried by Utah growers for local market purposes. Varieties of the Satsuma type are also of special interest among the 45 plum and prune varieties on trial.

In an effort to find superior new apricot varieties of the sweet-pit Chinese type, over 450 seedlings of that variety, planted in 1929, were fruited at Farmington, 15 of which are being propagated for a second test as well as for cooperative testing under orchard conditions. Several of these selections are promising.

Cherry Pollination and Varietal Problems

With the extensive plantings of solid blocks of the sweet-cherry varieties, Lambert, Bing, and Napoleon, from 1920 to 1930, pollination trouble in the form of poor sets and crops of fruit developed. The work of the Station solved the problem so far as the well-tested standard varieties are concerned by proving the need for pollinizers, the planting of which has now become a standard practice in Utah cherry orchards.
CANDOKA PEACH
A promising new peach of the J. H. Hale type and season from Washington. The station has over 100 varieties of peaches and nectarines under tests.
PRESIDENT PLUM
One of the outstanding new varieties under test in the Station orchard at Farmington. A large late shipping plum of excellent dessert and keeping quality.
Cherry Varieties Improved by Breeding

In order to obtain hardier, healthier varieties of large-fruit ed, firm-fleshed shipping cherries, 25,000 blossoms of Lambert, Bing, Napoleon, Windsor, and Elkhorn were crossed in 1936 with a view to recombining the good qualities of these varieties. Early ripening Seneca and the large-fruited Schmidt (Black Orb) cherries were used as male parents. Out of this work 200 seedlings were obtained for study and observation.

Pruning Fruit Trees

Apple-tree-pruning experiments showed that summer pruning reduced yields under Utah conditions, likewise that heavy dormant pruning to spread

A WELL PRUNED MODIFIED LEADER TREE

Note the heavy load of fruit carried by the well-spaced, wide-angled crotches of this peach tree. The Utah Station was one of the first to apply this system of training to peach trees and other stone fruits.

apple trees also reduced yields. This work pointed the way to higher production and lower costs in the growing of Utah apples.

An experiment in the pruning of bearing peach trees showed the heavy heading back in addition to the thinning out of the trees substantially reduced yields, lowered color, shipping, and dessert quality as compared to “long pruning,” which consisted of thinning out vigorous branches and heading back only weak shoots.
Fruit Harvesting and Maturity Studies

Heavy losses of apples in storage and of Utah peaches in transit led to studies on this problem. It was found that delayed harvesting of Jonathan apples was the principle cause of heavy losses from breakdown in stored apples.

The maturity studies on Elberta peaches were extended to include the Early Elberta and J. H. Hale varieties. As a result of this work, definite indexes of maturity for Utah peaches were formulated which now make possible the harvesting of peaches at the stage of maturity which will give the highest quality, color, yield, and condition arrival when shipped east. Immature picking was found not only to result in loss of quality and consumer demand but also in substantial losses in yield, size, and color.

Orchard Irrigation

Late irrigation, 6 weeks preceding harvest during which peaches make most of their growth, was found to be more important in determining size of fruit, yield, and quality than early irrigations.

Studies were made of the required amounts of water, frequency of irrigation, and number of furrows needed between tree rows in a peach orchard on stony loam soil, typical of the Utah peach orchard soils. Results showed that in such soils the use of 4 to 6 furrows between trees, with irrigation intervals of 3 to 4 weeks, gave better results than more frequent water application in one furrow on each side of the rows.

Weekly applications in 4 or 6 furrows gave the most growth, but required more water than usually available. Moisture penetration and spread studies showed that under Brigham conditions the water from 1 furrow spread only 15 inches on each side of the furrow during the time required to penetrate 6 feet deep. In order to store water for the use of the peach trees in all the soil occupied by the roots, these studies showed that furrows should be spaced not over 21/2 to 3 feet apart under similar conditions. Weekly watering in one furrow on each side of the trees was shown to result in heavy losses of water from deep percolation together with reduced tree vigor and yields of fruit. Irrigation of apples showed that young trees receiving frequent irrigation made approximately three times as much growth the first season as those irrigated but once or twice.

Small Fruits

The research work with small fruits has assumed two phases: (1) varietal trials of strawberries, raspberries, grapes, and blackberries, and (2) chlorosis resistance of grapes, raspberries, and strawberries. Only 1 result of outstanding importance has been achieved, namely, that chlorosis of Concord grapes can be overcome by grafting Concord scions on vinifera roots. While there is some resistance to chlorosis among raspberry varieties it is not important nor even consistent. No appreciable resistance to chlorosis has been found in strawberries.
IRRIGATION

From the urgent necessity of a small group of Utah Pioneers in 1847, who realized that they must produce food-supply crops at once or perish, agriculture under irrigation in the West has grown to a position of international importance. Although the American Indians on the Rio Grande had irrigated their lands for many generations before the Mormons entered Salt Lake Valley; the first great impetus of irrigation expansion in Western America under Anglo-Saxon leadership, followed the beginning of irrigation on July 23, 1847. The Mormons found the soil so hard and baked that it could not be plowed. They immediately placed a dam across the small City Creek and flooded the land in preparation for plowing and planting. Concerning their experience, Orson Pratt said:

"Encamped near the bank of a beautiful Creek of pure cold water * * * in about Two hours after our arrival we began To plow and the same afternoon Built a dam to irrigate the soil

"July 24th this forenoon commenced Planting our potatoes, after which we Turned the water upon them and gave The ground quite a soaking."

In view of the leadership of the Utah people in the founding of modern irrigation in America and of the vitally important role of irrigation in the agriculture and the life of the West, it was fitting that the Station early devoted serious consideration to research studies of irrigation and related problems.

Irrigation Science

Irrigation science includes the body of knowledge developed during the last half century concerning the relationships of irrigation to soils, to plants, to precipitation, to stream flow, and to communities in arid regions. The understanding of the relationships of soil and plants to irrigation practice has been developed largely through the research of the western agricultural experiment stations and the United States Department of Agriculture.

Contributions of the Utah Station to irrigation science were provided for almost immediately after the Station was created. Administrative and research officers of this Station recognized the basic importance of irrigation to Utah agriculture at the beginning of their work.

The Pioneer Work

Among the topics considered by the pioneer research workers are the following: (1) natural water for irrigation; (2) early vs. late irrigation; (3) amounts of water required and relation to crop yield, percolation, and
soil fertility; (4) seepage waters and the underflow of rivers; (5) time and frequency of irrigation; (6) orchard and vineyard irrigation; and (7) water-supply studies and canal capacities.

During the first ten years of station activity, irrigation studies were reported in numerous bulletins. Some of the topics which were given preliminary consideration during the first years have been studied further during recent years. Plans for the early research were carefully made and the work done constitutes an excellent beginning. Indeed, much of the pioneering work served both as a guide and inspiration to those who led in the more detailed research conducted during the second decade.

Intensive Irrigation Studies

The most intensive irrigation studies relating particularly to soil and plant relationships were conducted by the Station beginning about ten years after its organization. The Greenville experiment farm was purchased and consecrated largely to the study of irrigation problems. These studies, which lasted for many years, demonstrated the striking possibility of irrigation improvement in Utah. Particular attention was given to the influence of the quantity of water on the quality of the crop grown and it was found that, invariably, conservative irrigation produced crops of the highest quality.

Comprehensive study was also made of the movement of water in soils and of the depth of penetration of different amounts of irrigation water. It was found that large proportions of the natural precipitation are stored in deep, retentive soils; and that excessive irrigation results in losses through deep percolation. As a result of these studies it was found that water moves slowly in soil under the force of capillarity and as the amount of water
becomes less the rate of movement is greatly retarded. The moisture content at which the rate of movement became extremely slow was designated as the Lento-Capillary Point.

Methods of conserving water following irrigation, with special reference to cultivation and the prevention of evaporation losses were given thorough and painstaking experimental study.

**Water Application and Crop Yield**

Probably the greatest single contribution of these intensive irrigation studies was the establishment of relationships between the amount of water applied and the crop yield. These relationships are now commonly represented graphically by a curve known as the yield-water curve. There are, of course, variations in yield from season to season even with the same amounts of irrigation water, but, despite these seasonal differences, the aver-
acre feet, in the deep, well-drained soils of the Greenville farm, caused neither increase nor decrease in the yield of alfalfa.

**Irrigation Methods**

Beginning a quarter century after the Station was established, attention was given to a study of irrigation methods and their relation to efficient irrigation practices. The first step in this phase of research was a more comprehensive and detailed study of the capacity of soils for irrigation water. The Station found that very few, if any, soils under ordinary practice could absorb more than 1.5 inches depth of water per foot depth of soil. It also found that usually much smaller quantities were retained, and that the coarse-textured, shallow bench lands of Utah usually sustain heavy deep-percolation losses because of the fact that the amounts of water applied exceed the capacity of the soil for water.

It was found also, that long irrigation runs and small streams applied to coarse-textured soils result in low irrigation efficiencies because of excessive losses near the supply ditches. On the other hand, streams of proper size applied to the correct land areas result in uniform distribution of moisture in the productive soil and a minimum of loss into the gravelly sub-soil.

*WHERE THE SNOW-SURVEY IS TAKEN*

Scientific studies of snow mantle, including depth, water content, rate of melting and water yield have contributed greatly to our ability to make better use of the natural stream flow in irrigation and power development.

**Snow Surveys and Irrigation**

About fifteen years ago the Station began active and intensive work in snow-survey research. At that time, only one agricultural experiment station in the West had conducted research in this important field. Since 1923, the
Station has become a leader in research relating to the relationship between precipitation on mountain areas and the yield of river systems. Water-supply forecasts for important Utah streams are now made each year on the basis of Station snow-survey measurements. These forecasts enable irrigation companies to plan their seasonal water distribution activities intelligently. They also give irrigation farmers a sound basis for selecting and planting crops in harmony with available water supplies. Farmers no longer plant late-season crops that require large amounts of water in July and August only to find that because of water shortages which they could not foresee, their crops are doomed to failure. Moreover, farmers can now select proper acreages of crops, as well as kinds and varieties, according to the water-supply condi-

**A SNOW SURVEYING PARTY IN ACTION**

Precise data are being recorded of snow at this selected course. Its elevation is 9000 feet above sea level. This is one of the many typical snow survey courses.

tions from year to year. The value of this type of research to agriculture is now nationally recognized and several agricultural experiment stations, together with the Federal Department of Agriculture, are now conducting research in this field. The research work of the Station in this very important aspect of irrigation science is now widely recognized and its publications are considered authoritative.

**Future Irrigation Research**

The problems of water control and efficient use in arid regions are numerous and complex. Great and valuable results have come out of the wisdom, the vision, and the toil of the Station irrigation and drainage research workers of the years recently passed, and of those of the present; yet undoubtedly only a beginning has been made. The first and major factor
in the productivity of western lands is the intelligent control and use of water supplies. The research of the future must be concerned with water in all places and conditions. Whether our water supplies are on mountain tops, on the hillsides, in the creeks, the reservoirs, or the canals; or on the farms or in the soil—in any one and in all of these places they must be understood. Moreover, wherever they are, they must be controlled and used for the benefit of man if western civilization is to endure. The agricultural experiment station staffs of the future will doubtless contribute freely to the necessary research concerning water—its control and its use for the permanent good of man. By their understanding foresight and judgment, based on vigorous training and continuous research, the staffs of the Station must demonstrate that intelligent use of land and water constitute the basis of welfare for all and indeed the basis of perpetuation and advancement of civilization in arid regions.
Until about 1914 research at the Station had been concerned primarily with those problems which were definitely of an agricultural nature. Irrigation studies, however, led naturally into the science of physics. The problems of frost injury, dry farming, farm machinery, and labor-saving devices, led likewise into this domain of science. A course in meteorology was introduced into the College curriculum to help meet the needs of agricultural students and at about this time a meteorologist trained in physics was appointed on the Station staff.

Frost Studies

A considerable amount of research was initiated to study the relation of frost injury to early fruits, to the humidity, and to time of duration of freezing temperatures, and surveys were made to determine the influence of topography, and air drainage on frost injury. Tests were made concerning artificial heating to control the temperature over limited periods of time and limited areas in the fruit-growing regions. These studies contributed substantially to the solution of the problems of the horticulturists and fruit growers.

Soil Water Problems

In recent years the work of the Physics Department has centered around the soil moisture and ground-water problems. Their dynamical aspects had been given consideration by a few stations and government departments but the correct solution seemed to require a mathematical attack and for that reason most investigators had either avoided the problem entirely or had attempted by empirical means to obtain generalizations.

Fortunately, the mathematical problem proved to be similar to that which had been met previously by the physicists in the field of hydrodynamics and in the field of electricity and magnetism.

