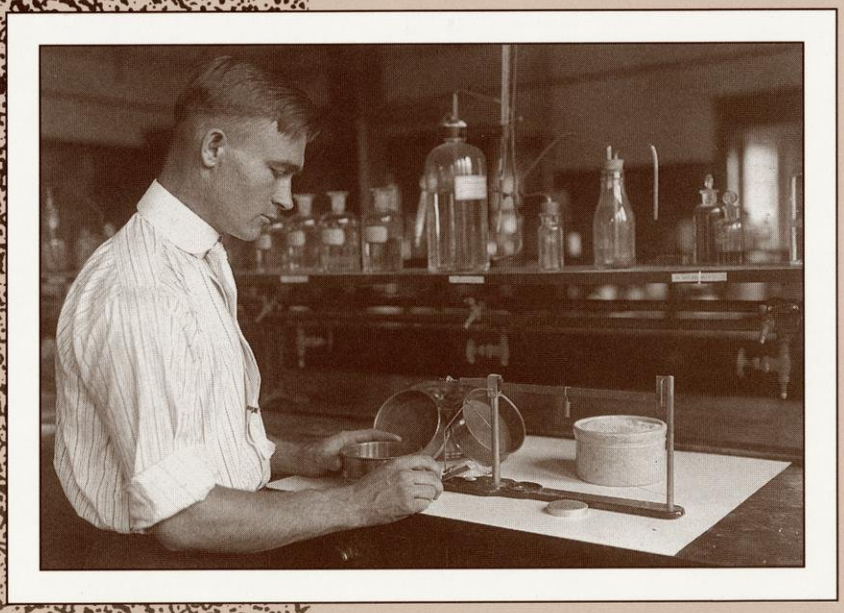
Soil science at the University of Wisconsin-Madison : a history of the department, 1889-1989. 1991

Beatty, Marvin T.
[Madison, Wisconsin]: Department of Soil Science, University of Wisconsin-Madison, 1991

https://digital.library.wisc.edu/1711.dl/XPYWMLGOQ7LGA86



SOIL SCIENCE

at the University of Wisconsin–Madison

A History of the Department, 1889-1989

Marvin T. Beatty

Soil Science at the University of Wisconsin–Madison
Marvin T. Beatty

Soil Science at the University of Wisconsin–Madison

A History of the Department, 1889–1989

This book is dedicated to Champ Bean Tanner, 1920–1990. One of his goals as chair of the Department of Soil Science was to have a history prepared as a part of the centennial observance of the department's founding. Champ read and helped me improve substantial parts of the manuscript. I wish he could have lived to see it in print.

MTB

TABLE OF CONTENTS

Foreword

It is an honor to have been asked to prepare a centennial history of the Department of Soil Science, University of Wisconsin–Madison. Preparing the document provided me with a chance to learn history and organize ideas, as well as many opportunities to get to know the current faculty, staff and program of the department. All of these were a pleasure.

Everyone whom I asked for information and/or assistance was extremely cooperative. My special thanks go to: John Murdock for writing the chapter on International Agriculture; Francis Hole for researching the life and activities of A.R. Whitson; the late C.B. Tanner for information and ideas, especially on F.H. King; Bill Roark for research assistance; John Harkin and Dick Corey for editing; and especially Sheri Speth for expert work on the manuscript.

MTB
April 1991

OPENING AND CLOSING CENTENARY ISSUES

In 1889 as the department came into being it was mostly ignored by prospective students, farmers and public leaders. The study of agriculture was considered beneath the dignity of most students at universities. Farmers and rural leaders could envision little that professors of agriculture in Madison could do via research to improve their success on the land, individually or collectively. As a new venture, the department, and the man who headed it, faced formidable challenges. Fortunately F.H. King, the department's founder, was also formidably astute, creative, courageous and energetic.

In 1989 the department faced many of the same challenges, but in a strikingly different setting. Students by and large did not identify with colleges of agriculture, nor with the Department of Soil Science, as places to pursue their interests in science, natural resources and the environment. A growing segment of farmers and rural leaders questioned whether research in soil science and the colleges of agriculture within which they are located was part of the solution or part of the problem. Like King, the faculty members of the department were asking new and probing questions. Should they continue to be identified only with the College of Agricultural and Life Sciences? How best could they reach the massive numbers of students in other schools and colleges of the university? How best to conceptualize and teach courses that deal with soil as a natural resource within ecological systems and not just as a medium for the growth of agricultural plants? How could they be recognized by research funding agencies as an entity which is important in the overall research enterprise of the United States? How to deal with the varying perceptions of the department's work?

These challenges are in part a direct result of the outstanding achievements of the department during its 100 year history, achievements that played key roles in the transition of a rural society into an urban one. The chapters which follow give some flavor of that exceptionally dynamic epoch and a few of the people who were a part of it.

Origins

The department now named Soil Science had its origins during the administration of President T.C. Chamberlin. Curti and Carstensen[1] describe Chamberlin's strong support for the agricultural college under the leadership of Professor Henry and note, "Chamberlin helped broaden its research base and was himself largely instrumental in establishing the department of soil physics under Professor King." Thus, in 1889, the beginnings of the department occurred, with the new entity being called Agricultural Physics—a title better suited to the breadth of King's scientific interests and activities. F.H. King actually had come to the University in January 1888, a little more than a year before department formation occurred in 1889.

Chamberlin, who has been described as an agricultural geologist by Tandarich & Darmody[2], undoubtedly saw introduction of a department to study the physics of soil, farm mechanics and meteorology as a priority because of his background as a geologist, his field work with the U.S. Geological Survey and his experiences in observing and mapping soils in the field while he was chief geologist of the Wisconsin Geological and Natural History Survey. Chamberlin's map of the soils of Wisconsin had been published in 1882 by WGNHS after Chamberlin had gone to Washington, DC to head the Glacial Division of the U.S. Geological Survey. Thus the seeds of the department were sown a number of years ahead of its actual formation.

King joined the faculty at a time when scientific studies relating to agriculture were beginning to be recognized as having value for a nation with massive areas of land to be settled by both foreign immigrants and settlers relocating westward from the eastern part of the United States.

---

1 Curti, M. and Carstensen, V. 1949. *The University of Wisconsin A History, 1848–1925.* Vols. I and II. Univ. of Wisconsin Press, Madison, WI.

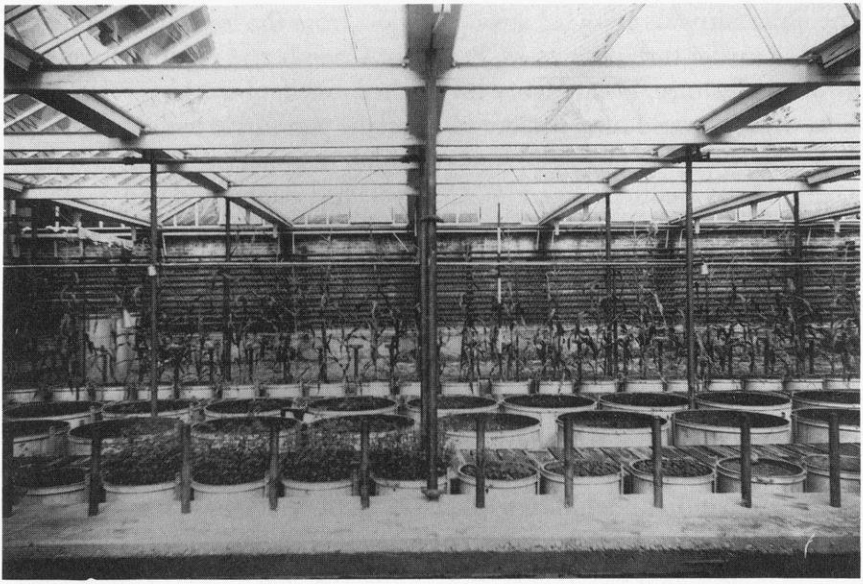
2 Tandarich, J.P and Darmody, R.G. 1989. *T.C. Chamberlin, Agricultural Geologist.* p. 6 *In* Geol. Soc. Amer. Abstracts 297.

The university was enjoying strong support from the legislature as compared to earlier turbulent years. President Chamberlin vigorously supported agriculture. Dean Henry established excellent working relationships with farm and rural leaders and became persuasive with legislative leaders in obtaining increased funds for both ongoing programs and new programs and facilities. The U.S. Congress had established and modestly funded the Agricultural Experiment Stations at each land grant university in 1887, an action which funded the research leading to rapid development of scientific agriculture. King clearly made creative, vigorous and effective use of this propitious environment.

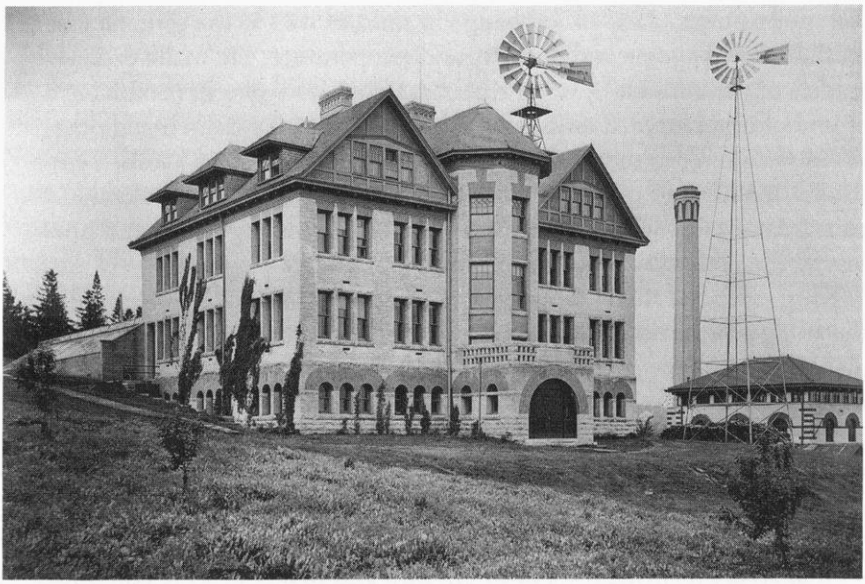
He quickly undertook investigations which established the scientific study of soils to be not only a fruitful area of investigation for the development of science *per se*, but also an area of studies which proved to be of immediate practical value to farmers and to developers of land in a state and a nation undergoing rapid settlement. With a great scientific and practical activity, he began investigations of: depth of soil from which plants obtain water, amount of water that soil in this depth is capable of storing, percentage of this stored water that is available to different crops, water movement in soils in relation to a variety of atmospheric factors, amount of water a soil should contain at the beginning of the growing season, supplemented by average rainfall to produce an average crop, methods of tillage and crops that give best results under varying soil moisture supplies, gas exchange in soils, as well as the influence of methods of tillage on soil porosity and temperature. He made extensive studies of the amount of water different crops transpire in producing a pound of dry matter. Concurrently, he began active research and observations of meteorology and related these to both crops and soils. These studies led King to pioneering studies of rooting of plants. He conducted painstaking excavations of the root systems of growing plants and preserved the results by excellent photographs and descriptions.

King extended this interest in soil-plant relationships by beginning the study of water soluble nutrients in soils in relation to nutrients in plants and to plant yields—an area of investigation which was expanded by A.R. Whitson when he joined King on the faculty in 1899. This work grew out of attempts to correct poor plant growth on muck soils in which King found that additions of potash fertilizers or barnyard manure, but not phosphate fertilizer, were highly beneficial.

King was a keen observer with a thorough understanding of fundamental scientific principles, both physical and biological. He combined these with a great facility for responding to the myriad of practical problems of the farming communities of the state and nation. For example,



Original Soils Greenhouse with F.H. King's lysimeters (large circular containers). *Department files.*



Horticulture Hall and Agricultural Physics, 1901, with F.H. King's windmills, and the West Campus heating plant to the left. *Department files.*

he took quick advantage of a disastrous windstorm which occurred in 1894 in central Wisconsin to make detailed observations of wind erosion of sandy soil and its effects on crops. He published the results, complete with sound recommendations for controlling wind erosion on sandy soils, within a year. He wrote extensively in a wide variety of popular farm publications on topics that included soil management, barn ventilation, construction of silos, farm road construction, farm machinery efficiency, farm implement draft, and a host of other problems to which applied physics provided sound solutions.

King brought an extensive background in teaching to his new position. In addition to teaching high school he had been Professor of Natural Resources at the River Falls State Normal School for ten years. Additionally he had studied two years at Cornell University and had worked with Chamberlin for a year after he had graduated from Whitewater Normal School. At Madison, King organized and taught three courses in the Long Course program. However, by far the largest number of students during the early years of the Department were in the Short Course. A Short Course catalog for 1900 lists Prof. King as teaching a first year course that was the practical application of physical principles, and for the second year students, generally the same topics as he taught in the Long Course. Clearly the level of treatment of the topics was less thorough, but still rigorous. Glover[3] states that in 1898, 33 of 99 short course students failed King's agricultural physics course!

The *Wisconsin Agriculturalist* magazine of April 27, 1899 contains a report of a visit by a staff member to the Short Course. Included is the following description of a visit to King's class: "Under Prof. King students are taught to manage and care for steam and gasoline engines and windmills, to set up and run feed mills, etc.; to take apart and put together the more complicated parts of binding machinery. In one of the greenhouses is practiced farm surveying, leveling, tile drainage, etc. Problems and experiments in dynamite are considered here, as [are] tests of drafts of farm machinery and wagons over various kinds of roads."

King served for three years as leader for the College's tiny four-year Long Course program, but Glover[4] reported that this assignment suited neither King nor Dean Henry. In addition to Experiment Station bulletins, King used publications such as the *Wisconsin Agriculturalist* and

---

[3] Glover, W.H. 1952. *Farm & College: the College of Agriculture of the University of Wisconsin: A History*, Univ. of Wisconsin Press. Madison, WI.

[4] Glover, W.H. 1952. *ibid.*

Hoard's Dairyman to disseminate his findings. The *Agriculturalist* for Feb. 10, 1898, for example, carried the complete text of King's address to the Forestry Association in which he spoke of reforestation, advocated mixed farming and forestry in northern Wisconsin, described woods and windbreaks for wind erosion control and proposed a 20– to 40–year tax exemption on farm woodlands—an amazingly forward-looking proposal.

King was ideally suited to begin a new discipline and at the same time respond rapidly and effectively to the needs and interests of an agriculture that was beginning to undergo rapid changes from the frontier subsistence system of a few decades earlier. As Glover[5] pointed out, farm organization leaders were looking to the fledgling College for scientific guidance for sectors of agriculture that were changing to a market orientation as railroads made the marketing of horticultural crops, dairy products, livestock and grain economically feasible, and at times quite profitable.

Established farmers in southern and parts of northeastern Wisconsin were looking for ways to improve drainage, increase yields and control erosion on sandy soils. The clearing and settlement of new lands in central and northern Wisconsin by new immigrant farmers was proceeding rapidly as well. Both groups were discovering that one key to their farming success was the nature of the soil they farmed and that another was the climate, particularly the length of the effective growing season. King's research, teaching and writing got to the heart of both of these variables, and illuminated the issues with sound and thoughtful conclusions and practical recommendations.

5 Glover, W.H. 1952. *ibid.*

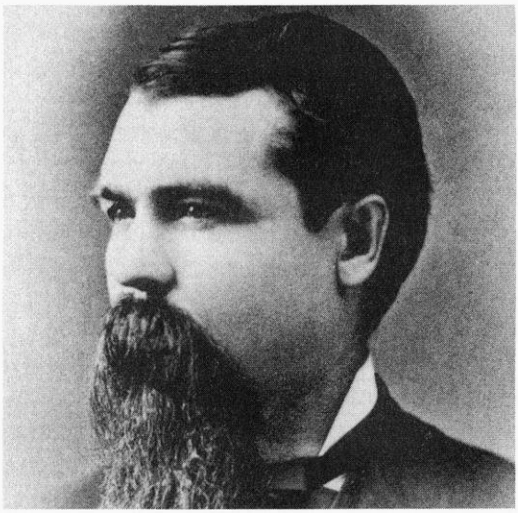
Franklin Hiram King

Franklin Hiram King was born June 8, 1848 and raised on a farm near Whitewater, WI. His paternal ancestors were Green Mountain folk, and his mother came from Nova Scotia. He attended Whitewater Normal (which is now the University of Wisconsin-Whitewater), graduating in 1872. An extra year was spent there in study under T.C. Chamberlin.

King was very much devoted to Chamberlin, who influenced his life greatly. After serious early misgivings Chamberlin apparently grew to respect King's abilities. King's sister reported that during an address at Whitewater after King's death Chamberlin admitted to real misjudgment of King as a student. He believed that King was slow rather than thorough and advised him, "King you're wasting your time here. Go back and follow the plow."

From 1873 to 1876 King taught high school at Berlin, WI. There he met Carrie Baker whom he married in 1880. Mrs. King, besides mothering five children, apparently carried out exhaustive literature reviews for her husband and helped him enormously in his professional undertakings in many other ways. After her husband's sudden death in 1911, she prepared two of his books and saw to their publication. Mrs. King lived a few months past 100 years and died in 1957. She suffered from crippled feet for which podiatrists could provide no relief. King, ever resourceful, devised a metal casting inserted in her shoe to provide relief. King's son, C. Howard, pointed out that, though it resembled a medieval torture instrument, it was the only device to cure his mother's pain.

While teaching high school King spent his summers working with Chamberlin for the State Geological and Natural History Survey. During the summer of 1873 King started a collection of bird specimens. In 1875 he published "A Scheme for Plant Analysis," later incorporated into the famous series of Wood's Botanical Textbooks. During 1876 to 1878 King studied physics, chemistry, biology and geology at Cornell University. Among many other undertakings, he augmented his knowledge of ornithology, including a study on the food of birds, by analyzing the stomach contents of 2,000 birds.



F.H. King, 1892 Badger Yearbook. *UW–Madison Archives.*

From 1878 to 1888 King served as Professor of Natural Science at River Falls State Normal, River Falls, WI (now the University of Wisconsin-River Falls). One summer during this period was spent at Johns Hopkins University's seaside laboratory, then at Beaufort, NC; another was spent with the U.S. Geological Survey studying terminal moraines in North Dakota. King and his wife devised models and relief maps of continents for use as instructional aids in physiography and meteorology while at River Falls. He also devised a method for the rapid reproduction of these models and maps and copies were supplied to other institutions.

An illuminating sidelight on one of King's experiences at River Falls was related by his son C. Howard. When King was addressing a youth group about nature he mentioned evolution, and this raised cries of "heretic" from some of the church members. Mrs. King told Howard that her husband never replied to the charges, but never entered a church again, although he continued to donate for his family.

In 1888, Chamberlin, by then President of the University of Wisconsin, and Dean Henry, of the College of Agriculture, created a post of Professor of Agricultural Physics and appointed King to it. It was the first position of its kind in the country. The work King did in the 13 years he was at the University was the most important of his career, except for two items. He earned such respect that E.W. Hilgard (the pioneering soil scientist in the United States) wrote in 1904, "by common consent, the mantle of Wolney" fell on King following Wolney's death. Wolney, a German, was regarded as the leading soil physicist in the world.

King left the University in November 1901, and until 1904 served as chief of the Division of Soil Climatology, later the Division of Soil Management of the U.S. Bureau of Soils, in the U.S. Department of Agriculture, in Washington, DC. There his work was devoted to the study of crop yields and soil composition in relation to soil productivity. Results of this work are summarized in Bulletin 26 of the U.S. Bureau of Soils, and in three papers published privately by King. Because of a disagreement with Milton Whitney, head of the USBS, about fundamental concepts in soil fertility, plant nutrition and scientific methods, Whitney asked for King's resignation in January 1904.

This dispute was a landmark event in soil management research. King had begun analyses of water soluble nutrients in some Wisconsin soils, and after joining the USBS continued the work in Wisconsin, Maryland, and North Carolina. Whitney contended that there was little difference among the nutrient concentrations in the soil solution of different soils throughout the country, and that solution of primary soil minerals maintained adequate nutrient levels to meet plant needs because total analysis of soils showed an abundance of the minerals needed to supply plant nutrients.

From this reasoning it followed that manures and fertilizers added to soil increased yields by destroying a "poisonous principle," probably excreted by plant roots, and that yield depended on soil physical properties alone. This had been published in USBS Bulletin 22 and in Farmers Bulletin 257. King opposed Bulletin 22 because he had conducted a series of fertilization experiments which showed that crop yields correlated well with amounts of nutrients in water extracts of soils, and that applications of fertilizers and manures increased the concentrations of these water extracts in line with increases in yields. These results directly contradicted Whitney's theory. When King submitted six bulletins for USBS publication, three were rejected and three accepted and eventually published. After resigning, King privately published the three rejected bulletins and mailed them to libraries and coworkers.