The so-called Darcy velocity law for the movement of water in a saturated soil presented a striking resemblance to Ohm’s law for the flow of electricity through resisting media, and this opened the way to a successful attack of the ground-water and drainage problem. The manner in which water moved into drains, into well networks, and into the water table from water-bearing strata, was no longer a mystery.

Volumes had been written concerning capillary moisture, and various so-called soil moisture constants had been defined, measured, and tabulated, but largely because those who had pioneered the way into the field had chosen to omit the use of the analytical methods of the physicist, the results were for the most part unsatisfactory. Some had urged that water would move great distances to supply the needs of plants by this capillary route while others contended that it would move at the most a few inches.

In the field of mechanics and hydrodynamics, however, physicists had investigated forces and velocities and vector fields, and had found an import-
ant criterion which served as a basis for dividing these vector quantities into 2 broad categories; namely, those which "have a potential" and those which do not. This meant that the analytical difficulties to be encountered in determining the nature of capillary flow were greatly reduced because the formal expression of the Darcy law constituted the evidence that the ground water-stream velocity "had a potential" and one term in this potential function was the ratio of the hydrostatic pressure to the density of the fluid. This term had been designated the capillary potential function and the Utah Station physicists were among the first to recognize that the capillary potential constituted therefore the one soil-moisture constant that had dynamical significance. They recognized also its intimate relation to various other soil-moisture constants that had appeared as a result of the empirical procedure of earlier investigators. Finally, because of this concept they were able to write the law of the movement of moisture in the soil by capillarity.

Field Studies Guided by Analysis

It was not to them, therefore, a difficult task to observe that from the standpoint of theory, the entire problem of the movement of moisture through the soil was susceptible to analytical treatment and the solution of practical problems concerned with drainage and well development resolved themselves into field studies to determine the nature of the soil profile and the pressure distribution throughout the locality concerned and to mathematical studies to be performed in the office.

This view of an important field of soil physics is held to be a far-reaching successful innovation, revolutionary in its implications. Not only is this true, but it furnished to the engineers a scientific, practical, and successful substitute for a method of approach that had proved to be inadequate.

During recent months, consideration has been given to the problem of erosion by irrigation water and a preliminary formulation of the problem gives promise of supplying to irrigation engineers a much needed basis for guiding the farmers in their efforts to conserve the fertility of our irrigated and dry-farm soils. It is unfortunate that the loose friable condition of the surface soil that is conducive to plant growth is conducive likewise to soil waste by erosion. Practical-minded men and engineers are coming to see the serious need for modifying our irrigation and tillage practices and operations on the cropped dry lands in order that we might conserve not only the fertility and moisture but the very soil itself. A scientific basis that can be supplied in no other way than by careful research of this type is unquestionably an absolute essential, and this preliminary study is a substantial step in the right direction.

It may seem unfortunate that these researches are of a mathematical character and are for that reason unavailable to the ordinary reader. On the other hand, the precision of the analytical methods enhances their value to engineers. It seems safe to say that no drainage or groundwater-development problem of consequence should be undertaken without giving careful consideration to the theoretical development presented by the physicists.
RANGE MANAGEMENT

Importance of Range Lands

Utah is essentially a livestock state. More than 85 percent of the area is range land fitted only for livestock production. It is evident that the proper usage of most of the land area, and the income of a large number of Utah’s citizens, indeed the very economic stability of the state, are dependent upon the maintenance and improvement of the range. The importance of proper range management is further exemplified when one considers the dependence of Utah’s agricultural production upon the mountain watersheds. These watersheds, if improperly grazed, may become so eroded as to threaten irrigation and culinary water. Resulting floods jeopardize homes, property, and even human lives.

BUNCH WHEATGRASS

Example of bunch wheatgrass range which is found along Utah’s foothills. This type of grass is now being artificially propagated in the nursery and tests are being made to determine the degree of grazing it can withstand.

Early Survey Project

The first range research project was approved in 1918 and consisted of a range survey designed to obtain general information on Utah’s range resources. A study was made of forage classes and types, their extent, location, proper seasonal use, and adaptation to different stock classes. Proper management practices, carrying capacity, and possible improvements were also investigated. Information was obtained which served to pave the way for further work along more specific lines.

Reseeding Research

A second project was started in 1921 in an attempt to study reseeding methods and species of plants which might increase the production of over-
grazed range lands. A 2-acre foothill tract of land was fenced and planted to species giving promise as good spring range plants. Many of these showed successful establishment. Mountain brome grass (*Bromus polyanthus*) was found to be as successful as any species tried in the early experiments. Several other species, notably western wheatgrass (*Agropyron smithii*) demonstrated the feasibility of sod planting for range revegetation. In 1934, 2 sections of the School of Forestry nursery were taken over by this project and an overhead spray system installed for artificial watering. This area is used primarily for starting rarer species, and for physiological and ecological experiments. About 25 browse species, both native and introduced, are also being investigated together with the physiological reactions of grass species.

Considerable attention has been given to Indian ricegrass (*Oryzopsis hymenoides*) in an effort to increase its germination to a point where economic reseeding is possible.
Active Projects

Other promising experiments now in operation are: (1) a physiological-ecological study of blue bunch wheatgrass \( A. \text{spicatum} \) to various intensities of grazing in which yield, seed viability, and root development will be studied; (2) a study of the possibilities of winter wheat as a spring forage in which grain yield will be measured under various seasons and intensities of grazing; (3) a study of the effect of various depths of seeding upon the germination, development, and successful establishment of selected native and cultivated grasses; (4) a study of some native forage species as constituents of pasture and range reseeding mixtures.

Flood Prevention Studies

In 1930 the Range Department in cooperation with the Geology Department of the College, the United States Forest Service, and the State Land Board began a study of flood-control problems in Utah. The object of this study was to ascertain causes of floods and possible prevention measures. The following conclusions were drawn from this investigation:

1. The serious floods in several canyons in the Centerville-Farmington section of northern Utah, which cut to extraordinary new depths in the previously undisturbed sands and gravels of the deltas and terraces of the ancient Lake Bonneville, afford evidence of the value of plant cover in regulating surface runoff and controlling erosion.

2. The origin of the floods was traced to relatively small areas in the heads of the canyons which in recent times have been depleted of vegetation chiefly by overgrazing, but to some extent by fire.

3. The torrential rains did not cause runoff sufficiently concentrated to cause gullying on thickly vegetated parts of the watersheds, regardless of the steepness of the slope.

4. The correction lies in protection of the watershed from overgrazing and in the establishment of good stands of plant cover.

Cooperative Feeding Research

The Range Management Department cooperated with the Animal Husbandry and Chemistry and Bacteriology Departments in 1931 in a project to determine the value of feeding corn and cottonseed cake as concentrated supplements for wintering sheep on desert ranges of Utah. The study also included a survey of range plants, observations of sheep activities, plant palatability and poisonous plants. A range reconnaissance was made of the Trout Creek area where grazing was studied in detail and the importance of each species determined. About fifty species were collected for identification. Sixteen of the most important forage species were collected at regular intervals for analysis by the Chemistry and Bacteriology Department. The results indicated that as long as sufficient forage was available supplementary feeding was not necessary.

The chemical analysis of the plants showed, however, that certain desert plants are low in phosphorus.
Resources Study

A study of agricultural resources of Utah and their utilization was begun in 1936 in cooperation with the departments of Agronomy and Soils, Agricultural Economics, and Irrigation and Drainage. The range division was designated to study the range resources of the entire state in order to determine the extent, condition, and best utilization of this resource. Work was started in 1936 in cooperation with several government agencies. The Uinta Basin, where the work began, was found to be in a serious condition of erosion due to improper seasonal as well as to excessive use of range lands.

During the field season of 1937 this project was continued in Wasatch County in cooperation with the Western Range Survey Division of the Agricultural Adjustment Administration. As a result of this work the Range Department with the cooperating agencies has completed a range inventory of slightly more than three counties within the state embracing an area of almost six million acres.

Recent Survey Work

Range-survey methods and vegetation analysis were investigated in 1937 to decide the adequacy of present grazing-reconnaissance methods and to study the effect of individual judgment upon results. The project also involves a study of several new methods. This study is an important and timely one because
of the immense amount of grazing survey being done in Utah and neighboring states. Studies during the past year have been confined to the following: (1) measurement of volume yield of various types of plants and a correlation of this yield with reconnaissance density estimates; (2) a comparison of measurements made by different individuals on the same area by various methods, both old and new; (3) a study of the long-time performance of range areas in comparison with capacity estimates made by range reconnaissance and a study of the ecological condition of the vegetation cover on these areas.

In 1937 the Range Management Department in cooperation with the Western Range Survey Division of the Agricultural Adjustment Administration began compilation of a bibliography of all range-management literature written concerning the State of Utah. A bibliography of about 1,500 references has been compiled and submitted as "A bibliography of range management and related subjects. Part I Utah. Part II General." 1938. Part I of this bibliography is now available in mimeograph form.
RURAL SOCIOLOGY

The Department of Rural Sociology, organized in 1926, is one of the latest additions to the Utah Agricultural Experiment Station. This state, however, had not lagged greatly behind other states, for it is only 22 years since the first research bulletin appeared and it is only 25 years since the first text book on rural sociology was written.

The contribution of scientific knowledge about rural culture in Utah is the purpose of the Department. Utah's town, village, and open country organization presents an inviting field for study. A brief resume of the work attempted during the past decade follows:

Fields of Study

While major effort has been directed to intensive studies of selected villages and towns of Utah, some larger units have been included. One area on which considerable work has been done includes 7 communities and the Federal Rural Research undertaking involved 6 counties.

Housing

The department participated in the Bruce Melvin studies for the President's Conference on Home Building and Home Ownership. Although this pioneer study was necessarily limited in extent, being confined to Box Elder County, it nevertheless revealed for the first time, the large proportion of Utah rural homes which fall short of reasonable conditions of health and comfort.

Schedules were further refined and groups isolated and defined in the studies at Plain City, Tremonton, Oak City, Avon, and the Delta area, to provide more satisfactory information. The difference in housing conditions between farm dweller families, village farm families, and village non-farm families was ascertained; also, the extent to which the mountain resources of electric power and spring water have been converted into use, in terms of electric conveniences and hot and cold water facilities in the homes of all the people, was determined.

Social Participation

For the intensive studies of village life in the state, 4 type villages were selected: (1) a village located near an urban center; (2) a trade center located at considerable distance from city influences; (3) an isolated Mormon community; (4) a canyon (string town) community.

The studies of the village located near a city have progressed farther than any of the others. The organized institutions and agencies of Plain City through which participation is brought about are noted for stability and permanency.

To obtain a satisfactory picture of social participation in the village located as it was only ten miles from Ogden—Utah's second largest city—it
was necessary to obtain information on the extent to which the principal groups, farm and non-farm, used: (1) the local agencies and institutions; (2) semi-local agencies which Plain City in cooperation with other villages and local units in the county maintain, usually in the county seat, such as a county consolidated high school; (3) the agencies belonging to and located in other population centers, chiefly the near-by city of Ogden, such as public dance halls, movies, libraries, hospitals; (4) non-community agencies, maintained by the federal government, the state, churches and others, such as national parks, mountain resorts, colleges, temples, tabernacles. Data gathered on extent of participation indicated that community life in its organized forms is of more importance to childhood and youth than to adult life. The importance of local community functions even in a village, close to a city and subject to many urbanizing influences, may be seen in the comparatively large amount of time which the people in Plain City give to their own institutions.

Definition of Utah Rural Groups

In order to determine the extent of use of the various types of community agencies listed previously, attention was directed to the groups. The question was raised, what are the most important groups in a rural community concerning which extensive information should be obtained? The census classification of rural, rural farm, and rural non-farm was considered. While valuable, this classification unfortunately for Utah rural people was inadequate for the reason that a rural farm family was defined for the census classification as "a family which lives on the farm." A very large proportion of Utah's farm families do not live on farms but live in villages and towns and operate farms in the vicinity. So the task of devising a classification was necessary and it was decided to divide the farm groups into 3 classes, defined as follows:

(1) Farm-dweller families include all farm families living on their farms who are not included in the edge-of-village or town or city farm families.

(2) Edge-of-town, or edge-of-village, or edge-of-city farm families include the farm families living on their farms immediately on the edge of the compactly settled areas. These families actually are a part of the population center but they also live on their farms and are strongly influenced by the vocational determinants of the farm business. This is the only farm group which comes strongly under the grip of both village and farm influences.

(3) Village-farm families include farm families which live in the village and own or operate a farm or farms in the neighboring territory.

The village farm family, particularly the wife and children, is not subject to farm influences as much as is either the farm-dweller families or the edge-of-village farm families. On the other hand, village social influences, both good and bad, are likely to be stronger and many of the comforts and conveniences of life can be had more easily and more cheaply. Further studies are revealing significant differences between these groups in family solidarity, in relief status, in economic situation, in juvenile delinquency, extent of crime, and in extent of indebtedness.
The comparatively large number of non-farm people in the towns and villages required classification also. Decision was reached to use for preliminary studies the Works Progress Administration classification into (1) professional and technical, (2) proprietors, managers and officials, (3) clerical and allied workers, (4) skilled workers and foreman, (5) semi-skilled workers, (6) unskilled workers, (7) servants and allied workers, (8) no usual occupation which includes inexperienced persons and not a "worker."