Hilgard published a ringing denunciation of Whitney's actions in the journal *Science*, describing them as a "return to medievalism" and noted that it was doubtful that "the puissant head of the Russian Empire himself would undertake to pass the censor's black brush over inductive scientific papers like those of King."

King, the father of soil physics in the United States, thus ended the phase of his multifaceted career which involved field and laboratory experiments proposing the concepts of available soil nutrients which became the foundation for the part of soil science now called soil fertility.

Following his resignation from the USDA and return to Madison, King pursued his interest in farm building design, including the distinctive round barn, and building ventilation. He published a book on the latter topic, and his unpatented system was used until the 1930s, often under other names. He also wrote for agricultural magazines and began his book *Soil Management*.

In 1909–10 King visited Japan, China and Korea because he believed that much could be learned from these ancient civilizations about how to give continued productivity to the agriculture of a young nation that was wearing out land at an extravagant rate. He used funds from his life insurance to finance the trip. His famous book, *Farmers of Forty Centuries*, was written as a result of that extensive trip. As this history is being prepared, students from a broad range of disciplines and interests have organized an F.H. King Society on the UW–Madison campus to discuss topics and issues in sustainable agriculture.

King was involved with his mentor, T.C. Chamberlin, in a scientific dispute over the role of lime for acid soils. King felt that Chamberlin was mistaken in his views but was reluctant to criticize Chamberlin, whom he greatly admired. Hilgard wrote King, "either you answer Chamberlin (in print) or we will,—and we will not be gentle." C. Howard King relates that his father reluctantly agreed to respond to Chamberlin's assertions via an article in *Science*, but that before sending the manuscript to the publisher King sent it to Chamberlin for comment. When it was returned without comment King sent it to the publisher with tears in his eyes.

Upon King's death in 1911, C.G. Hopkins, a leading early soil scientist, wrote:

"... when the science of agricultural physics is mentioned, we think first of F.H. King, for he laid that foundation, and for many years he was also the master workman upon the superstructure; yea, more—he developed methods of work and fashioned tools for the workmen; and he worked not only in agricultural physics, but he knew more chemistry than most chemists.

"But above and beyond all his work, we value most the spirit of the worker ... The discovery of truth is the joy of the scientists, and whether the discovery was made by himself or another, the satisfaction seemed equally great to this man."

This is a fitting tribute indeed to the man of great energy, common sense, intuition and devotion to society who founded what is now the Department of Soil Science.

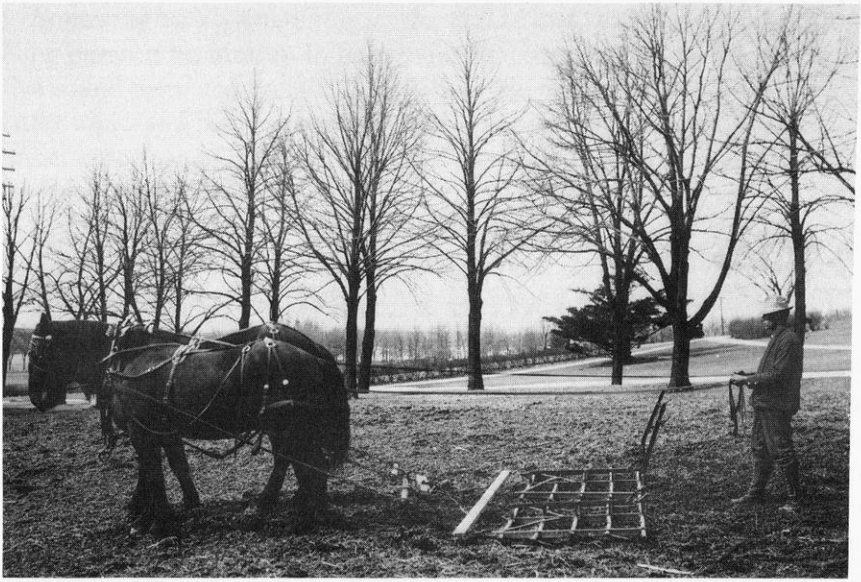
Serving a Growing State—Starting a Science

As the nineteenth century was ending, a few farmers and some of their leaders began to look increasingly toward the College of Agriculture for answers to a great variety of questions. The area of chemical relationships between soils and plants demanded answers that were more soundly based than the multitude of anecdotal experiences being shared around the state and nation. In 1899 King engaged A.R. Whitson as Assistant Physicist and Assistant Professor after his prior assistant, J.A. Jeffery resigned to take charge of agricultural physics and mechanics at Michigan State University. It was the beginning of a long and distinguished career for Whitson.

King and Jeffery had begun studies of the soluble salts in cultivated soils and of how best to treat swamp or humus soils. Whitson continued the studies started by King and Jeffery, and by 1900 he was studying the effects of various types of potassium fertilizers on organic soils, an area of research that he pursued for several years. In 1900 he reported on the first trials on mode of application and depth of placement of potash fertilizers. Studies of nitrate nitrogen in soils were started at the same time. Carryover effects of different potassium fertilizers and of barnyard manure were studied shortly thereafter.

In November 1901, King left the University to join the USDA in a new position which turned out to be one in which he gained long-term recognition for his honest support of the scientific process, even though it cost him his job. Whitson, who was promoted to Professor, and his assistant, F.J. Wells began to study variations in soils by studying the influence of different soils on the protein content of crops. The variation among soils was something which was to occupy Whitson for the rest of his career.

Among the many types of agriculture in the state, the growing of cranberries achieved a place in the department's research agenda by 1903. Dean Henry reported in his annual report for 1904 that studies of peat and moorland soils in central and northern Wisconsin were of special im-

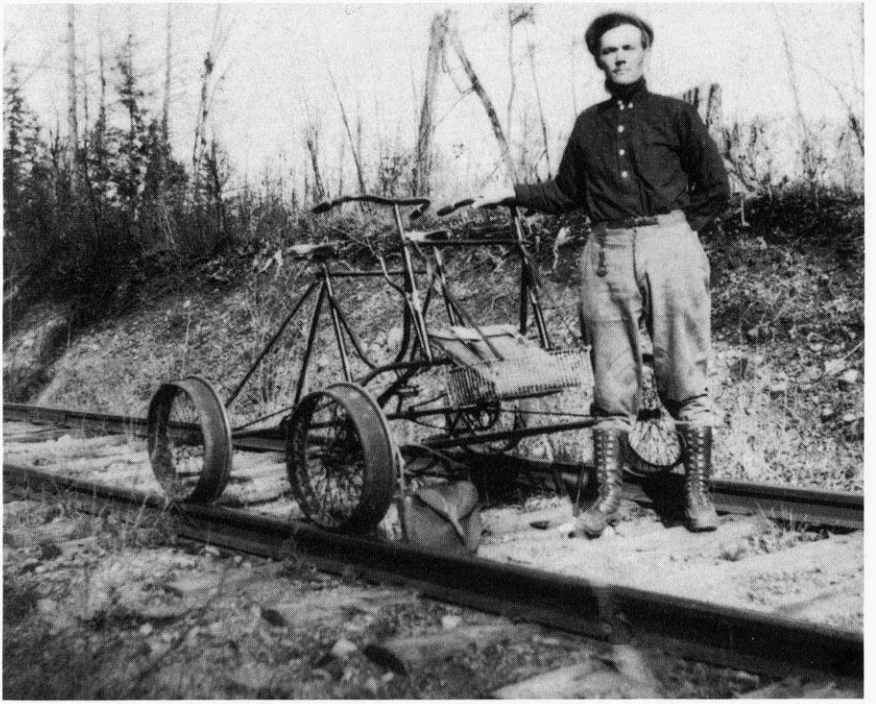


Plot tillage, West Campus. Date unknown. *Department files.*

portance, and noted that Agricultural Physics was carrying out studies on these soils in Juneau, Marinette and Wood counties. By 1904 Whitson had published a bulletin on water supplies for cranberries and joined other Experiment Station staff in authoring a comprehensive bulletin on cranberry production, harvesting and storage. Work on cranberries continued under the overall direction of the Soils Department for some years thereafter.

Whitson's influence in the department began to show very clearly by 1905 when he and C.W. Stoddard (who replaced the deceased F.J. Wells) published a report on the soils of Wisconsin which included a small colored soil map. While the map units were similar to those of Chamberlin's map of 1882, the basis for differentiating map units was genetic rather than physical soil properties, with emphasis on the parent materials from which the soils were derived. The research reports for 1900–05 make clear the growing awareness on the part of Whitson and Stoddard of the importance of soil-plant chemical relationships and the need to understand the distribution of soils within the state. Studies on potash and nitrogen were continuing and in 1906 the first results of studies on phosphorus in relation to cropping and soil acidity were published. Field research was being carried out at Sparta, Iron River, Marinette and Mather, in addition to the locations already under study.

In the years immediately after 1900, growing demands for research and growing numbers of undergraduate and short course students



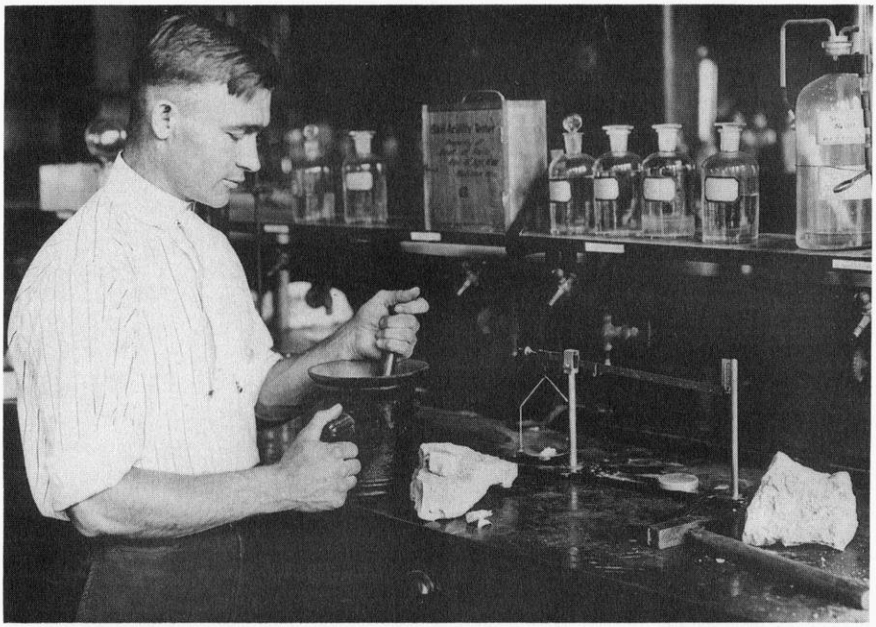
Carl Thompson conducting a soil survey in northern Wisconsin in 1913. ***A.E. Peterson.***

strained the resources of the department to the breaking point. So, in 1905 the Department of Agricultural Physics was divided, creating Agricultural Engineering and, at the request of Whitson, renaming the remaining department Soils. This narrowed the scope of the department to much more nearly what has come to be the discipline of soil science. It made the expansion of research and teaching by Whitson and colleagues much more manageable. (The name Department of Soil Science was adopted in 1965.)

Glover[1] reported that Whitson was also a strong advocate of the two-year Middle Course program which combined basic and practical courses in a two-year applied curriculum. Such a stance was consistent with the department's involvement in giving both scientific and practical field training to a multitude of young students who came to study and major in the science of soil. The soil survey, initiated in cooperation with the Wisconsin Geological and Natural History Survey and the USDA,

---

1 Glover, W.H. 1952. *ibid.*



Early Soils laboratory scene. Note Hellige–Truog Soil Acidity Test unit, number 6 on lab bench. *Department files.*

was one of the principal instruments for such combined education. So were the extensive field studies in soil fertility. A partial list of coauthors of soil survey reports over the years shows the array of soil scientists who got their early field training in this program: A.R. Albert, B.S. Butman, F.J. Carlisle, H.D. Chapman, Guy Conrey, T.J. Dunnewald, M.J. Edwards, J. Fudge, W.J. Geib, E.J. Graul, F.D. Hole, H.H. Hull, C.E. Kellogg, O. Magistad, R.J. Muckenhirn, F.L. Musbach, E.F. Nelson, O.J. Noer, W.M. Pierre, S. Rieger, G.H. Robinson, G.D. Scarseth, L.R. Schoenemann, S.W. Torrance, E. Truog, E.H. Tyner, G.M. Volk, and S.A. Wilde. Others, such as H.L. Walster, W.W. Weir, and O.R. Zeasman, joined the faculty shortly after completing undergraduate and graduate study.

The soil survey was initiated in 1909 with a special appropriation from the Legislature and was charged with the preparation and production of multi-county maps and reports for northern Wisconsin and county-by-county maps and reports for the more densely settled counties in central and southern Wisconsin. Surveys of Iowa, Waukesha and Waushara counties were completed in 1910, and the mapping, analytical work, cartography and publication of county and area soil survey reports continued at a rapid pace for more than 20 years under Whitson's direction.

In 1913 the Soil Testing Laboratory was established through action of the Legislature. Its mission included both sampling soils and performing laboratory analyses upon request for land owners and operators. The laboratory heightened the need for research on soil acidity, soil fertility and soil-plant relationships.

The faculty in Soils grew rapidly from Whitson and one or two colleagues to six, then seven, and by 1914, ten individuals. By then the program of research and extension had as major elements: field investigations in management of representative soils in regions of the state considered to have severe problems (central sandy soils, sandy soils in northeast and northwest Wisconsin, red clay soils along Lake Superior and poorly drained organic and mineral soils); laboratory and greenhouse studies of soil fertility; and the progressive soil survey. The scope, extent and results achieved prompted Dean H.L. Russell to feature the department's work in his 1914 annual report of the Agricultural Experiment Station. His opening paragraphs quoted below show the influence of King and Whitson on his thought.

"The soil is the great fundamental asset of our national wealth. Out of it come life and sustenance for the whole world of nature and mankind. Formerly it was customary to look upon it merely as a mass of inert particles, but we know it is composed of the most complex materials and in place of being dead and inert, it is pulsing with myriad forms of life."

"To conserve this bank account, and transmit it unimpaired to future generations is a duty which the human race owes to posterity, but, as with nearly all of our natural resources, man has wasted more than he has used."

"Every virgin area that has been opened up for settlement by man has had its pioneer generation of soil-miners, but if future human life is to receive adequate support from the soil, sooner or later the soil-tiller must quit robbing the land and feed his soil as he feeds his flocks."

"The last decade or two has brought the American farmer to a more complete realization than he has ever before known, of the duty that lies before him. The lessons that China and Japan learned a thousand years ago or more made their way slowly to the occidental world. Even the teachings of old England and the plains of continental Europe fell heedless on American ears. To our fathers the so-called inexhaustible fertility of the magnificent Mississippi valley could never be used up, but the declining crop yield of a section, whether it is wheat, corn, or cotton spell lessening profit and impairment of capital."

Dean Russell went on to summarize the work of the department. He first described Truog's zinc sulfide test for soil acidity which replaced the use of litmus paper; cited work on phosphorus availability, the relation of soil acidity to nitrogen availability, management of sandy soils, heavy clay soils, Colby silt loam soils, marsh soils and concluded with an

overview of the work on field drainage problems and progress in the soil survey. It was an overview of an active, young department which was beginning to make progress in getting answers to an array of the pressing problems facing farmers and other rural people.

Subsequent Experiment Station reports describe Truog's work on forms of soil acidity and the work of E.J. Graul (Soils) and E.B. Fred (Bacteriology) on inoculation of legumes to enhance nitrogen fixation. This collaboration continued as E.B. Fred and O.C. Bryan studied effects of soil acidity on nodule formation and growth in cowpeas and soybeans.

One departmental response to the distinctive needs of farmers on particular soil and climatic conditions was a series of bulletins which brought together the results of research on those soils under one cover in a publication designed to be used to guide farming practices. Such bulletins were prepared for red clay soils of the north, poorly drained silty soils of central Wisconsin, marsh soils and sandy soils. Bulletin 204, "Ways of Improving Our Sandy Soils," issued in 1914, is an example of the comprehensive approach used. Today it would fit well in the concept of sustainable agriculture. The authors, A.R. Whitson, F.J. Sievers and H.W. Ullsperger, stated that sandy soils needed special care when farmed because they were relatively easy to clear and because they were so easily exhausted when improperly farmed. They then dealt with the importance of adding "vegetable matter" to increase waterholding capacity; controlling wind erosion by shelterbelts; strip cropping; cover cropping with rye and legumes; fertilizing with phosphate and potash; liming and rotating crops and including legumes in the rotations. The revolutionary idea of fitting practices to the soils of each farm and field is prominent as a summation.

As research on soils of various farming regions of the state continued, Emil Truog began to develop a distinctive program of research which was to make him famous among soil scientists throughout the world. Experiment Station Bulletin 215, issued in Feb. 1915, spells out Truog's "New Test For Soil Acidity." The test, the apparatus and the bulletin that describes them are characteristically Truogian. The ingenious test is based on a simple application of fundamental chemistry—which no one had previously thought to use. Truog boiled a measured volume of soil suspension with zinc sulfide and calcium chloride and measured the resulting hydrogen sulfide by allowing it to react with white filter paper treated with lead acetate. The hydrogen sulfide gas formed gray lead sulfide in proportion to the soil acidity and darkened the white paper in

proportion to the volume of gas produced—thus indicating for the first time the degree of soil acidity.

The test was sound, simple and quick. The apparatus Truog developed for the test was in the very best tradition of a son of Switzerland trained in science. It consisted of an alcohol burner, flask, measuring spoon, two bottles of reagents, lead acetate-treated filter paper and calibration chart for reading the test results—all packaged in a sturdy, portable case so that it could be used in the field, in a farm kitchen or in an office. The entire kit could be purchased at a small cost.

Bulletin 215 is an excellent example of Truog's method of doing research, and reporting and using his results. His logic and application of chemistry in developing the test are followed by a thorough explanation of absolutely every detail of how to carry it out and interpret the results. Nothing was left to chance. Truog's only assumption was that the user was functionally literate enough to follow simple instructions. Even details such as how to obtain refills of the reagents at the local pharmacy and prepare the lead acetate paper were included.

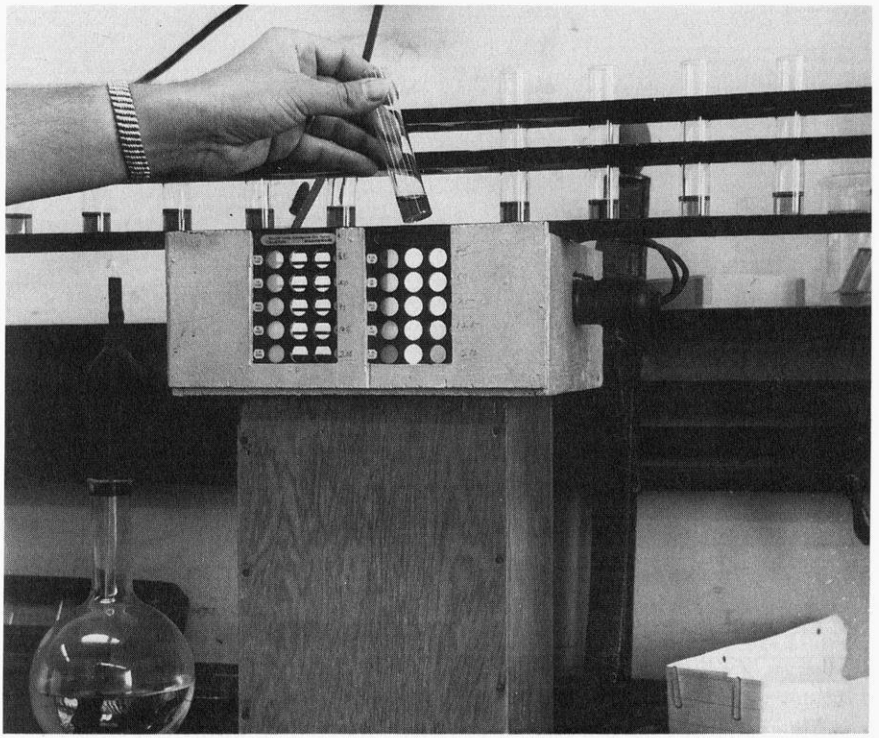
When it came to interpreting the test results in terms of liming needs, Truog performed a neat piece of tightrope walking to avoid conflicts with older colleagues and earlier recommendations. He first stated that the test showed that up to five tons of lime per acre might be needed, but then referred the reader to a bulletin by Whitson and others which recommended one to three tons of lime per acre. Probably Truog had already done enough greenhouse work on plant responses to lime to suspect that rates much higher than the one to three tons then recommended would be beneficial. Clearly he did not just pick the five ton figure out of the air; neither was he ready to contradict his department chairman. This test had all the elements that characterized Truog's work throughout his career—sound science, simple procedures, exact detailed descriptions, a complete equipment package and interpretations that were frequently ahead of everyone else's.