Relief

In a cooperative project with a federal agency in which 6 counties were studied, it was found that farm families and edge-of-village farm families contributed over three times as many youths to the relief rolls as do rural farm families.
resist relief status more strongly than do village-farm families and that all farm families remain off relief rolls much more effectively than do non-farm rural people. It is in the non-farm rural field that plans for social security are most urgent.

Standard of Living

In view of the fact that Utah has a number of irrigation and drainage districts that have become badly involved in debt and have been unable to meet bonded-debt obligations, it was decided in 1930 to undertake a cooperative study in an effort to ascertain factual conditions underlying the unfortunate financial status of the Delta area. This district involved 115,200 acres of land and included within it 7 communities. The Rural Sociology Department undertook to ascertain family-living conditions and the status of the community assets. Its significance in bringing enlightenment with respect to determining conditions may be noted at several points.

1) The bonding of an entire area so that all the farms are tied up in a single liability making it impossible for a farmer to pay off his portion of the indebtedness and release his farm from the common liability has worked out unfortunately for the investor as well as the borrower. Although the courts, both state and federal, have declared the “blanket” lien unconstitutional, this conception of liability of each farm for the payment of the obligations of the other farms has led to undue and unnecessary difficulties, such as undue and widespread fear, on the part of those who could pay their own obligations, that their land would ultimately be forfeited for obligations which farms on poorer lands could not meet.

2) Family expenditures revealed that, while a considerable proportion of the farmers who could have met their bond payments did not do so, a large proportion could not meet them and maintain family life on a decent basis.

3) The very large proportion of vacant and abandoned houses numbering 195 out of a total of 937, (20.8%) indicates the severity and unhappy outcome of the struggle to succeed on the poorer soils.

4) The high percentage of homes without hot and cold water conveniences, the absence of central heating systems in the great majority of the homes, and the limited extent of electric refrigeration, reflect the inability of these people to provide themselves with conveniences which are necessary for comfort, sanitation, and good health.

Community Assets

The brief study of community assets which was undertaken in the Delta area was organized to show the relative state of development of community assets. This showed that institutions connected with education, religious life, and recreation absorb nearly all of the community financial resources of the people. School buildings, church buildings, recreation halls, gymnasiums and fair grounds are comparatively well developed. Health facilities and public and private organizations for health, on the other hand, are
meager and inadequate. Agencies providing expert assistance for the improvement of family life, or child welfare are largely nonexistent.

**Purposes of Rural Social Life Studies**

The purpose behind the accumulation of facts in selected fields pertaining to organized rural social life in this state varies with the worker as well as with the immediate or the remote need which prompts the study. Some of the purposes which exercise a considerable influence on the present personnel of the department are: (1) the awakening of an interest among the people in their own social problems; (2) providing more accurate and more inclusive information about social conditions; (3) isolating and measuring some of the more significant factors and forces which influence social relations and culture accumulations at the present time.

**Resume**

Some of the groups in Utah have been defined; they now need to be observed. A few community assets have been inventoried. Standard forms and means of appraisal need to be developed. Beginnings have been made in measuring and interpreting social participation. Community organization in Utah shows signs of institutionalization. Studies have not yet provided a basis for appraising an unfavorable trend. Individual studies of family life have been made, but the strengths in family living that are known to exist have neither been enumerated, classified, nor appraised. Initial studies of mobility have been undertaken. Population studies have hardly begun to be made. Studies of institutions in the field of government, religion, and health challenge students of social science. The vitality of the rural heritage is taken for granted but its content has been determined or classified only to a limited degree. The rich field for social research in Utah is only beginning to be worked.
The first bulletin to be issued by the Utah Agricultural Experiment Station was published in 1890. It was written by Director Sanborn and was titled "A general statement of the purposes of the Utah Agricultural Experiment Station and of the experiment work in progress and to be entered upon." It contained as expressed in the title "a general statement of its organization and its proposed work." In this bulletin, Dr. Sanborn defined the purpose of a bulletin to be a medium through which the results of station research should be reported to the public rather than a means of "compilation and proclamation." This bulletin also contained the floor plan of a house and barn and the elevation cut of the first Experiment Station building. One other bulletin was issued during the first year on plow trials.

The next year 8 additional bulletins were published. They covered a variety of topics including experiments with vegetables, time of watering horses, and trial of sleds and tillage tools. Some of these bulletins and many of the later ones covered more than one subject.

Dr. Sanborn, the first director, was a prolific writer, publishing 24 bulletins between 1890 and 1894. Other authors of early bulletins included Samuel Fortier, E. S. Richman, James Dryden, Lewis A. Merrill and J. A. Widtsoe. The total number of bulletins published by the Station from its organization in 1888 to the present time is 281.

Beginning in 1904, the circular series was started. The purpose of this series was to present timely material, not necessarily original data, to help the farmers in solving many of their problems. This series now numbers 110.

In 1925, the news circulars were instituted as a form for sending out announcements of Station publications as issued. This series was closed with no. 79, 1931.

A series of mimeographed sheets, for quick and cheap distribution of ephemeral material was instituted in 1926, and now numbers 166. In this year a miscellaneous series, for publications that did not fit in any of the regular series, was also published. Sixteen publications have been issued in this series.

In 1933, a leaflet series was instigated to put material in a form that could be used by staff members to answer questions asked by individuals throughout the state. These are 2- to 4-page publications and can be enclosed in a letter. This series now numbers 76.

Reprints of articles of scientific nature, written by staff members and published in the various technical journals, are numbered and distributed by the Station. Since these reprints have been numbered, 386 have been issued.
STATION PERSONNEL, 1888-1938

Abell, Tracy H., assistant horticulturist, 1918-27
Alder, Byron, poultryman, 1913-
Aldous, Alfred Evan, assistant chemist, 1910-11
Anderson, Hans Peter, assistant chemist and bacteriologist, 1916-17
Ball, Elmer Darwin, entomologist, 1903-07; director, 1907-16
Ballantyne, Alando Bannerman, assistant horticulturist, 1910-13
Batchelor, Leon Dexter, horticulturist, 1910-16
Bateman, George Quayle, superintendent Dairy experiment farm, agent, United States Bureau of Dairy Industry, 1925-
Bateman, James Robert, superintendent Panquitch livestock farm, 1926-28 (deceased)
Batt, Charles, horticultural foreman, 1900-01
Becraft, Raymond John, assistant in range management, 1918-28; associate 1928-35
Beers, William Duke, assistant in irrigation, 1901-03
Bell, Donna Barton, stenographer, 1937-
Bexell, John Andrew, secretary, 1906-07
Berntson, Russell Ellwood, secretary and purchasing agent, 1927-
Blanch, George Thomas, associate agricultural economist, 1934-
Blood, Heber Loran, assistant plant pathologist, 1926-30; associate, 1930-31; pathologist and agent, United States Department of Agriculture, Division of Horticultural Crops and diseases, 1931-37; pathologist, United States Department of Agriculture, 1937-
Bolte, John Willard, poultryman, 1906-07
Bowman, Albert Elijah, assistant agronomist, 1911-12
Bracken, Aaron Francis, assistant agronomist, 1915-17; scientific assistant, United States Department of Agriculture, 1918-20; assistant agronomist and superintendent Nephi dry-land station, 1920-33; associate agronomist and superintendent Nephi- dry-land station, 1933-
Brainerd, Walton Kirk, dairyman, 1908-09
Brewer, F. William, biologist, 1893-97
Brossard, Edgar Bernard, agricultural economist, 1919-23
Brown, Almeda Perry, assistant in home economics research, 1926-37; associate home economist, 1937-
Brown, Charles Franklin, drainage engineer, United States Department of Agriculture, 1909-11 (deceased)
Burgoyne, David Alvin, secretary to director, 1922-36; executive secretary, 1937-
Butt, Newbern Isaac, assistant agronomist, 1916-19
Caine, George Ballif, assistant animal husbandman, 1918-19; dairy husbandman, 1919-
Caine, John Thomas III., assistant animal husbandman, 1906-07; animal husbandman, 1907-12
Cannon, Clawson Young, assistant animal husbandman, 1913-14
Cardon, Phillip Vincent, assistant agronomist, 1909-13; scientific assistant, United States Department of Agriculture, superintendent Nephi dry-land station, 1910-13; agricultural economist, 1925-28; director, 1928-35
Carlson, John Wilford, superintendent Uinta Basin experiment farm, 1925-33; assistant agronomist, United States Bureau Plant Industry, 1937-
Carroll, William Ernest, associate animal husbandman, 1911-12; animal husbandman, 1912-24, 1937-
Carter, Ezra Grover, assistant bacteriologist, 1916-20; associate, 1920-29
Clark, Robert Wallace, animal husbandman, 1903-07
Close, Charles Phillip, horticulturist, 1899-1901
Clyde, George Dewey, assistant irrigation engineer, 1924-29; associate, 1929-32; irrigation engineer, 1932-
Coburn, John Latham, secretary and purchasing agent, 1906-24
Coe, Francis Morse, assistant horticulturist, 1927-34; associate, 1934-
Cooper, Blanch, associate home economist, 1919-21
Crockett, Henry Wallace, assistant horticulturist, 1907-09
Crockett, John Alvin, assistant dairyman, 1898-1907
Cutler, Harold Harris, assistant agricultural economist, 1934-
Cutter, William P., chemist, 1890-93
Daines, Henry, assistant in sugar-plant investigations, United States Bureau of Plant Industry, 1930-31
Dorst, Howard Earl, junior entomologist, United States Department of Agriculture, 1936-
Dozier, Carrie Castle, home economist, 1926-27
Dryden, James, clerk, 1892-98; poultryman and meteorologist, 1898-1904
Eager, James H., superintendent San Juan dry-land station, 1929-33
Edlefsen, Niels Edlef, assistant physicist, 1920-21
Egbert, Archie, assistant poultryman, 1913-16
Ellison, Arthur Daniel, scientific assistant, United States Department of Agriculture, superintendent, Nephi dry-land station, 1913-15
Erwin, R. W., assistant chemist, 1893-95
Esplin, Alma Cox, assistant sheep husbandman, 1925-29; associate, 1929-
Evans, Robert James, agronomist in charge of arid farms, 1912-31; agronomist, 1931-
Ewing, Scott, assistant meteorologist, 1918-20; assistant physicist, 1920
Farrell, Francis David, assistant agronomist, 1907-08; scientific assistant, United States Department of Agriculture, superintendent Nephi dry-land station, 1908-10
Favor, E. H., assistant horticulturist, 1908
Fife, Arthur, assistant irrigation engineer, 1919-21
Fisher, Paul, veterinarian, 1895-96
Fleming, Allan M., treasurer, 1892-94
Fortier, Samuel, irrigation engineer, 1892-93 (deceased)
Foster, Luther, director, 1896-1900
Fox, Feramorz Wilcken, secretary to director, 1936-38
Frederick, Hyrum John, veterinarian, 1906-33
Froerer, Frederick, assistant animal husbandman, 1911-12
Fuhriman, Walter Ulrich, associate agricultural economist, 1934-
Gardner, Willard, clerk, 1910-13; associate physicist, 1918-24; physicist, 1924-
Geddes, Joseph Arch, associate rural sociologist, 1926-36; rural sociologist, 1936-
Goldthorpe, Harold, assistant chemist, 1918-20
Goodspeed, William Emmett, assistant horticulturist, 1915-17
Goodwin, Samuel Henry, ornithologist, 1907-17
Gowans, Ephraim Gowans, biologist, 1900-01
Greaves, Joseph Eames, assistant chemist, 1904-09; associate, 1909-12; bacteriologist, 1912-
Greenhalgh, Violet M. (Snow), clerk, 1914-16
Hagan, Harold Raymond, assistant entomologist, 1916-18; associate, 1918-20
Hall, H. Vernon, superintendent of sheep farm, 1926-28
Hanson, Reuben, assistant in irrigation and drainage, 1918-19
Harris, Franklin Stewart, assistant chemist, 1908-09; agronomist, 1911-16; director, 1916-22
Harrison, Gladys Loynd, librarian and editor, 1936-
Hart, Richard Ambrose, drainage engineer, United States Department of Agriculture, 1909-10
Hatch, Hezekiah Eastman, treasurer, 1894-96
Hawley, Ira Myron, entomologist, 1923-26
Hayball, Edith, research assistant in agricultural economics, 1929-
Hedrick, Ulysses Prentiss, horticulturist, 1897-99
Henderson, William Williams, entomologist, 1918-19, 1929-
Hendricks, George B., economist, 1920-21 (deceased)
Hill, George Richard, botanist, 1917-25
Hill, Reuben Lorenzo, human nutritionist, 1919-
Hirst, Charles Terry, assistant chemist, 1910-16; associate, 1916-
Hoff, Ernest Prior, assistant entomologist, 1909-10
Hogenson, James Christian, agronomist, 1920-21
Hulme, Benjamin F., superintendent Panguitch livestock farm, 1928-33
Hutt, William Nichol, horticulturist, 1902-04
Hymas, Charles Alfred, superintendent sheep experiment farm, 1928-29
Ikler, Kenneth Cole, animal husbandman, 1926-30
Israelsen, Orson Winso, irrigation and drainage engineer, 1916-
Jardine, William Marion, assistant agronomist, 1903-06; agronomist, 1906-07
Jennings, David Stout, associate agronomist, 1918-
Jensen, Charles A., assistant chemist, 1900
Jensen, Christian Nephi, plant pathologist, 1912-13
Jensen, Irving Joseph, assistant agronomist, 1918-20
Jones, Jenkin William, scientific assistant, United States Bureau of Plant Industry, superintendent Nephi dry-land station, 1915-18
Jones, Vilate, stenographer, 1931-34
Keller, Wesley, agent, United States Department of Agriculture; sugar-beet investigations, 1929-30; United States Bureau of Plant Industry, forage investigations, 1936-
Kerr, William Jasper, president, 1900-07
King, George Edward, assistant entomologist, 1919-21
Klomp, Dorothy Wallace, stenographer, 1936-37
Knowlton, George Franklin, assistant entomologist, 1926-30; associate, 1930-
Knudson, William Warren, assistant horticulturist, 1913-14
Larson, Andrew Olaf, assistant entomologist, 1917-19
Larson, Christian, dairyman, 1906-07
Lauritzen, John Irvin, assistant pathologist, 1913-14
Linfield, Frederick Bloomfield, dairyman, 1894-1902
Lund, Yeppa, assistant chemist and bacteriologist, 1918-21
McAlister, Dean Ferdinand, assistant physiologist, United States Bureau of Plant Industry, forage crops, 1936-
McFarlane, Wallace, assistant chemist, 1910
McLaughlin, Walter Wesley, assistant chemist, 1901-03; irrigation engineer, 1903-07, United States Department of Agriculture, 1909-13
McNatt, H. E. assistant animal husbandman, 1913-14
Madsen, David Edward, animal pathologist, 1929-
Madsen, Milton, assistant animal husbandman, 1935-
Madsen, Orson Perry, assistant poultryman, 1916-18
Maughan, Howard John, assistant agronomist, 1913-18
Maynard, Edward Jackson, animal husbandman, 1931-36
Mecham, Lucian, Jr., assistant botanist, 1918
Merrill, Charles Leo, assistant agronomist, 1912-13
Merrill, Lewis Alford, assistant agriculturist, 1897-1901; agronomist, 1901-06
Merrill, Melvin Clarence, horticulturist, 1918-21
Merrill, William Marion Johnson, secretary to director, 1916-18
Mills, Alonzo Albert, superintendent Station farm, 1890-94; agriculturist, 1894-97
Morgan, Harriet, assistant home economist, 1927-28
Muir, Maida (Stewart), stenographer, 1928-35
Nelson, Daniel Hans, assistant bacteriologist and chemist, 1924-25
Nelson, J. B., farm foreman, 1901-06; assistant agronomist, 1906
Nelson, Lowry, director, 1936-37
Nelson, Matthew A., assistant agronomist, 1911-12
Nelson, Peter, farm superintendent, 1921-25
Nichols, Bevard, assistant horticulturist, 1918
Northrop, Robert Starr, horticulturist, 1905-09
Nuffer, Louis Ferdinand, assistant botanist, 1919-26
Pack, Herbert John, assistant entomologist, 1920-25; associate, 1925-26; entomologist, 1926-29 (deceased)
Paul, Joshua H., president and director, 1894-96
Peterson, Elmer George, assistant entomologist, 1906-07; president, 1916-
Peterson, Erastus, assistant agronomist, 1910-11
Peterson, William, assistant horticulturist, 1899-1915; geologist, 1915-33; director, 1922-28
Pittman, Blanche Condit, clerk, editor and librarian, 1915-36
Pittman, Don Warren, assistant agronomist, 1916-26; associate, 1926-
Porter, Charles Walter, photographer, 1906-07
Pulley, Hamlet C., assistant bacteriologist, 1929-30
Quayle, William Littlefair, assistant chemist, 1911-13
Rasmussen, D. Irwin, associate biologist, Bureau of Biological Survey, 1937-
Richards, Bert Lorin, assistant plant pathologist, 1918-19; associate, 1919-25; plant pathologist, 1925-
Richman, Evert S., horticulturist, 1890-97
Sadler, Vincent A., assistant entomologist, 1911-12
Sanborn, Jeremiah Wilson, president and director, 1889-94
Sauls, Keifer Branham, secretary to the director, 1918-21
Schweitzer, Howard, assistant horticulturist, 1912-13
Smith, Harry Herbert, assistant animal husbandman, 1929-32; associate, 1932-
Smith, Leslie Albert, assistant bacteriologist, 1914-16
Snow, Willard Conrad, assistant chemist, 1906-07
Sorensen, Charles James, assistant entomologist, 1918-20; 1926-29; associate, 1930-
Sorensen, Stella (Burnham), stenographer, 1928-31
Stark, Arvil Lane, assistant horticulturist, 1934-35
Stephens, John, assistant agronomist, 1906-07
Stevens, Kenneth Richards, assistant bacteriologist, 1930-
Stewart, George, assistant agronomist, 1914-18; associate, 1918-19; agronomist, 1919-30
Stewart, John, assistant chemist, 1897-1900; associate, 1912-15
Stewart, Robert, assistant chemist, 1902-07; chemist, 1907-15
Stoddart, Laurence A., associate in range management, 1935-37; range ecologist, 1937-
Stucki, Herman Wilford, assistant agronomist, 1914-16; 1919-20
Swendsen, George Lewis, irrigation engineer, 1898-1903
Symons, Joseph Nathaniel, assistant rural sociologist, 1936-
Tanner, Joseph Marion, president, 1896-1900
Taylor, Estes Park, horticulturist, 1916-18
Thomas, Carrie, (Ely), clerk, 1917-20
Thomas, James Clayborne, assistant chemist, 1897-1900
Thomas, Moyer Delwyn, assistant agronomist, 1919-20; associate, 1920-27
Thomas, William Preston, assistant agricultural economist, 1926-29; agricultural economist, 1929.
Tingey, Delmar Clive, assistant agronomist, 1924-33; associate, 1933-
Titus, Edward Gaige, associate entomologist, 1907-09; entomologist, 1909-16
Tompkins, Christian Milton, assistant plant pathologist, United States Department of Agriculture, 1928-29
Turpin, George Melvin, assistant chemist, 1906-07; assistant poultryman, 1907-10; poultryman, 1910-12
Twombly, S. S., veterinarian, 1892-95
Venstrom, Cruz, assistant agricultural economist, 1934-35
Walker, James Henson, clerk, 1890-92
Walker, Rudger Harper, director, 1938-
Walker, William Lawrence, assistant chemist, 1908-10
Walters, Edward Haslam, assistant chemist, 1909-11
Wanlass, William Lawrence, economist, 1921
Wann, Frank Burkett, plant physiologist, 1927-
Warner, William H., assistant poultryman, 1926-28
Webb, Heber J., assistant entomologist, 1912-13
West, Franklin Lorenzo, meteorologist, 1911-24
Widtsoe, John Andreas, chemist, 1894-1900; director, 1900-05; president, 1907-16
Whornham, George, assistant field agronomist, 1929-33
Wilson, Alma Lavoy, superintendent, Farmington farm, 1920-31; associate horticulturist, 1931-35; horticulturist, 1935-
Wilson, John, assistant animal husbandman, 1912
Wilson, LeMoyne, superintendent, Sanpete experiment farm, 1927-33; assistant agronomist, 1937-
Wilster, Gustav, assistant dairyman, 1922-25
Winsor, Luther Murkins, assistant irrigation engineer, 1911-12; irrigation engineer, United States Department of Agriculture, 1918-28
Woodward, Rollo William, junior agronomist, United States Bureau of Plant Industry, 1930-
Woodward, Thomas Elwyn, dairyman, 1908-10
Wright, Joseph Alma, horticulturist, 1901-02
Yoder, Peter A., assistant chemist, 1901-02; associate, 1902-06; director, 1906-07
Zobell, Ira Deloss, superintendent, Carbon County experiment farm, 1928-33
PART II
Report of the Director
for the
BIENNIAL ENDING
JUNE 30, 1938
BIENNIAL REPORT OF THE DIRECTOR

Fifty years ago the Agricultural Experiment Station was established coordinately with the College as a result of the Federal Hatch Act of 1887 and the Territorial Legislative Act of 1888 for the purpose of conducting experiments that would lead toward a more prosperous, permanent and efficient agriculture and for the development and improvement of the rural home and rural life. These objectives were to be attained through the avenue of scientific research.

Immediately upon receipt of funds by the Experiment Station, a staff was organized and investigations were planned and initiated. Since that time an able staff of well-trained men and woman has been working diligently to solve the problems with which the agricultural people of Utah have been confronted. The contributions made by these people over the years have been reviewed briefly in Part I of this report.

In the early years of the College there was no organized body of knowledge available for the teaching of agriculture, either to the students at the College or the adult agricultural people of the state. Throughout these formative years, the College and the Extension Service were very largely dependent upon the Experiment Station for the discovery and development of knowledge relating to the agriculture of the state. Hence the success of the College teaching and the extension program in agriculture has been largely the result of the contributions made by the Experiment Station through its research program. The general agricultural efficiency throughout the state has also been materially increased as a result of investigations conducted by the Experiment Station. These have to do with every phase of agriculture and rural home life. Indeed practically every crop grown and every farm practice employed on Utah farms have been improved by experiment station investigators either in this or in other states.

Agricultural Problems Reveal the Need for Research

But the need for a thorough-going agricultural research program is no less today than it was fifty years ago. In fact such a program is even more urgent now than it was then, owing to complications developing through misuse and mismanagement of certain agricultural resources, particularly the soil and the range, and through the introduction of plant disease and insect pests following the more intensive cultivation of the land. Changing economic conditions, improved transportation facilities, new scientific developments in commerce and industry and many other factors have greatly affected agriculture in the past few years and have developed new problems that are urgently in need of study and solution for the development of a permanent and efficient agriculture. Without an adequate research program, the agricultural people of this state will probably be faced with insurmountable difficulties in a very short time. Even now, from day to day, they are
making insistent appeals to the Experiment Station for help in the solution of their problems and the Station, in many instances, is unable to tackle these problems, and must appear as one with his hands tied, owing to insufficient funds to conduct the necessary investigations.

**Funds Available for Agricultural Research**

Owing to the strained financial condition of the state during the years of the recent economic depression, it was found necessary to reduce materially the funds made available for research at the Experiment Station. As a result the funds from the state appropriation were reduced from $86,500 a year for the biennium 1931-33 to $35,000 a year for the next biennium. This fund was again reduced to $28,500 a year during the biennium 1935-37. During the present biennium, state funds available to the Station amount to only $37,500 per year. The trend of the legislative funds available to the Station for research work during the past twenty years is shown below.

![Graph showing funds available for Agricultural Research](image)

The most significant facts indicated by this chart are (1) the year-to-year increasing support to the Station to meet the growing demands in the solution of agricultural problems up to and including the fiscal year 1933, (2) the sharp reduction of funds beginning with the fiscal year 1934 as a result of the economic depression, and (3) the failure of past legislative assemblies to bring these appropriations back to the level needed to meet the demands placed on the Experiment Station by the people of the state. This is a very serious situation, and one that now threatens to impair materially the activities of the Station, and to greatly reduce the size of the program that can be conducted on an adequate basis.
This restriction in state funds is doubly serious because of the fact that the demands upon the Station for service—which the farmers have a right to expect of it—have greatly multiplied in recent years. Furthermore, the federal and state programs in soil conservation, land planning, social and economic adjustments in land use, reclamation and irrigation developments, range improvement, and in many other phases of agricultural and rural home improvement, have all called for assistance from the Experiment Station. The demands for help and cooperation in these activities have been numerous during the past few years, and no small portion of the Experiment Station activity has been devoted to these problems, which has meant serious curtailment and neglect in many instances of the normal research functions of the Station. Without adequate financial support the Station cannot hope to investigate the pressing agricultural problems before the people of the state and at the same time cooperate with the federal and state agencies in their various programs in which the Station should take an active part.