During the 1920s research work continued along the broad lines of endeavor started a decade or more earlier. The soil survey continued and map units were refined to show slope phases of some soils where erosion was an obvious problem; for other soils stony phases were delineated, and in Bayfield County the soil map units were related to forestry. Programs of active research at Ashland, Coddington, Hancock, Marshfield and Spooner grew and continued to respond to both ongoing and new problems. A.R. Albert was established as leader of the work at Coddington and Hancock stations and on the wet and sandy soil areas, respectively, which were associated with these stations. F.L. Musbach

was located in Marshfield as superintendent of that station and also was responsible for soils research at the Ashland and Spooner stations. Both men were beginning to have strong followings among farmers and community leaders in their geographic regions of specialization. Whitson continued to be actively involved in work with Musbach on crop rotations, farmyard manure, chemical fertilizers, liming and tillage.

Truog continued to develop his laboratory and greenhouse research systematically during the '20s in a way that had impact far beyond the research results obtained. After he had published his first, revolutionary work on testing for soil acidity, talented students began to come to work with him for the MS and PhD degrees. F.W. Parker received a fellowship from the Soil Improvement Association and shortly thereafter published results of work he and Truog did on obtaining the true soil solution, effects of lime on phosphorus availability and a comparison of methods of determining soil acidity. O.J. Noer, with support from the Milwaukee Metropolitan Sewerage Commission, did extensive studies in the field and laboratory on uses for activated sludge and determined that such sludge was especially valuable as a fertilizer for lawns and golf courses. Milorganite was the net result for the public. Support for a program of turfgrass research and a training program for students in turfgrass management grew out of this work. H.J. Harper worked with Truog on determining nitrates and ammonia in soils with the goal of developing practical tests for determining nitrogen supplying power of soils. O.C. Magistad worked on the osmotic pressure of plant sap in relation to fertilizer uptake, as well as on aluminum in relation to toxic effects of acid soils. W.H. Pierre also studied soil acidity with Truog, and began to apply electrometric methods of determining soil acidity at the beginning of the pH era. By 1927 Truog and H.W. Kerr reported that soil acidity was the result of chemical reactions and that the principles of base (cation) exchange applied to soils "in a surprisingly definite manner." In the same year Truog reported his improved method for determining phosphorus. A year later Kerr, Truog and J.A. Chucka reported studies that showed the inorganic cause of soil acidity to be an aluminosilicic acid—which they associated with the clay mineral bentonite. They foresaw the findings as giving a much more sound basis for understanding and managing acid soils. Chucka also studied the micronutrient composition of activated sewage sludge, a forerunner to research 40 years later on microcontaminants in sludge.

The Wisconsin Experiment Station Report for 1928 summarized the soil acidity research of Truog, Kerr and Chucka, and on a facing page is the report of research by A.R. Whitson, H.D. Chapman and H.H. Hull

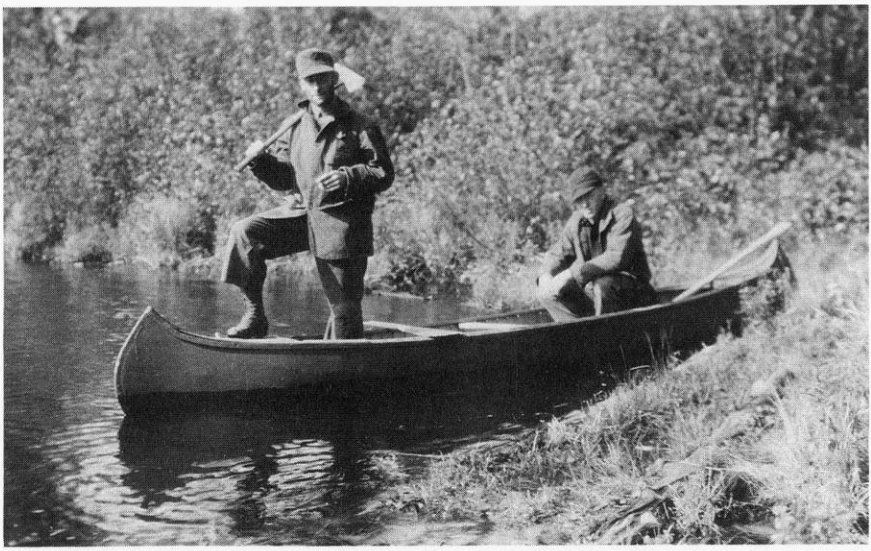


Soil test determination using color comparator. *A.E. Peterson.*

entitled "Not Soil Acidity, But Lack of Calcium, Which Limits Alfalfa Culture." Thus a long-running debate in soil science was brought clearly into focus. One wonders if the editors of the Experiment Station annual report juxtaposed the two conflicting research findings deliberately, since the disparate views of Whitson and Truog on this issue must have been widely known among their colleagues. Neither man was shy.

Continuing the basic laboratory work, M.C. Ford and Truog reported in 1929 on studies of iron phosphates in soils, and included X-ray diffractograms of basic iron phosphates. Their report noted that the addition of lime to acidic soil reduced the rate of formation of insoluble iron phosphates and favored the formation of calcium phosphates. Ford also prepared some of the first X-ray diffractograms of the clay fraction of soils.

The State Soil Testing Laboratory continued to expand and to incorporate new methods as they were developed. C.J. Chapman, R.P. Bartholomew and E.J. Graul operated the laboratory during the 1920s. As Truog and his succession of graduate students continued to pursue basic studies of soil-plant relationships and to understand more clearly



S.A. Wilde, with axe, and companion, circa 1935. *J.G. Iyer.*

the mechanisms governing them, Truog incorporated the results into new methodology for the Laboratory and the quick test kits marketed as Hellige–Truog soil test kits. In 1932 Truog announced the test for readily available phosphorus; in 1933 he reported an improved colorimetric method of determining soil pH in which neutral barium sulfate powder was used as a background for the indicator solution, and by 1934 Truog and N.J. Volk had developed a quick test for available potassium that was usable in the State Soil Testing Laboratory and in the quick test kit. In 1935 L.A. Dean and Truog announced methods for testing soils for manganese and magnesium, and in 1938 Truog and K.C. Berger reported their test for available boron in soils and plants. The pattern that Truog started early in his career of developing rapid chemical tests based on sound principles and giving meticulous attention to the apparatus and the details of the methodology has paid handsome dividends for farmers, trained many future leaders of the discipline of soil science and established the international reputation of the Soils Department.

In 1934 a new sector of the department started when S.A. Wilde joined the faculty and began intensive research on soil conditions in forest nurseries. Wilde's studies encompassed such topics as soil pH, types of organic matter, and nutrient amounts and balances as they affected the growth and hardiness of nursery seedlings. This was the era in which reforestation of cutover and abandoned cropland was gaining great popularity, so a dependable and economical supply of hardy nursery stock that was ready to grow after transplanting was imperative. Concurrently

Wilde studied site conditions for forest production in Wisconsin and nearby states using knowledge and experience he had gained in Czechoslovakia and other central European countries. Wilde worked with numerous graduate students, including H.M. Galloway, J.G. Cady, D.P. White, E.L. Stone, Garth Voigt and J.C. Kopitke. Again, the integration of research to solve immediate problems with sound science and the training of graduate students helped to create a whole generation of forest soil scientists who got their start from "Doc" Wilde.

A 1928 report by Truog on his teaching, advising and graduate student training gives a good idea of one part of the student-related programs of the department. He reported teaching Soil Science and Plant Nutrition to 18 students in 1927–28, Soil Analysis to 12, Seminar to 14 and Soil Research to 9. Truog's report also summarizes graduate degrees given during the mid-twenties. A total of 11 MS and 12 PhD degrees were awarded by the department in a five year period. The department ranked third in the College behind Plant Pathology and Agricultural Chemistry in PhDs granted in the five year period. He noted that, "Students who took higher degrees in Soils at Wisconsin are now located in practically every section of the country. There is always a greater call for our students for positions of this kind than can be filled."

The department's outreach into the state and beyond grew enormously at the same time as the research program and the soil mapping program were in full swing. In 1917 the department formed the Wisconsin Soil Improvement Association, an organization which published the *Journal of Soil Improvement*. H.W. Ullsperger was president of the association, W.W. Weir, vice president, and W.J. Geib was secretary-treasurer and editor-in-chief. The association had 261 members by 1918 and charged $1.00 per year for membership. The journals consisted of articles written for farmers and agricultural technicians on such topics as: seedbed preparation (Truog and Ullsperger), importance of legume inoculation (Graul), when and how to apply lime (Weir), commercial fertilizer for farm and garden (Whitson), depleting the soil with the dairy cow (Musbach), as well as articles by county agents and farmers. Truog's methods and equipment for chemical analyses of soil were becoming widely used throughout the nation and elsewhere in the world, in addition to their use in Wisconsin.

In 1921 the department hired C.J. Chapman, a former student of Whitson, to take charge of the State Soil Testing Laboratory. "Chappie" had been profoundly influenced by his experiences as a field representative for the American Chemical Company, a fertilizer manufacturer and distributor, where he had observed first hand the striking yield responses

of common crops to lime and fertilizers and the effects of increased crop productivity on the well-being of farm families. Since the lab operated by visiting farms and sampling the soils of the fields for analysis and then preparing recommendations for lime and fertilizer in the context of a soil management plan for the farm, Chapman, E.J. Graul and their colleagues had great opportunity to get to know the soils and farmers around the state. After several years as head of the laboratory, Chapman was appointed as Extension Soil Specialist with responsibilities for developing and carrying out an extension program with the county agricultural agents as a part of the overall program of the Agricultural Extension Service of the College.

One of the outgrowths of the New Deal era of social and public works programs was the test-demonstration program operated in cooperation with the Tennessee Valley Authority. The program started under Chapman's leadership, with research by Truog and Albert directly related to the effort. From 1943 through 1952 Forrest Turner led the test-demonstration program, which emphasized working with the same farm families over a five-year period in order to help them achieve real progress in adopting improved soil conservation, crop production, livestock production and overall farm management practices. He operated with an advisory committee consisting of representatives from the departments of Agricultural Economics, Agronomy, Dairy Science, and Extension District Directors. Following Turner's departure, A.E. Peterson gave leadership to the program until 1958.

With the advent of Truog's quick tests the department moved to equip each county extension office with a Hellige–Truog soil testing system and to train county agents in its correct use. Chappie developed county soil testing clinics with agents to heighten interest in soil testing and the use of lime and fertilizer among farmers. Chappie had been a believer in field demonstrations ever since his employment by American Chemical and these became the cornerstone of his extension program.

Complementing the work of Extension Specialists Chapman and O.R. Zeasman were the regional efforts of A.R. Albert and F.L. Musbach. Albert concentrated on the sandy soils and mucks of central Wisconsin; Musbach on the poorly drained soils of north central Wisconsin and the northern red clays. In 1936 Musbach was honored by the people of north central Wisconsin for his many years of leadership in developing a science-based agriculture which fitted the conditions of that region. The Marshfield newspaper reported that 1,000 people attended! Clearly Musbach was a person held in great esteem by the people of the area.

A.R. was notorious for his driving habits. H.L. Ahlgren related one trip with A.R. from Marshfield to Hancock and the encounter with a traffic officer it entailed. Albert, who was profoundly deaf without his hearing aid, always drove big Chrysler automobiles—and he drove them as fast as they would go. Ahlgren stated that A.R. had taken a graveled county road, removed his hearing aid, which closely resembled a "walk-man" radio in size and shape, and put the accelerator to the floor. A county highway patrolman came up behind and turned on his siren, to no avail. Finally, the officer pulled alongside and angrily motioned A.R. to stop. When the officer walked up to A.R.'s car, he started a tongue-lashing that lasted several minutes. A.R. was impassive until the officer's anger began to abate. Then he reached down on the seat, picked up his hearing aid, put on the headpiece, held the amplifier out the window, and said, "Here, Sonny, talk into this!"

Andrew Robeson Whitson

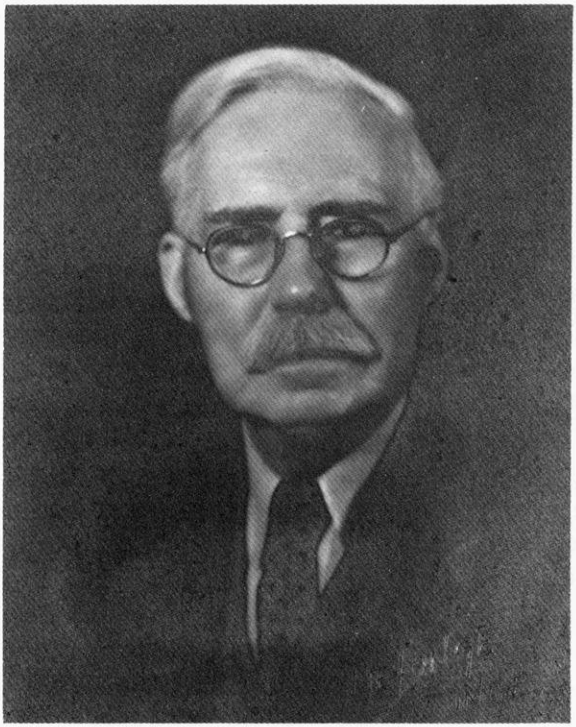
by F.D. Hole and M.T. Beatty

Andrew Robeson Whitson was born on a farm near Stanton, MN on Oct. 9, 1870. He was of English, Irish and Scotch ancestry, and his family had come to Minnesota from Canada. He was the sixth of seven children. His father operated a substantial farm and when Andrew was seven he was put behind the walking plow by his father and assigned to plow an 80 acre field. By age 10 he was hauling wagon loads of wheat 28 miles to Red Wing, MN for shipment down the Mississippi River. In 1881 the family moved a short distance to Northfield, MN where good schools and an academy were accessible for the children.

Whitson attended public school at Northfield and then took college preparatory work at Northfield Academy (now Carlton College). He is reported to have enjoyed studying rocks and plants more than he did Greek and Latin. He attended the University of Wisconsin from 1890–92 where he enrolled in courses in geology taught by Professors Chamberlin, Hobbs and Salisbury. When Chamberlin and Salisbury left Wisconsin to join the faculty of the University of Chicago in 1892 Whitson transferred to that institution and completed the BS degree there in 1894. During the summers of 1892 and 1893 he served as field assistant for Chamberlin and Salisbury in the employ of the U.S. Geological Survey. In that capacity he mapped glacial features, soils and soil erosion in the state of New Jersey. Whitson completed one year of graduate study at the University of Chicago in 1894–95.

In 1895 Whitson moved to Beloit, WI where he served as principal and instructor in sciences at the local high school until 1899. In 1897 he married Louise Fitch, a teacher of modern languages at the high school. During the summers of 1897 and 1898 he worked for F.H. King on King's research regarding groundwater, irrigation and water supply.

In 1899 Whitson was appointed to the position of Assistant Professor of Agricultural Physics at the University of Wisconsin, with the understanding that his duties at the University would begin in the spring of



A.R. Whitson. *Margaret Stitgen.*

1900 after he had taken further graduate training in soils and crop production at the University of Chicago.

He began work as a faculty member in Madison in April 1900 and initiated research on the fertility of marsh soils and the distribution of nitrates under major crops of the state. On the first Saturday of November Professor King informed Whitson that, on the following Monday 200 Short Course students would begin classes, and that Whitson would be responsible for teaching soils, land drainage, and the principles and practices of operating gasoline and steam engines and feed grinders. The experience convinced Whitson that a separate department of Agricultural Engineering was essential. It is probable that Whitson did not have King's natural facility for things physical and mechanical.

After King accepted an appointment with the USDA Bureau of Soils in 1901 Whitson was made Professor and Head of the Department of Agricultural Physics. He continued in this capacity, and after Agricultural Physics was divided into two departments, Agricultural Engineering and Soils, Whitson headed the Soils Department until 1939. In this capacity he led the development of the department and its programs of teaching, research, extension, routine soil testing, soil survey, and guided

it in the creation of positions for expanding the faculty and staff and selection of individuals to fill them.

Whitson was an able teacher who encouraged many young people to enter careers in soil science. He carried a heavy work load of teaching, research, administration and direction of the soil survey himself, and he expected others to match his dedication. On one occasion when he had travelled from Madison to Wood County to monitor the progress of the soil survey there, W.J. Geib and the other soil surveyors proposed that they move their operations from the swampy southern part of the county to the northern part for the summer because they were being eaten alive by mosquitoes, and return to the south in the fall when the mosquitoes had diminished. Whitson would have none of such ease and admonished the men, "The work will continue as planned from south to north in an orderly manner. I can assure you that the things that you complain most about in the present are the things that you will boast about in the future." Apparently Whitson was at least partly right. Geib related the story to Francis Hole nearly 50 years after the event occurred as one of the most memorable events in his long career in soil survey.

Whitson had a strong holistic view of the soil and the people supported by it. This engendered in him strong concerns about land use, soil erosion and the loss of organic matter as the soils of the state continued to be cultivated after conversion from supporting native vegetation for millennia.

Whitson died November 20, 1945. At his memorial service these words were offered in tribute to the man who shaped the department during its formative years.

"Professor Whitson planted at least three things in the good earth: Conservation of the Soil—He saw soil as almost a holy thing, to be kept and conserved and made to serve man and do God's will. Culture of Mind and Personality—He mixed farming with poetry and believed that an essential ingredient in the character of the countryside was in the minds and thoughts of the people who inhabited it. With his friends he sought the treasures of the mind and heart kept in the great literature of the ages. Character—He himself was quiet, steady, sturdy, not merely in person but in intent."

UNDERGIRDING THE SCIENTIFIC AND TECHNOLOGICAL REVOLUTION IN AGRICULTURE

All the work on soil fertility done from 1900 through about 1940 provided a new approach to soil fertility practices. In 1938 Truog presented a presidential address to the American Society of Agronomy in which he spelled out his beliefs that "the soil is a frugal custodian of plant nutrients" and that farmers and others raising plants could make deposits of plant nutrients in most soils just as they would make deposits of money in the bank, and then receive "interest" in the form of profitable increases in crop yields. This conceptual approach laid the basis for new approaches to soil fertility experiments for field and horticultural crops.

World War II gave a forceful impetus to increasing food production. Truog developed a plan to have several faculty undertake special field research aimed at achieving that goal. O.J. Attoe, Berger and M.L. Jackson began to study the possibilities for greatly increasing yields of common crops in Wisconsin by simultaneously optimizing all the soil and plant-related conditions necessary for maximum yields. Berger and Truog used this approach in 1942 to increase potato yields, and reported yields of 500 to 600 bushels per acre—about three times the usual yield! Canning crop acreage increased greatly as a result of wartime needs and Berger led the laboratory and field studies of nutrient needs and fertilizer requirements of crops such as canning peas, sweet corn, sugar beets, table beets and potatoes in the 1940s. He expanded his work on boron deficiency in crops such as alfalfa and began to study minor element deficiencies in other crops as well. He worked on achieving high crop yields throughout his career in the department.

Attoe and Jackson concentrated on drastically increasing high quality forage production in north central Wisconsin. Ingvald Hembre, Agricultural Agent in Barron County, had watched farmers there struggle with low productivity of crops and dairy cattle. He contacted the department and asked if some field experiments could be established to show local farmers and businesses what could be done to make the major soils of

Promotion of the Surefire Alfalfa program in Central Wisconsin. *A.E. Peterson.*

the county more productive of forage crops. The department responded by establishing long-term field research plots at two locations in the county in 1944. Attoe led the field research and Truog took an avid interest in the results, using them as a basis for numerous greenhouse and laboratory studies by his students. The experiment introduced what was then a powerful new concept in field studies—liming and fertilizing to correct soil conditions to what were considered optimum levels of acidity, available phosphorus and available potassium based on soil test, rather than applying small incremental amounts of lime and fertilizer as had been the approach used by earlier researchers. The results were spectacular in increasing the yields and longevity of alfalfa—now the major high-protein roughage for dairy cattle in Wisconsin. Similar studies were established on the Clark County farm under the leadership of Jackson with equally striking results. These plots were shortly transferred to Attoe's leadership as Jackson began to concentrate on laboratory research. Truog viewed the spectacular yield increases in Clark County and arranged to have the Board of Regents visit the experiment and observe the results. Taken together these studies laid the basis for a revolution in the production of forage crops for dairy cattle across a wide belt in north central Wisconsin—an area that is the heart of the state's dairy production industry today.