Major Problems Confronting the Station

A few major problems stand out as being of primary importance in assisting the farm people of this state to develop their business on a permanent and profitable basis. These problems, in the main, have to do with the range livestock industry, the fruit and vegetable production industry, and the planning for proper utilization of land resources for the economic and social security and well-being of the people of the state.

These problems are of vital concern not only to the people directly engaged in farming but also to all the people of the state regardless of their business and particular interests. The dependence of the nation as a whole on agriculture and the relation of the success in the various fields of business activity to success in agriculture is as true today as it has been at any time in the past.

The Range Livestock Industry

In this state that consists largely of desert, foothill and mountain lands, 85 percent or more of the total land area is best suited for grazing of livestock. Hence the range livestock industry has developed until it is now the source of considerably more income than is derived from any other agricultural enterprise in the state. In fact, this industry is the backbone of the state's agriculture. Approximately two and one-half million sheep and one-half million cattle are produced annually in the state, practically all of which are grazed upon the range from six to twelve months of the year.

In the early days when the ranges were free to all and feed was abundant, efficiency of production was not an important item for profit in the business. But with increased numbers of livestock on the ranges, with curtailment of grazing privileges, and with badly depleted ranges in many places, the time is rapidly approaching when the strictest efficiency measures must be put into operation for any margin of profit at all to the industry.
It has been reliably determined that many ranges of the state are supporting no more than half the forage they once produced. This arises partly from the fact that the kind of vegetation now produced consists in many places largely of annual weeds, sagebrush and unpalatable species of little value. Only about one-fifth of the forage now grown consists of the good grasses whereas these once made up 60 to 70 percent of the forage value of the range. It is obvious, therefore, that the grazing capacity of Utah’s ranges is considerably less than it once was.

Complicating the situation still further is the fact that the annual calf crop of the state is approximately 58 percent. The average lamb crop is probably somewhat higher than this but it is reported to be no more than 60 lambs per 100 ewes in certain important sheep-producing areas, and some individual sheepmen report lamb crops as low as 40 percent. That means that approximately two beef cows, and two ewes must be grazed on our present overgrazed ranges in order to obtain one unit of animal increase. The inefficiency of such practices is obvious, and is certainly an important factor in the present distressed condition of the range beef cattle and sheep industries.

The livestock men of the state are not unaware of this critical situation, in fact it is all too real to them for many are in a serious financial situation; some are on the verge of losing their equity in the business and some are even approaching bankruptcy. Fortunately, however, they still have faith that something can be done to help them meet these difficult problems, and they have made repeated and strong appeals to the Experiment Station for help.

The Experiment Station, on the other hand, has not been able to make a vigorous attack on the problems of this industry owing to an inadequacy of funds. It has been able to employ less than one full time worker to investigate these problems. Studies have been made, therefore, of only minor problems because these studies more nearly fit the personnel and budget available. A vigorous attack on the problems at hand, and on those most urgently needed for saving the industry, calls for adequate support and continuity of funds over a period of years. Without these two—adequacy and continuity of support—little real accomplishment can be made in time to save this important industry. But with this type of support for scientific investigation into the problems at hand much progress can be made. It is within reason to expect that the calf crop can be raised to the neighborhood of 85 percent without increasing operating costs, the increase coming largely from improved management practices. Likewise, lamb crops of 100 percent or more may reasonably be expected. This would seem to be a simple and effective method of increasing the income from these industries. The increased efficiency would more than pay for the cost of the research, but of greater importance, the industry would be saved.

Already the U. S. Forest Service has offered its assistance in the prosecution of this research program. This assistance would be in the way of furnishing range land for experimental pastures, the labor of CCC boys in
cutting fence posts, and in building pasture and drift fences around the grazed areas. Such assistance would be of great consequence in the prosecution of this research and should be taken advantage of as quickly as possible.

Research in Animal Diseases Needed

Utah has a 50-million dollar livestock industry whose health must be protected, not only because of the economic issues involved, but because of the menace to public health. The toll exacted from Utah livestock by disease and parasites is difficult to estimate, but is known to reach astounding figures. Bang’s abortion disease of cattle is estimated to produce an annual loss to this state of $100,000. The combined loss due to trichomoniasis (a protozoan genital disease), mastitis and other infections of cattle probably exceeds the above figure. Many range cattle herds are reported to have as low as a 50-percent calf crop. Sheepmen commonly report increases as low as 60 percent. Stockmen cannot survive in the face of such a handicap. There is critical need for investigations to determine what relationship disease and parasites have to this loss.

Loss of poultry through disease is even more acute than loss in other livestock. The U. S. Bureau of Animal Industry estimates the loss from fowl paralysis alone to be 50 million dollars annually in the northcentral and northeastern states. Records show that this disease in Utah accounts for over one-half of the mortality in laying hens. Records obtained by the poultry extension specialist of Utah indicate that the mortality from disease in laying hens amounts to over 25 percent annually. It is probably true that the annual net proceeds received from the poultry industry are reduced by this or even a larger percentage.

It is impossible to make progress in control of various livestock diseases until information is available concerning the nature of each disease, its distribution, life cycle, and many other factors. It is the prerogative and responsibility of the Experiment Station to determine these facts.

The personnel in animal pathology now consists of only one trained veterinarian who devotes only three-fourths of his time to Experiment Station work. About one-half of this time is devoted to medical care of Experiment Station animals and general diagnosis such as autopsy and examination of various animals brought or sent to the laboratory for diagnosis, and reporting of same to the owner. It also includes directing the testing of large numbers of blood samples for Bang’s disease. The volume of diagnostic work has grown tremendously and it has been far-reaching in its effect. Since the inception of this diagnostic service in 1929, a total of 329,861 specimens have been examined. It is estimated the service has reached 20,000 farmers throughout the state.

Only about three-eighths of one man’s time, therefore, is available for research on the pressing animal-disease problems. This amount of time cannot possibly do justice to the highly important task of obtaining fundamental information for an industry so greatly in need of assistance. Additional personnel and a more adequate working budget are essential for the necessary experimental study of the animal-disease problems of the state.
The Utah Fruit Industry

Another agricultural industry sorely in need of assistance by the Experiment Station is the Utah fruit industry whose very existence is threatened by serious problems that have not only prevented development of the state's horticultural resources but are responsible for the serious decline of several of the more important phases of fruit production, notably of the apple and peach. Owing to lack of suitable fruit lands and operating funds, the Station has been unable to adequately attack the major problems which are contributing to this decline and preventing the profitable development of this industry.

Utah has many thousands of acres of irrigated upper bench lands in the more populous districts of the state, particularly in the Salt Lake and Utah valleys, which because of high water and land values must be devoted to intensive crops with a high return per acre. Completion of the Pine View and Deer Creek projects will provide an adequate water supply on several thousand more acres of such lands. Most of these lands because of their stony and gravelly character are poorly suited to the growing of staple crops, but are well adapted to fruit production. The water cost is high, and only intensive crops can hope to support families on small farms and pay back the water and land cost. Profitable development of these orchard lands, with resultant increase in rural population, income, wealth, and purchasing power, will provide increased demand for labor, broaden the state's taxable wealth and income, and contribute substantially to its growth and prosperity. Industries such as canning, refrigeration, by-products, and transportation would be directly benefited.

Such development, of course, is dependent upon profitable returns from well-managed Utah orchards and successful marketing of the fruit and fruit products produced. While it is true that the industry is at present encountering severe competition and serious difficulties in marketing the state's fruit output, it is also true that a well-developed demand exists for the fruits and fruit products which we grow, providing the Utah fruit industry meets the market demands for quality and pack at a competitive price. Not higher average prices but improved market quality and lower unit costs of production are needed to place Utah's fruit industry on a sound economic basis which will bring about its profitable development.

To this end, the Utah fruit industry badly needs better adapted fruit varieties and rootstocks which will increase average yields and thereby reduce unit costs of production, lessen severe losses from winterkilling of buds and trees, and better meet market demands. Similarly, losses from insects and diseases can be reduced by finding better methods of control and by the breeding of resistant varieties; low yields and quality can be overcome by improved methods of soil management, irrigation, fertilization, pruning, thinning, harvesting, grading, packing, precoothing, storage, and other orchard management practices. Markets can be extended by introduction of better early and late varieties to extend the season, as well as by varieties more suited to frozen pack, canning, drying, and other fruit products industries.
These needs can be met only by a vigorous and well-financed program of research on the more important problems facing the Utah fruit industry.

Land Planning for Agricultural Prosperity and for the Security of Rural Home Life

Agricultural prosperity and the security of the rural people and rural home life in Utah are closely linked with the proper utilization of the natural resources, particularly the soil, irrigation water and the range. Many of the past and present economic and social difficulties in the state can be traced to certain maladjustments in the utilization of these resources. State history is replete with stories of failure in land settlement in areas unsuited for farming, owing to insufficient precipitation, soils highly impregnated with alkali salts, or other unfavorable relationships between farm land and other natural resources or environmental factors.

In some sections the farm people are now in strained economic circumstances, as a result of an unfavorable balance or relationship between these various factors. Water rights are often controlled by the poorer soil areas, or insufficient water is available for adequate crop production. Farm units are frequently too small for economic production and in other instances adequate range facilities are not available to make the proper balance with the cultivated farm area for economic livestock production.

Moreover, real estate booms from time to time have encouraged the purchase of land and the building of homesteads in areas entirely unsuited for cultivated agriculture. Abandoned land and the loss of efforts and often the savings of a lifetime now stand as monuments of misdirected efforts in the settlement of land that nature never intended for cultivation. These practices are still going on in certain areas of the state.

It was only natural that many failures should have resulted from the trial and error method of settlement in the development of a new country. However, the people of the state are now faced with these mistakes of the past, and it is of first importance that something be done in the immediate future to make the necessary corrections and adjustments in land use in order to make possible a profitable agriculture and the security of rural home life. This can be done only through careful land planning based on scientific information concerning the numerous factors involved. Federal action programs such as those sponsored by the Soil Conservation Service, the Agricultural Adjustment Administration, the Bureau of Agricultural Economics and others, should be preceded or at least accompanied by a careful study of the natural agricultural resources of the state and a carefully developed plan of land use.

Certain basic information is essential before an adequate land-use plan can be developed for any area. A soil survey must be made to determine the soil resources; the characteristics, location, crop producing capabilities and limitations, and the proper management methods for the various individual soil types. Likewise, it is important to have an adequate inventory of the irrigation water supply and a careful study of the manner in which
it can be most efficiently utilized for the well being of the larger agricultural interests of the state. Local surveys already made by the Station indicate that this precious natural resource is being dissipated in many places on land which is inferior in quality and cannot give profitable returns.

The relation of the economic and social organizations to the natural resources is also fundamental to proper land planning and to the welfare of the people concerned. Too frequently in the past these important human factors have been neglected in planning for land use, but in this modern age of invention, improved transportation and communication, and with the necessity for a nationalistic or even inter-nationalistic attitude in economic and social relations, these factors cannot be neglected.

At the present time the Station is making an effort toward accomplishing something of real value in land planning in certain areas where the agricultural people have found themselves under extremely strained economic circumstances.

In the Uinta Basin a detailed investigation has been under way for the past three years where, in cooperation with certain federal agencies and the State Planning Board, studies have been made of the farm management and taxation problems. A soil survey and also an irrigation survey are in progress, and in the very near future an attempt will be made, on the basis of the data obtained, to develop a comprehensive plan of land utilization for the entire basin. Owing to the lack of funds with which to tackle these problems, the Station has not been able to make as vigorous an attack as the people of the area would like. It has seemed to them that the work has been slow and drawn out.

Likewise, in other areas, an attempt is being made by the Station to gather the information needed for proper land planning, but the work is extremely slow in comparison with the hugeness of the task. In order to keep pace with the developments going on and the need for a planned agricultural use of land on a scientific and economic basis, the Station will need to be more adequately supported with funds with which to do the work thrown upon it. It cannot hope to meet the needs of the agricultural people of the state with the present allotment of funds.

Other Problems Before the Station

Noxious Weeds

Weeds, within the past quarter century, have become a major problem to farmers of Utah. Already they have forced the abandonment of considerable agricultural land. Only supreme effort in recent years has checked the insidious advance upon farm and range of white-top, Knapp weed, morning glory, Canada thistle, and perennial sow thistle. Through the special appropriation by the last legislature for studies on weed control, a substantial beginning has been made toward the solution of weed eradication problems. This work has only well begun, however, and it would be extremely uneconomical to stop the work at this time. A special effort should be made to obtain
a renewal of this appropriation in order that the work might be carried forward to completion. Continuity of funds over a period of years is quite essential to a successful research program on problems of this type.

Diseases and Pests of Canning Crops

Disaster faces the canning crops industry on account of the increasing ravages of curly top and other virulent diseases. Very properly, the canning industry—both growers and processors—has appealed to the Station for relief from the risks which burden it. Each year of major outbreak of curly top results in loss estimated at several hundred thousand dollars to farmers and canners of Utah. The only hope lies in scientific research. A few thousand dollars a year spent on research may save an industry. While curly top has been particularly destructive to the tomato crop, it also attacks the other canning crops as well. There are several other serious diseases which do enormous damage and which need further study in order to develop methods of control.

Improving Quality and Disease Resistance of Cereal and Forage Crops

In recent years a deadly disease has invaded the alfalfa fields of the state. Alfalfa is our most valuable crop, and when disease strikes it, it strikes at a vulnerable part of our economy. It is imperative that a long-time program of alfalfa improvement be launched, to develop resistant varieties which can withstand the ravages of this disease. Similarly, in other crops, we are faced with what appears to be an eternal struggle against diseases and pests.

There are thousands of acres of alkaline land in the state which can be made productive and profitable to operate by the development of varieties of crops which are adapted to alkali soils. There is no question that investment of funds in research along these lines will repay the state many fold in increased agricultural wealth.

Physical Needs of the Station

Seed House for Plant Breeding

One of the most pressing needs of the Station is a seed house in which to store and work with valuable plant-breeding materials. At the present time no place is available for properly working with these materials and the seed-storage facilities are extremely inadequate. Much valuable experimental material is lost or destroyed annually owing to this situation. The Bureau of Plant Industry has 4 full-time men assigned to work on plant breeding problems at this Station, and 3 men of our own staff are conducting investigations along similar and related lines of research. These men have made important contributions in the breeding of cereals adapted to growing under Utah conditions and in the development of varieties resistant to the ravages of disease. Special emphasis is now being directed to the development of superior varieties of forage plants for range and pasture lands of the state. Untold benefit to Utah's agriculture has resulted from these investigations. It appears ridiculous for the Station to sponsor so complete a program in
this highly important field without providing adequate facilities for the proper conduct of the work. The result is inefficiency of a high degree. It is strongly urged, therefore, that funds be obtained for the construction in the very near future of a seed house of such size and quality to meet the needs of experimental work in plant breeding.

**Greenhouses**

Much of the work in plant research in its various aspects is dependent on the availability of greenhouse space in which to conduct experiments under controlled conditions of temperature, soil, and humidity during the fall and winter months when plants cannot be grown out-of-doors. Insufficient greenhouse space is now available to meet the needs for plant research, and this will need to be increased by the addition of at least two greenhouses before a well rounded-out program of plant research can be developed.

**Garage for Car Storage**

A number of small pickup trucks are used by the Station staff and by the various United State Department of Agriculture men stationed here. At present there are no facilities for housing and caring for these cars. The trucks are left standing over night on campus driveways and the streets of Logan, and they are frequently kept at the homes of persons using them. It is obvious that this is an extremely undesirable practice and one that should be corrected immediately by the construction of adequate garage facilities for the housing and care of these cars.

**Land Acquisition Program**

The Agricultural Experiment Station is inadequately provided with land for experimental purposes. It probably owns less land than any other state agricultural experiment station in the United States. Only 125½ acres of owned land are available to the Station for research. Consequently, it is necessary each year to rent from 150 to 200 acres of land in order to meet the needs of the Station work. Rent on this land varies from $15 to $25 per acre, and during the past biennium the amount paid from Experiment Station funds for land rent was over $7,000. It is clear that this amount is an appreciable portion of the total state appropriation and it amounts to more than a fair interest return on the land investment. From a strictly economical standpoint, it would be better business for the state to purchase the land than to continue to rent it.

It is of far greater importance that the state should own the land used for experimental purposes for other reasons, however, than the land-cost item. Many of the experiments conducted call for the construction of buildings for the housing of animals, machinery and other equipment. This cannot be done on rented land. Moreover, certain experiments are of such a nature as to require a continuity of study on the same plots of land over a period of years. Such experiments cannot be conducted on rented land for fear the
land will be sold or otherwise taken over by the owner before the experiments are completed. Such a move would be disastrous to long-time experiments, and it would bring to naught most of the effort and money already expended on the experiments. This has happened to the Station program in times past and the progress of the work has been set back materially. The only solution is for the Station to own the land upon which experiments are to be conducted.

For economy and efficiency of operation, the Station should have title to 200 to 300 acres of land in addition to and in the vicinity of its present holdings near Logan. Another 40 to 50 acres should be acquired for horticultural research in one of the important fruit-producing sections of the state. This will be essential to the proper development of a horticultural research program of the type the fruit growers of the state are now demanding.

Although it is not essential that all of this land be purchased immediately, there should be developed a definite land acquisition program whereby certain pieces of land will be purchased from time to time as they can be secured. Special legislative appropriations should be set up for this purpose rather than attempting to make the purchases from the regular Station funds which might jeopardize the progress of the experimental program.

**Active Projects of the Station**

The work of the Agricultural Experiment Station is organized under specific projects with certain staff members assigned the responsibility of conducting the research. During the biennium, research has been actively prosecuted on 84 projects. Progress reports on certain projects have been made available in the bulletins and other publications of the Station, a list of which is given in another section of this report.

Owing to the desirability of publishing a review of the first half-century of work in the Station in this report, a detailed account of progress for each project is not given here as has been the custom in previous reports. Instead, only a list of active projects and project leaders is given, together with the name of the fund by which it is supported.

1 Nephi dry farm substation. (State) Agronomy and Soils: A. F. Bracken, leader.
10 Miscellaneous crop tests. (State) Agronomy and Soils: R. J. Evans, leader.
22 Factors influencing the bacterial activities of the soil. (Adams) Chemistry and Bacteriology: J. E. Greaves, leader.
34 Plant disease survey. (State) Botany and Plant Pathology: B. L. Richards, F. B. Wann, and H. L. Blood, leaders.
51-B Miscellaneous insects of cereals, forage, deciduous fruits, and stored products. (Hatch) Entomology: C. J. Sorenson, leader.


59 Davis County Farm. (State) Horticulture: A. L. Wilson, leader.

61 Range reseeding studies with native forage plants. (Purnell) Range Management: L. A. Stoddart, leader.


65 Weed control. (State) Agronomy and Soils: D. C. Tingey and R. J. Evans, leaders.

72 Relationship of stream discharge to precipitation with special reference to forecasting the supply of water for irrigation from seasonal surveys of snow cover on mountain watersheds. (Purnell) Irrigation and Drainage: George D. Clyde, leader.


90-C A study of factors influencing the financial conditions of certain Utah irrigation and drainage projects: C. Social aspects. (Purnell) Rural Sociology: J. A. Geddes, leader.

91 The effect of fertilizers on various properties of a highly calcareous soil and on the yield and quality of crops produced. (Purnell) Agronomy and Soils, Chemistry and Bacteriology: D. W. Pittman, J. E. Greaves, and D. S. Jennings, leaders.

93 Orchard rootstock investigations. (Hatch) Horticulture: F. M. Coe, leader.

95 Varietal testing of tree fruits. (Hatch) Horticulture: F. M. Coe, leader.

105 The nutritive value of high versus low calcium and phosphorus-carrying wheats. (Purnell) Chemistry and Bacteriology: J. E. Greaves, leader.

107 The mineral content of different varieties of wheat. (Purnell) Chemistry and Bacteriology: J. E. Greaves and C. T. Hirst, leaders.


126 Factors influencing the formation of double onions. (Purnell) Horticulture: A. L. Wilson, leader.


130 Plant growing and plant growing structures. (State) Horticulture: A. L. Wilson, leader.


135 Intermountain herbarium. (State) Botany: Bassett Maguire, leader.
137 Miscellaneous fertilizer tests. (State) Agronomy: D. W. Pittman, leader.
138 Grasshoppers and their allies with special reference to the species which menace farm crops and range forage. (Hatch) Entomology: W. W. Henderson, leader.
141 Curly top and psyllid yellows investigations. (Purnell) Botany and Plant Pathology: H. L. Blood and F. B. Wann, leaders.
143 Farm mortgage, land values and transfers, and farm taxation. (Purnell) Agricultural Economics: W. P. Thomas and W. U. Fuhriman, leaders.
146 Effect of calcium-phosphorus ratio on rate and economy of gain in fattening beef calves. (Purnell) Animal Husbandry, Chemistry and Bacteriology: W. E. Carroll and J. E. Greaves, leaders.
153 Miscellaneous tests on Greenville farm. (State) Agronomy and Soils: D. W. Pittman, leader.
161 Silage corn improvement. (State) Agronomy and Soils: R. J. Evans and D. C. Tingey, leaders.
163 A study of the relative efficiency of various phosphorus supplements. (State) Animal Husbandry, Chemistry and Bacteriology: W. E. Carroll and J. E. Greaves, leaders.
165 Application of a capillary resistance test to determine vitamin-C deficiency and the relationship of such deficiency to incidence of dental caries. (Purnell) Home Economics: Mrs. A. P. Brown, leader.
168 The application of hydrodynamics to the design of structures for controlling ground water. (Adams) Physics: Willard Gardner, leader.


176 Causes of country bank difficulties in Utah and effect of such difficulties upon supply of credit to farmers. (Purnell) Agricultural Economics: W. P. Thomas and H. H. Cutler, leaders.


180 Beet leafhopper investigations relative to tomatoes and other truck crops. (Adams) Entomology: G. F. Knowlton, leader.


182 Forage crops improvement. (State) Agronomy and Soils: R. J. Evans, Wesley Keller and Dean McAllister, leaders.

183 The vitamin-C value of tomatoes at various intervals during the tomato season (Purnell) Home Economics: Mrs. A. P. Brown, leader.


186 I. Results of applying a capillary resistance test to college students. II. Effect of varied vitamin-C intake upon reaction of a small group to the test and to urinary output of the vitamin. (Purnell) Home Economics: Mrs. A. P. Brown, leader.


188 Ewe lamb feeding investigations. (State) Animal Husbandry: A. C. Esplin, M. A. Madsen and Sumner Hatch, leaders.

189 A study of income parity for agriculture. (State) Agricultural Economics: W. P. Thomas, leader.


191 A study of range survey methods and vegetation analysis (Purnell) Range Management: L. A. Stoddart, leader.

192 Food studies I and II. (State) Home Economics: Mrs. A. P. Brown, leader.


194 Bibliography of Utah range management literature. (State) Range Management: L. A. Stoddart, leader.


196 Ascorbic acid excretion of college students on their customary diets and their response to a single dose of 600 milligrams of ascorbic acid. (Purnell) Home Economics: Mrs. A. P. Brown, leader.
Station Committees

1. **Greenhouse committee.** This committee was appointed to investigate and make recommendations on the apportionment of greenhouse space, and to consider ways and means of obtaining additional greenhouse facilities. The members are W. W. Henderson, chairman, J. E. Greaves, A. L. Wilson, F. B. Wann, and R. J. Evans.

2. **Peach mosaic committee.** The committee is to consider the proper approach to the study of peach mosaic. The members are B. L. Richards, chairman, J. E. Greaves, F. M. Coe, C. J. Sorenson, H. L. Blood, and F. B. Wann.

3. **Soil conservation committee.** The work of this committee is to cooperate with the United States Soil Conservation Service in working out a research program in soil conservation for Utah. Members of the committee are George D. Clyde, chairman, R. J. Evans, Willard Gardner, A. C. Esplin, and L. A. Stoddart.

4. **Farm tracts committee.** Organized to consider possible uses of various farm tracts owned or leased by the Station. Members, appointed for five years, include R. J. Evans, D. W. Pittman, G. Q. Bateman, D. C. Tingey, and H. L. Blood.

5. **Project committee.** The purpose of this committee is to make an inventory of the research program and to determine whether or not the Station is studying the most pertinent problems of the state’s agriculture and also whether it is making these studies in the most efficient manner. The members are R. H. Walker, chairman, W. E. Carroll, Willard Gardner, D. C. Tingey and D. A. Burgoyne.

6. **Manuscript committee.** Each time a manuscript is presented to the Director’s Office for publication a special committee is appointed to review the manuscript and to make recommendations concerning desirable changes in form or content and method of publication; i.e., whether it should be published as a station bulletin, circular, journal article or otherwise. The bulletin editor is a member of each of these committees.

Coordination of Research Program with that of Other Agencies

Cooperative Regional Agreements and Memoranda of Understanding

**Regional sheep breeding station.** A cooperative sheep breeding project with the United States Department of Agriculture and the 12 western states of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming, has been established. The work of this project is to be conducted at the regional laboratory known as the “Western Sheep Breeding Laboratory at Dubois, Idaho.” The object of the research is the improvement of western range sheep through the application of breeding methods.
Regional salinity station. This station is established in connection with the Rubideaux Station at Riverside, California, for the purpose of conducting cooperative research on the relationships of salinity of irrigation water, and of soil conditions to plant growth and related factors involved in a permanently successful irrigated agriculture. The project is established under an agreement between the United States Department of Agriculture and the experiment stations in the western region of the United States, including Hawaii.