Plot harvesting crew (left to right): Sali Tun Than, Tom Nimlos, Art Peterson, Connie Olsen, Carrol Wells, Warren Sharrat, Dick Corey, Marc Cordes. *A.E. Peterson.*

The results of Attoe's and Jackson's field studies and Truog's insistence were keys to developing the "sure fire" alfalfa program. John Allen of the Neillsville Bank provided financing for farmers who undertook the program. A.E. Peterson and L.E. Engelbert provided leadership to the entire effort of transferring research results to farmers' fields. John Stauber, a banker and community leader in Marshfield was invaluable in promoting the availability of credit to farmers who would undertake to correct low soil fertility and strong acidity in order to shift to the new system of producing alfalfa as the principal forage for their dairy cattle. In 1951 fifty farmers were reported to have adopted this "sure fire" alfalfa method.

With its scientific, financial and technological foundations well laid the department moved to strengthen the basis for gaining widespread adoption of practices essential to alfalfa production in north central Wisconsin. A soil testing laboratory was established at the Marshfield Experiment Station and an extension specialist, Conrad Olsen, was added to the Soils faculty to run it and to conduct intensive educational work with farmers and agri-businesses in the area. Change has been steady and today alfalfa is the cornerstone of the dairy economy of north central Wisconsin. Yields of alfalfa and other crops have continued to increase as new varieties and cultural practices have evolved so that an acre which once produced a ton or so of poor quality, grassy hay now produces up to six tons of high-protein alfalfa.

Corn—a crop that had benefited from the recent advances of hybridization—was studied by Jackson and graduate students Leo Orth and Larry Marriott, who used the same approach of optimizing as many

Emil Truog with corn from the Pacemaker Corn Club program, about 1955.
A.E. Peterson.

growing conditions as possible to achieve the maximum attainable yields. They worked principally with increased plant populations and high levels of fertilization. Their work gave particular emphasis to massively higher applications of nitrogen than had been used previously in Wisconsin. By then the price of nitrogen was far lower than in the years prior to World War II as a result of conversion of munitions plants to nitrogen fertilizer production. Field trials on land at the Badger Ordnance Works near Baraboo in 1948 produced yields which reached 140 bushels per

acre from replicated plots. Truog, who had told Jackson earlier, "I think you should go ahead with it (the high yield field trial), since you are young and need the experience, even though I don't think it will work in Wisconsin," saw the results and mobilized all the faculty and graduate students in the department to visit the research and view the results first hand. By 1950 Jackson and the students had proposed a set of fertilizer recommendations and plant populations for producing 150 bushels per acre—more than three times the average yield for the state at that time, and still a bumper crop in 1989.

Truog grasped the implications of this research at once and promptly led the organization of the Pacemaker Corn Club program. This program had a goal of having as many farmers as possible compete in the Pacemaker contest and become members of the Pacemaker Corn Club by producing a measured yield of 100 bushels per acre on one or more of their fields. The program involved extensive cooperation with the departments of Agronomy, Entomology and Plant Pathology and active involvement of county Agricultural Agents across the state.

Participating farmers selected a field, had the soil tested, and received a recommendation for lime and fertilizer needed to produce the 100 bushel target yield. They were also advised on higher planting rates, suitable hybrids, and weed, insect and disease control methods. As the corn matured, Agricultural Agents in each county visited each farm, harvested and weighed samples from representative rows throughout the fields and sent representative ears to the Soils Department for determination of moisture content. Peterson and J. R. Love determined the moisture corrections and final yields, notified the winning farmers through their Agricultural Agent, and arranged for them to come to Farm and Home Week on campus in January to be recognized. The Memorial Union Theatre and Great Hall were alive with people on the appointed day each year. Participating farmers commonly selected a field with a history of high productivity, used liberal amounts of barnyard manure and did not skimp on commercial fertilizer. This may have led some to practice the "if a little is good more is better" approach to agricultural chemicals more widely than is sustainable when long term effects on water quality are considered.

The Pacemaker program did much to elevate the expectations and the skills among farmers which allowed them to grow far higher yields of corn than had previously been thought possible. It was a classic example of rapid technology transfer and clearly in the tradition of departmental concern for developing basic science, using the results for applied needs,

Walter Patzer making determination of available soil potassium using flame photometer. *A.E. Peterson.*

and then becoming directly and actively involved in the extension education programs to get the results widely adopted and applied.

Chapman continued the work with high-yield corn and preached the value of lime and fertilizer, especially nitrogen, for increasing corn yields up and down the state. He followed his usual plan of concentrating on a particular issue, in this case nitrogen fertilization of corn, for several years until he felt that a suitable level of adoption had been reached; then moving on to new problems and issues. One of his major continuing efforts was pasture improvement through fertilization. A sure sign of approaching spring was Chappie's truck loaded with fertilizer parked by the Soils building early in the morning as he completed a few office chores before setting out to deliver the fertilizers to County Agents for use in field demonstrations on pastures of cooperating farmers. Equally as certain a sign of the changing season was an early summer announcement of a series of extensive tours to see the spectacular results of fertilizing worn out bluegrass pastures.

A natural outgrowth of these revolutionary advances in crop yields on selected plots was a revitalization of the TVA whole-farm demonstrations. J.T. Murdock spearheaded this effort and, working with Farm and Home Development Agents in a wide array of counties, led the selection of participating farmers, soil sampling, recommendations for lime and fertilizer (some of which was supplied by TVA at favorable prices). In collaboration with Extension Specialists from Agronomy, Agricultural

Engineering, Entomology and Agricultural Economics, Murdock helped to guide the (mostly young) farm families in a planned, comprehensive upgrading of their plans and practices for crop and livestock production and marketing along with collateral improvements in their farm homes and buildings, soil and water conservation practices and equipment. Many of these farm families have since become leaders both in farming *per se*, and in agricultural cooperatives and livestock breed organizations.

The new advances in soil fertility research spawned the need for a wide array of additional research studies. Attoe, Engelbert and graduate student T.A. Richards developed a test for readily available nitrogen in the soil to help guide application of nitrogen fertilizers by farmers. L.M. Walsh and Murdock followed with studies of fixed ammonium and ammonia fixation in major soils of the state. Love, Peterson and Engelbert studied lime incorporation into soils. Their work led to additional studies by Olsen and R.B. Corey which helped to fine tune the recommendations for "sure fire" alfalfa. Berger and a series of graduate students studied micronutrient availabilities and responses of horticultural and field crops to micronutrient fertilization at high yield levels.

Attoe and students worked on ways to treat or encapsulate fertilizer pellets to achieve slow, steady release of the nutrients they contained. Even though their goal achieved only modest acceptance in commercial adoption, it may see much greater acceptance in future years as concern for groundwater pollution from leaching of fertilizer components such as nitrogen becomes more acute.

Soil testing has received sustained attention of the department from the time the State Soil Testing Laboratory was created until the present. After Chapman became involved in programs of lime and fertilizer demonstration H.H. Hull directed the laboratory for many years. The Wisconsin laboratory was among the first to shift from handwritten recommendations to computer-prepared recommendations. Early in the 1960s Corey and Walsh devised a system which allowed the Dairy Herd Improvement Cooperative to use its computer to write soil test recommendations in the era when keypunched cards were still in their heyday. Corey did major conceptual work which led to the preparation of corrective and maintenance fertilizer recommendations that expressed Truog's perception of "the soil as a frugal custodian of plant nutrients" in operational terms usable by agribusinesses, farmers, and urban residents alike. Walsh conducted both research and demonstration work on plant tissue analyses as a means of diagnosing the nutritional status of growing and harvested plants. This led E.E. Schulte to incorporate analyses of plant tissue into the lab's array of services and the redesignation of the Soil

Plot harvest crew relaxing after work, Owen, WI, 1957. Nilkanth Bhure, Stan Thompson, D. Hafs, Marc Cordes, Connie Olsen, Kanu Shah, Gordon Chesters (behind car), Jim Love (on car), Duane Moore (kneeling in front of car). *A.E. Peterson.*

Testing Laboratory as the Soil and Plant Analysis Laboratory, with subsequent addition of mobile vans for analyses of forage samples for the factors which determine forage quality. These mobile labs were deployed at hay auctions to give on-the-spot data on quality of the hay being sold, and led to the buying and selling of hay on the basis of scientific analyses rather than traditional subjective measures of hay quality.

As soil and plant tissue analyses became more widespread, and as more and more commercial enterprises supplying such services became established, the need for a laboratory to serve as a quality control center became very apparent. The Soil and Plant Analysis Laboratory now serves that role for both other public laboratories and the host of private laboratories which now operate throughout the state. The role of the laboratory in summarizing the trends in soil fertility statewide has been invaluable to fertilizer dealers as well as researchers. It is now proving useful as a basis for refining soil test recommendations to prevent excessive buildup of available phosphorus and potassium in farmed soils across the state.

As environmental concerns become more frequent and widespread, S.M. Combs, present director of the laboratory, is expanding its role in supporting the ongoing task of refining recommendations for lime and fertilizer to reduce the risks of groundwater contamination, along with increased emphasis on analysis of subsoils for nitrate as a means of avoiding excessive nitrogen applications. Analyses for heavy metal contaminants and other products of contemporary society in soils are also

increasing. To minimize possible contamination of groundwater from leaching of soluble nutrients such as nitrates, computer-generated recommendations now give appropriate credit to carryover nitrogen from animal manure and legumes in calculating recommendations.

Agribusiness, one of the key components of the technological revolution in agriculture, has received attention from department faculty ever since that sector of business began to develop. After Farm and Home Week, at which the department held an annual Lime and Fertilizer Dealers' meeting, was discontinued Walsh led development of creative alternatives. They included regional meetings held in winter and field meetings during the growing season at locations where dealers could view and discuss field research by department members. As the faculty who held major extension appointments assumed the primary responsibility for applied research in soil fertility they developed a written proceedings of the annual winter meetings at which research results were presented as a potent educational tool for their agribusiness clientele. This publication is a part of a larger, interdisciplinary effort by specialists in the Agriculture-Agribusiness program area of Cooperative Extension to meet needs of agribusinesses.