Cooperative western range survey. A memorandum of understanding between the Agricultural Adjustment Administration, Forest Service, Soil Conservation Service, Resettlement Administration (now Bureau of Agricultural Economics), Agricultural Experiment Stations of Utah, Idaho, Nevada and Wyoming, and the Division of Grazing and Bureau of Indian Affairs has been agreed to, to assemble, analyze and interpret all usable data on the present condition and potential use of range lands within the region and to present the results on maps and by tabulations by counties to serve as a basis for future programs. It is proposed to coordinate and round out the range survey work of all cooperating agencies to insure uniformity in methods, procedure, analyses and results, to determine the location, extent, type and composition of plant cover and grazing capacity.

Cooperative Agreements and Memoranda of Understanding with Various Federal Agencies

The following is a list of the memoranda and agreements, indicating titles, bureaus and sections concerned and the general scope of the research:

1. Fusarium and related wilts, bacterial canker and mosaic diseases of tomatoes. (Botany and Plant Pathology Department; Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry) The purpose is to find tomato varieties resistant to the diseases most prevalent in the intermountain west. (Project 33)

2. Peach mosaic survey. (Botany and Plant Pathology Department, State Board of Agriculture, Bureau of Entomology and Plant Quarantine) This is a cooperative project with the state and federal government in an effort to eradicate the peach mosaic disease in Utah. (Project 34)

3. Grasshopper survey. (Entomology Department, Bureau of Entomology and Plant Quarantine) This project was established to check on the grasshopper abundance as an indication of points of outbreak during the coming season. (Project 51-A)

4. Insect pest survey. (Entomology Department; Insect Pest Survey, Bureau of Entomology and Plant Quarantine) This cooperative agreement is for the purpose of reporting upon insect outbreaks and abundance. (Project 51-A)

5. Relationship of stream discharge to precipitation with special reference to forecasting the supply of water for irrigation from seasonal surveys
of snow cover on mountain watersheds. (Irrigation and Drainage Department, Weather Bureau, Bureau of Agricultural Engineering, Forest Service) To make possible the collection of snow cover data over a wide area, the cooperation of the Forest Service and the use of its personnel in making annual snow surveys on the national forests was solicited. The Weather Bureau supplies some equipment, furnishes records, and publishes the results of the annual snow surveys in the climatological data sheet for March. (Project 72)

6. Production costs in dairying. (Animal Husbandry Department, Bureau of Dairy Industry) The project was initiated to work out problems in feeding, breeding, and management that will be useful to the dairy industry of the state. (Project 73)

7. Machinery for control of weeds. (Utah Agricultural Experiment Station, Bureau of Agricultural Engineering) The object of this cooperative project is the development of machinery suitable for the eradication and control of weeds on irrigated lands.

8. Alfalfa breeding and improvement. (Agronomy and Soils Department, Bureau of Plant Industry) This project is for the purpose of (1) increasing superior strains of alfalfa, (2) studying factors influencing seed production, (3) testing of alfalfa strains from various parts of the United States. This is part of a general alfalfa improvement program. (Project 128)

9. Agglutination testing for Bang's disease. (Animal Husbandry Department, Bureau of Animal Industry) This project is part of a federal program for elimination of cattle affected with Bang's disease. (Project 140)

10. Curly top and psyllid yellows investigation. (Botany and Plant Pathology Department; Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry) The vital and regional importance of the tomato disease problems in this section makes this problem of special significance. (Project 141)

11. Farm mortgage, land values and transfers, and farm taxation. (Agricultural Economics Department; Division of Finance and Taxation, Bureau of Agricultural Economics; Federal Works Progress Administration) This project proposes to investigate farm mortgages to find reasons for foreclosures and transfers. (Project 143)

12. Types of farming in Utah. (Agricultural Economics Department; Division of Farm Management and Costs, Bureau of Agricultural Economics; Agricultural Adjustment Administration) The object of this cooperation is to make a general description of the type of farming areas in Utah and to make a detailed analysis of these types. (Project 149)

13. Water application efficiencies in irrigation and their relation to irrigation methods. (Irrigation and Drainage Department, Bureau of Agricultural Engineering) To study water application efficiencies and the improvement of irrigation methods is the objective of this agreement. (Project 151)

14. Strawberry clover investigations. (Department of Agronomy and Soils; Range Management Department; Division of Forage Crops, Bureau
of Plant Industry) This project is for the purpose of testing strawberry clover under a wide range of conditions as a forage crop in Utah. (Project 160-B)

15. **Silage corn improvement.** (Agronomy and Soils Department; Division of Cereal Crops, Bureau of Plant Industry) To develop varieties of corn that are disease resistant and that are good silage yielders. (Project 161)

16. **Soil survey of Utah.** (Agronomy and Soils Department, Bureau of Chemistry and Soils, Resettlement Administration, Soil Conservation Service) This cooperation is for the purpose of making soil and land classification maps of the state to aid in land planning projects. (Project 169)

17. **Research in soil erosion and its control.** (Agronomy and Soils Department, Soil Conservation Service) The object of this project is to study in a thoroughly coordinated manner the main factors and forces involved in the incidence of soil erosion under general farming conditions, methods of prevention or control, and the most economic method of restoring lands already injured to varying degrees by the uncontrolled action of wind or water. (Project 171)

18. **Tomato fruitworm investigations.** (Entomology Department, Bureau of Entomology and Plant Quarantine) This is part of a regional program to investigate methods of control of insect pests that attack tomatoes. (Project 173)

19. **Causes of country bank difficulties in Utah and effect of such difficulties upon supply of credit for farmers.** (Agricultural Economics Department; Division of Finance and Taxation, Bureau of Agricultural Economics; Federal Land Bank, Berkeley, California) This project is for the purpose of making a detailed comparison of the loan and general credit policies of the Utah banks which closed during the depression and a corresponding number of country banks which survived. (Project 176)

20. **Study of agricultural resources of Utah and their utilization.** (Agricultural Economics Department, Agronomy and Soils Department, Irrigation and Drainage Department, Bureau of Chemistry and Soils, Bureau of Agricultural Engineering, Resettlement Administration, Forest Service, Bureau of Agricultural Economics, Farm Credit Administration) The object of this project is to measure by area the basic agricultural resources of the state and to translate the information collected into a program of more efficient use. The more specific objectives are: (1) classification of agricultural lands of Utah according to present and potential productivity and use; (2) determination of the net productive area of agricultural lands and water supply now available, or which may be developed; and (3) determination of the present use and methods of achieving utilization of land, water, and other resources as they relate to the welfare of the people of the state. (Project 179)

21. **Beet leafhopper investigations relative to tomatoes and other truck crops.** (Entomology Department, Bureau of Entomology and Plant Quarantine) The beet leafhopper investigation has great economic importance in
Utah because of the extensive damage done to sugar beets and truck crops by this pest. (Project 180)

22. **Forage crops improvement.** (Department of Agronomy and Soils; Forest Service; Division of Forage Crops and Diseases, Bureau of Plant Industry) This project was undertaken as part of the general cooperative forage plant improvement project. (Project 182)

23. **A study of income parity for agriculture.** (Department of Agricultural Economics; Division of Historical Research, Bureau of Agricultural Economics) This project is part of a nation-wide study in estimating income parity for agriculture. (Project 189)

24. **Soil Conservation Surveys.** (Agronomy and Soils Department, Soil Conservation Service) The agreement is for the purpose of covering cooperative efforts in soil erosion control. The specific object is to study the main factors and forces involved in the incidence of soil erosion under general farming conditions. (Project to be set up)

25. **Investigations on potato breeding and culture.** (Agronomy and Soils Department, Bureau of Plant Industry) The object of these cooperative investigations is to conduct potato breeding and cultural experiments including pathological investigations, with special reference to breeding for disease resistance. (Project to be set up)

26. **A study of farm organization and soil management practices in relation to agricultural conservation and adjustment with special reference to formulation of programs under the Soil Conservation and Domestic Allotment Act.** (Department of Agricultural Economics, Bureau of Agricultural Economics, Agricultural Adjustment Administration) The object of this project is to provide information to be used in revising and improving the Agricultural Conservation Program by a study of farm and ranch organization and operation, and a study of present land use. (Project 149)

27. **A study of range lands and range management practices in relation to agricultural conservation and adjustment with special reference to formulation of programs under the Soil Conservation and Domestic Allotment Act.** (Range Management Department, Bureau of Agricultural Economics, Forest Service, Agricultural Adjustment Administration) This study has as its object the providing of information to be used in revising and improving the agricultural conservation program by a study of the volume and kind of forage on range lands, a study of the productive power of these ranges as measured by plant cover, and by vigor of forages, and a study of the relation of forage type and plant vigor to needed adjustments in livestock numbers and seasons of grazing use in providing a better basis for planning the management of grazing lands. (Project 179)

28. **Breeding and improvement of range and pasture grasses and reseeding investigations.** (Agronomy and Soils Department, Forest Service, Bureau of Plant Industry) The object of these cooperative investigations is to obtain, through basic research, facts and materials applicable in pasture and range improvement. (Project 182)
Cooperative Agreements and Memoranda of Understanding with Non-Federal Agencies

The Station has cooperative agreements with several organizations. The list of these agreements indicating organizations, departments, purposes and scope, follows:

1. **Peach mosaic survey.** (Botany and Plant Pathology Department, State Board of Agriculture, Bureau of Entomology and Plant Quarantine) The peach-growing areas of Utah have been surveyed for identification of peach mosaic, so that any diseased trees could be eradicated in an effort to stamp out the disease in Utah. (Project 34)

2. **Noxious weed eradication.** (Agronomy and Soils Department, State Department of Agriculture, various counties) This cooperative agreement is made as a working basis for the state-wide campaign for weed eradication. Fifteen thousand dollars of the $100,000 provided by the last legislature for weed control has been turned over to the Station for experimental work. Under these agreements the counties furnish plots of land for 3 years, fence posts, irrigation water, and labor to construct fences. The Experiment Station plans and lays out experimental plots, furnishes chemicals and labor involved in treating plots and measuring results. (Project 159)

3. **Snow Surveys.** (Irrigation and Drainage Department, State Engineer) This project is established to make annual snow surveys of precipitation on, and the runoff from, the various watersheds of the state and to disseminate the information gathered in the form of reports. (Project 72)

4. **Turkey production studies.** (Animal Husbandry Department, Utah Poultry Producers’ Cooperative Association) This project is for the study of better methods in turkey production and marketing. (Project 172)

5. **W. P. A. weed eradication project.** (Agronomy and Soils Department, State Works Progress Administration) In this project the Experiment Station outlines the methods to be used in the state W.P.A. weed eradication project and checks on the results.

6. **Correlation committee.** (Agricultural Experiment Station, Extension Service, State Department of Agriculture, State Farm Bureau) This committee was organized by the various state agencies for the purpose of correlating the study of agricultural problems throughout the state.

7. **Bee-poisoning committee.** (Agricultural Experiment Station and State Bee-Keepers’ Association) An agreement was made to study the effect on bees of spraying crops with poisonous insecticides, and to devise methods whereby the danger of bee poisoning would be lessened.

8. **Survey of irrigation conditions, practices and methods in Salt Lake and Utah Counties on lands supplied with irrigation water from Utah Lake.** (Irrigation and Drainage Department, State Engineer) This cooperation is for the intensive study of water-application efficiencies and their relation to irrigation and water use. The U. S. Bureau of Agricultural Engineering also cooperates on this project. (Project 151)
9. Irrigation surveys in Utah Lake Drainage Area. (Irrigation and Drainage Department, Irrigation Companies of Utah, Wasatch and Summit Counties) Through this agreement, the Station is making a survey of lands irrigated by Provo River and its tributaries and classifying all lands, both irrigated and non-irrigated. (Project 151)

10. Groundwater and pumping studies in the Beryl, Cedar Valley, and Parowan Valley Areas, Iron County. (Irrigation and Drainage Department, State Engineer) The purpose of this investigation is to secure fundamental information with respect to pump operation, costs, and discharge from ground-water areas and water use, that will aid in obtaining a more efficient use of the ground-water resources.

Publications

The work of the Experiment Station is reported from time to time in its bulletins, circulars, leaflets and in articles published in various scientific and technical journals. These are distributed widely to farmers and other people throughout the state. They are also sent on exchange to libraries and scientific workers throughout the United States and to 893 foreign persons and institutions. Among the countries represented, are China, Great Britain, India, New Zealand, Syria, Turkey, Russia, Brazil, Sweden, Tanganyika, Egypt, Peru, Germany, Argentina, and Japan. From these countries are received publications of much value in research study.

At the close of each year an annual summary of publications is issued and distributed widely in order that interested persons may make requests for new publications of the Station.

During the biennium, 9 bulletins, 2 circulars and 1 leaflet were published. Besides this, 71 articles written by staff members and edited by the publications office appeared in scientific periodicals. Reprints of these articles were added to the reprint series. Forty-two mimeograph sheets on subjects of immediate importance were issued for state distribution. Each month a partial list of publications received by the Station library was also issued in mimeograph form.

The following is a list of Station publications for the biennium:

Bulletins


273 Drainage and irrigation, soil, economic, and social conditions, Delta Area, Utah: Division 3 - Economic Conditions, by W. Preston Thomas and George T. Blanch. Project 90.


276 How science aids Utah agriculture; biennial report of the director, 1934-36.
152 PIONEERING IN WESTERN AGRICULTURE—BUL. 282


279 The fruit tree situation in Utah, by A. L. Wilson and A. L. Stark. Work done under AAA project.


Circulars

108 Annual summary of publications. 1936.

109 Annual summary of publications. 1937.

Leaflets


Reprints from Technical Articles


Problemoj de agrikultura gruadscienco kaj skize de grundenklasigado (Problems of agricultural soil science and scheme of soil classification), by D. W. Pittman. Scienca gazeto. no. 35: 97-102. September-October 1937.


Research Library

The Station library is maintained as a research library with a collection of over 7,500 bound volumes, made up almost entirely of serial publications issued by governmental agencies and scientific organizations. Practically complete files of United States Department of Agriculture publications, United States Geological Survey reports, and state agricultural experiment station publications are available. It subscribes to over 150 scientific periodicals in agriculture and related fields which mainly supplement those taken by the College Library. During the last biennium 448 volumes were added to the collection.

The various departments of the Experiment Station also maintain collections of books in their special fields which are cataloged in the Station library. Ninety-six volumes were added during the 2-year period by the various departments.

The files of the library are available to Experiment Station staff and other faculty members, also to advanced students for research purposes.
# Financial Statement of the Utah Agricultural Experiment Station for the Fiscal Year 1936-37, Including the Amount and Source of Funds and the Classification of Expenditures

## Federal Funds

<table>
<thead>
<tr>
<th>Appropriation</th>
<th>Hatch</th>
<th>Adams</th>
<th>Purnell</th>
<th>Bankhead-Jones</th>
<th>State Fund</th>
<th>Total</th>
</tr>
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<td></td>
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## Expenditures

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<th>Purnell</th>
<th>Bankhead-Jones</th>
<th>State Fund</th>
<th>Total</th>
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*Includes Allotment from College State Appropriation: $28,500.00
Sales and miscellaneous: $18,962.23
Contributions: 4,121.70
Balance from previous year: 5,467.37
Total: 57,051.30
## Financial Statement of the Utah Agricultural Experiment Station for the Fiscal Year 1937-38, Including the Amount and Source of Funds and the Classification of Expenditures

### Federal Funds

<table>
<thead>
<tr>
<th>Expenditures</th>
<th>Hatch</th>
<th>Adams</th>
<th>Purnell</th>
<th>Bankhead-Jones</th>
<th>State Fund</th>
<th>Total</th>
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*Includes Allotment from College state appropriation: $37,500.00

Sales and miscellaneous: $14,274.25

Balance from previous year: $4,510.78

Contributions: $6,187.18

Total: $62,472.21
PERSONNEL

Staff

Peterson, Elmer George, B.S., A.M., Ph.D. ............................................................. President
Walker, Rudger H., B.S., M.S., Ph.D. ................................................................. Director
Peterson, William, B.S. ................................................................. Co-operator, Director, Agricultural Exten Service
Bernston, Russell E. ................................................................. Secretary-Treasurer
Burgoyne, David A., B.S., M.S. ............................................................... Executive Secretary
Porter, Wilford D., B.S., M.S. ................................................................. Editor
Harrison, Gladys L., A.B., Cert. Lib. ................................................... Librarian and Associate Editor
Bell, Donna Barton, B.S. ................................................................. Stenographer

Research Professors

Alder, Byron, B.S. ................................................................. Poultry Husbandry
Caine, George Ballif, B.S., M.S. ................................................................. Dairy Husbandry
Carroll, William Ernest, B.S., M.S., Ph.D. ......................................................... Animal Husbandry
Clayton, Christine Bockholt, B.S., M.S. ......................................................... Co-operator, Home Economics
Clyde, George Dewey, B.S., M.S. ................................................................. Irrigation and Drainage
Dunn, Paul M., B.S., M.S. ................................................................. Co-operator, Forestry
Evans, Robert J., B.S., Ph.D. ................................................................. Agronomy
Gardner, Willard, B.S., M.S., Ph.D. ................................................................. Physics
Geddes, Joseph Arch, B.S., M.S., Ph.D. ........................................................ Rural Sociology
Greaves, Joseph Eames, B.S., M.S., Ph.D. ................................................ Chemistry and Bacteriology
Henderson, William Williams, B.S., M.A., Ph.D. ................................................ Entomology
Hill, Reuben Lorenzo, B.S., Ph.D. ................................................................. Chemistry
Iverson, Orson Winso, B.S., M.S., Ph.D. ......................................................... Irrigation and Drainage
Madsen, David Edward, B.S., D.V.M. ........................................................ Animal Pathology
Richards, Bert Lorin, B.S., M.S., Ph.D. ........................................................ Botany and Plant Pathology
Stoddart, Laurence A., B.S., M.S., Ph.D. ........................................................ Range Management
Thomas, W. Preston, B.S., M.S. ................................................................. Agricultural Economics
Walker, Rudger H., B.S., M.S., Ph.D. ........................................................ Agronomy
Wilson, Alma L., B.S., M.A., Ph.D. ........................................................ Horticulture

Research Associate Professors

Bracken, Aaron F., B.S., M.S. ................................................................. Agronomy
Brown, Almeda Perry, B.S., M.A. ................................................................. Home Economics
Blanch, George T., B.S., M.S. ................................................................. Agricultural Economics
Coe, Francis M., B.S., M.S. ................................................................. Horticulture
Esplin, Alma C., B.S. ................................................................. Animal Husbandry
Fuhriman, Walter U., B.S., Ph.D. ................................................................. Agricultural Economics
Hirst, Charles Terry, B.S., M.S. ................................................................. Chemistry
Jennings, David Stout, B.S., Ph.D. ................................................................. Agronomy
Knowlton, George F., B.S., M.S., Ph.D. ........................................................ Entomology
Maguire, Bassett, B.S., Ph.D. ................................................................. Co-operator, Botany and Plant Pathology
Morris, Sadie O., B.S., Ph.D. ................................................................. Co-operator, Home Economics
Pittman, Don Warren, B.S., M.S. ................................................................. Agronomy
Smith, Harry H., B.S., M.S. ................................................................. Animal Husbandry
Sorenson, Charles J., B.S., M.S. ................................................................. Entomology
Stevens, Kenneth R., B.S., M.S., Ph.D.* ........................................................ Bacteriology
Tingey, Delmar Clive, B.S., M.A. ................................................................. Agronomy
Wann, Frank B., A.B., Ph.D. ................................................................. Botany and Plant Pathology

*On leave of absence.
Research Assistant Professors

Bateman, George Q., B.S. .......................................................... Dairy Husbandry
Cutler, Harold H., B.S., M.S. .................................................... Agricultural Economics
Madsen, Milton A., B.S. ............................................................ Animal Husbandry
Sargent, David L., B.S., M.S. ...................................................... Agronomy
Stark, Arvil L., B.S., M.S., Ph.D. .............................................. Co-operator, Horticulture
Stock, Eldon M., B.S. ............................................................... Irrigation and Drainage
Smith, Arthur D., B.S., M.S. ...................................................... Co-operator, Range Management
Symons, Joseph N., B.S., M.S. .................................................... Rural Sociology
Wilson, LeMoyne, B.S., M.S. ....................................................... Agronomy

Research Assistants

Anderson, Ariel, B.S., M.S. ...................................................... Bacteriology
Christiansen, Roy M., B.S. ....................................................... Botany and Plant Pathology
Hayball, Edith, B.S. ................................................................. Agricultural Economics
Larson, Everett H., B.S. ............................................................. Irrigation and Drainage
Jones, Louis W., B.S., M.S. ....................................................... Bacteriology
Wright, Ianthus, B.S. ............................................................... Agricultural Economics

Research Fellows

Chadwick, Raymond, B.S. ........................................................ Agronomy
Crandall, Bliss H., B.S. ............................................................ Agronomy
Domingo, W. E., B.S. ............................................................... Agronomy
Hanson, Wallace R., B.Sc. ...................................................... Range Management
Hardy, D. Elmo, B.S. ............................................................... Entomology
Thorne, James Perry, B.S. ....................................................... Agronomy

United States Department of Agriculture Collaborators

Bailey, Reed W., B.S., M.S. ...................................................... U. S. Forest Service
Bartholomew, O. F., B.S., M.S. .............................................. Bureau of Chemistry and Soils
Bateman, George Q., B.S. ....................................................... Bureau of Dairy Industry
Blood, H. Loran, B.S., Ph.D. .................................................. Bureau of Plant Industry
Carlson, John W., B.S., M.S. .................................................... Bureau of Plant Industry
Christiansen, Roy M., B.S. ....................................................... Bureau of Plant Industry
Dieffenbach, E. M., B.S. ........................................................ Bureau of Agricultural Engineering
Dorst, Howard E., B.S., M.A. ................................................... Bureau of Entomology and Plant Quarantine
Keller, Wesley, B.S., M.S. ...................................................... Bureau of Plant Industry
Krull, Wendell Henry, A.B., Ph.D. ......................................... Bureau of Animal Industry
Marshall, William H., B.S., M.S. .............................................. Bureau of Biological Survey
Maughn, J. Howard, B.S., M.S. ................................................ Bureau of Agricultural Economics
McAlister, Dean F., B.S., Ph.D. ................................................ Bureau of Plant Industry
Rasmussen, D. I., B.S., M.S., Ph.D. ......................................... Bureau of Biological Survey
Shapovalov, Michael, B.A., M.S. ............................................ Bureau of Plant Industry
Stewart, George, B.S., M.S., Ph.D. .......................................... U. S. Forest Service
Woodward, Rollo W., B.S., M.S. ............................................. Bureau of Plant Industry
Leaves of Absence

Dr. B. L. Richards, botanist and plant pathologist, was on leave of absence for the year 1936-37, which time was spent in study at Cornell University.

David Burgoyne, secretary to the director, spent the year 1936-37 in study at the University of Illinois.

John W. Carlson, assistant agronomist and former superintendent of the Uinta Basin alfalfa-seed experimental farm, who spent six months in advanced study at the University of Wisconsin, returned to the Station as associate agronomist in the United States Bureau of Plant Industry, and is working on the cooperative project on alfalfa.

D. C. Tingey, associate agronomist, returned in October, 1936, from a nine-months' leave to work with the Soil Conservation Service in Pullman, Washington.

D. W. Pittman, associate agronomist, spent six weeks in advanced study at Iowa State College in the summer of 1937.

Harry H. Smith, associate animal husbandman, did graduate work at the Kansas State College during the year 1937-38.

H. Loran Blood, associate plant pathologist, working for the division of fruit and vegetable crops and diseases, United States Bureau of Plant Industry, spent eight months in South America collecting native tomato plants to be used in breeding new adapted varieties resistant to curly top disease. He returned June 1, 1938.

Appointments

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<tr>
<th>Name</th>
<th>Position</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>Nelson, Lowry, Ph.D.</td>
<td>Director</td>
<td>July 1936</td>
</tr>
<tr>
<td>Stock, Eldon, B.S.</td>
<td>Assistant irrigation engineer</td>
<td>July 1936</td>
</tr>
<tr>
<td>Fox, F. Wilcken, B.S.</td>
<td>Secretary to the director</td>
<td>August 1936</td>
</tr>
<tr>
<td>Harrison, Gladys L., A.B.</td>
<td>Librarian and editor</td>
<td>September 1936</td>
</tr>
<tr>
<td>Bell, Donna Barton, B.S.</td>
<td>Stenographer</td>
<td>June 1937</td>
</tr>
<tr>
<td>Carroll, William E., Ph.D.</td>
<td>Animal husbandman</td>
<td>July 1937</td>
</tr>
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<td>Walker, Rudger H., Ph.D.</td>
<td>Director</td>
<td>April 1938</td>
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Resignations

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<tr>
<th>Name</th>
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<tr>
<td>Maynard, Edward J.</td>
<td>Animal husbandman</td>
<td>August 1, 1936</td>
</tr>
<tr>
<td>Klomp, Dorothy W.</td>
<td>Stenographer</td>
<td>June 30, 1937</td>
</tr>
<tr>
<td>Nelson, Lowry</td>
<td>Director</td>
<td>Sept. 1, 1937</td>
</tr>
<tr>
<td>Fox, F. Wilcken</td>
<td>Secretary to the director</td>
<td>June 30, 1938</td>
</tr>
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