As the department neared the end of its first century the movement generally called sustainable agriculture became a strong and sometimes controversial presence. Many of the goals of the movement are ones that Truog, Whitson and King would endorse heartily. As the movement started in the late 1980s, K.A. Kelling joined R.M. Klemme of Agricultural Economics in organizing a series of "listening sessions" at which University faculty listened to the concerns of farmers and rural leaders. These sessions provided a forum for useful dialog between the two groups and gave the farmers and rural leaders an opportunity to influence research and field demonstrations of the department, and other departments in the college. By 1989 the education and research programs of L.G. Bundy, Kelling, F.W. Madison and Schulte integrated themes of environmental protection with those of efficiency in agricultural production. In this context the external consequences of human use of the soil assume increasing importance.

The department's ability to conduct research in soil fertility has been greatly enhanced during the last two decades by creation of the Wisconsin Fertilizer Research Fund. This fund is supported by an allotment from sales of aglime and fertilizers in the state. Much of the other funding to support research in soil fertility comes from a multitude of small grants from public and privates donors. This pattern of private sector support reflects the striking changes which have occurred over the approximately 90 years during which the department has been engaged in research on soil fertility.

Fundamental Research

The point at which this chapter begins is arbitrary. It could begin with King and his work on soil-water-plant relations, with Whitson's first work on soil-plant nutrient relationships or with Truog's first work on the nature of clay minerals and soil acidity. Here it is treated as a separate chapter beginning in the 1940s because there has been a continuous and multi-faceted program of fundamental research in the department since that time. One of the prime requisites for a program of fundamental research in a public university is legitimation; a second is money. The first was pioneered by Dean H.L. Russell for the College of Agriculture. The second was greatly aided by funding from the Wisconsin Alumni Research Foundation administered through the Graduate School. By the 1940s the college and the department were already known as entities which conducted basic research. Funding from WARF grew substantially during and after World War II and was invaluable to the Soils Department. After 1962, grants from National Science Foundation, the Department of Defense, AEC, National Institute of Health, and other public entities which support research became important funding sources for departmental research.

A major line of fundamental research began in 1940 when Jackson began X-ray diffraction studies of the occurrence and transformations of clay minerals in soils. By 1947 he and a series of graduate students had enough evidence to propose the first version of a comprehensive weathering sequence for the layer silicate minerals which form the bulk of the clay-sized fraction of soils. Jackson and his students developed methods for and made intensive use of X-ray diffraction and electron microscopy of key soils from many locations throughout the world. This use of a global array of soils rather than just Wisconsin soils represented a shift towards a comprehensive, basic approach to one aspect of soil science. It attracted students from many nations to Jackson's laboratory and made the Soils Department known worldwide for outstanding work in clay mineralogy.

In 1954 Truog succeeded in having the first electron microscope on campus installed in the Soils building. Proximity made it easy to have access to the equipment and the presence of a campus-wide research tool augmented the sense among both graduate students and faculty that the department was committed to and proficient in basic research endeavors. P.J. Kaesberg was added to the faculty to operate the microscope, with the Graduate School contributing to his salary. The microscope and Kaesberg were later move to the Biochemistry Department and Kaesberg's career in virology and molecular biology was launched.

An integral part of Jackson's research was investigation of aluminum, potassium, copper and other ions during weathering and their influence on soil pH, and cation exchange capacities. The work on aluminum led to Jackson's development of a unified theory of soil acidity which laid to rest a controversy over the inorganic source(s) of soil acidity that had been ongoing for nearly 60 years.

Subsequently Jackson and his graduate students and postdoctoral scholars extended earlier work on clay minerals to achieve the quantitative analysis of clays and the resolution of complexly interstratified mixtures of three to five clay minerals in some soil fractions by X-ray diffraction combined with various pretreatments with organic liquids and heating. After developing methods for isolating quartz in soils Jackson, J.K. Syers and D.L. Mokma showed that quartz in Hawaiian soils was derived from eroded dusts from continents. This work was extended to clarify the worldwide patterns of stratospheric dust movements and deposition and relate patterns of chert distribution to long-term continental drift patterns.

An integral aspect of Jackson's work included methodological development for soil analysis. First this involved modernization, systematization and publication of methods for classical soil analyses. Then came the privately published methods for segregation, purification and analyses of clay-sized minerals which became the essential reference for everyone working in soil clay mineralogy anywhere in the world. Jackson's methodological research and publications laid the groundwork for later publication of more comprehensive assemblages of methods of soil chemical and mineralogical analysis by the Soil Science Society of America. The Society's latest book on minerals in soil environments is dedicated to Jackson, in recognition of his pioneering work in the methodological research which made the current understandings of this complex field possible.

Jackson's interest in selenium distribution in relation to risk of heart disease and cancer let to a sustained collaboration with Chinese scientists in further elaboration of the possible relationships of trace element

Installing large weighing lysimeter in Plainfield sand at Hancock Agricultural Research Station. C.B. Tanner is folding plastic at left. *Department files.*

contents of soils and foods to human health. This line of research was a small part of a much larger concern by many researchers and non-scientists into the question of how composition of the foods we eat affects health and longevity.

In 1952 C.B. Tanner, who had joined the faculty as soil physicist three years earlier filling the position vacant since the departure of F.H. King, encountered the PhD dissertation of V.E. Suomi of the University of Chicago on the heat budget approach to understanding soil-plant-water relationships. This document gave new direction to Tanner's research in soil physics, and started him on a path of research on the soil-plant-atmosphere system which continued throughout his career. Shortly thereafter he and Suomi, who was by now a jointly appointed faculty member in the Meteorology and Soils departments, were publishing steadily on both the instrumentation for and the results of research on energy-driven interactions which take place at the soil-plant-atmosphere interfaces. The west end of the basement of the Soils building, which a few years before had housed Chappie's threshing machine and fertilizer storage bins, became the site for the design, construction and testing of exquisite and sophisticated electronic instruments to measure the ratio of evapotranspiration to sensible heat flux. These included the ventilated

net radiometer, averaging soil thermometer, sophisticated weighing lysimeter and other instruments which allowed measurement of each term in the energy and water budget equations. Tanner recognized that understanding the movements of fluids and energy in the soil-plant-air system was fundamental to scientific and technological advances in agricultural and ecological systems. In his work Tanner moved from understanding only the soil system to intensive work on the soil-atmosphere interactions of energy and moisture. Then he, W.R. Gardner, and E.E. Miller moved to develop rigorous theoretical parameters and empirical data on the soil-plant-atmosphere system through which energy, moisture and nutrients move. In this productive collaboration, they developed deep insights into the basic physics and biology underlying plant growth and development. This work has laid the basis for modelling studies of plant nutrient movements within soils, from soils to plants and within plants during growth and development. J.M. Norman has built on this foundation with computer-based models which apply to a growing array of plant species and soil conditions. Tanner's exceptional rigor in planning, execution and interpretation of experimental work and his consummate skills in designing and building instrumentation combined to make his contributions the standards by which other work is judged. His accomplishments led to his election in 1981 as the first soil scientist to be a member of the National Academy of Sciences.

The atomic age entered departmental research as radioactive isotopes of elements such as phosphorus and sulfur became available. Murdock and Engelbert began greenhouse studies of phosphorus uptake by corn using 32P, and later Murdock and Corey moved to the field for studies of phosphorus uptake from both surface soils and subsoils by corn, alfalfa and clover. Their results led to improved calibration of soil test recommendations by taking into account the contributions of phosphorus from the subsoil to plant growth.

Attoe, collaborating with O.N. Allen of Bacteriology, directed a series of graduate students, including G. Chesters and R.F. Harris, in a series of studies on the mold and bacterial products which act to form and stabilize soil aggregates. Chesters continued research on the organic fraction of soils after he joined the faculty, working with students C.S. Helling and D.E. Armstrong on the chemistry of organic matter and mineral contributions to the cation exchange capacities of soils. He and his graduate student, S.O. Thompson, studied the acidic properties of lignins and compared the properties of plant lignins to humic acids from soils.

In the 1960s Chesters and numerous graduate students carried out studies of the mechanisms and extents of degradation of widely used pesti-

Classified staff in the main office, about 1963. Margaret Stitgen is seated in the foreground; behind her are (left to right) Lois Skolaski, Beverly Pipkorn, Carolyn Elsie and Darlene White. *A.E. Peterson.*

cides such as atrazine, diazinon and lindane. The lindane study included revolutionary research on its adsorption by lake sediments. Armstrong and Chesters began study of the pesticide atrazine and published the first refereed journal article on its degradation processes in soil. This work was among the first to elucidate the basic mechanisms and the optimum conditions for degradation of these so-called "soft" pesticides in soil or sedimentary environments. Chesters' work on dieldrin was continued by D.R. Keeney with studies of its uptake, translocation and accumulation by plants. Chesters continued characterization studies of pesticides with his student, J. Konrad, as they worked on degradation of malathion, ciodrin and other organochloride and organophosphate insecticides. The work on pesticides in soils, water and the environment was a major, multi-year effort with substantial long term funding from the Agricultural Research Service-USDA, the U.S. Public Health Service and the Office of Water Resources Research, U.S. Department of Interior.

Chesters, J.M. Harkin, a lignin expert and organic chemist, and a continuing series of students proceeded to develop methodology for the study of reactions of many major pesticides in soils and waters. These studies not only helped to define the processes of movement and

transformation of organic chemicals applied as pesticides but also helped to form the basis for regulation of their application, as state and federal regulations were developed in the 1980s.

Fundamental research often develops from efforts to address everyday problems. One such development in the department has been fundamental work on modelling behaviors of plant nutrients and other elements in soils which grew out of concern for how these elements and compounds behaved in complex terrestrial and aquatic ecosystems. Corey, Keeney, Gardner and Norman pursued this modelling. For Corey this led to work on methods of providing nutrition for plants in weightless environments of outer space—an essential part of long space journeys by humans, since plants can recycle carbon dioxide and nutrients from wastes to provide food on such journeys.

The growth in scope and diversity of fundamental research, as well as the prospects for growth in funding for basic research, often led to consideration of future programs and facilities needs. A departmental position paper prepared in 1965 proposed to rename the department Soil and Water Science. It noted that the department's program had by then grown to include "physics of soil and water, chemistry of soil water and minerals, biochemistry of soil and water, soil classification, and soil and water conservation." The position paper pointed out that current competitive grants for basic research included:

Biochemistry of soil organic matter (Chesters)
Physics of soil/water atmosphere environment (Tanner)
Energy transfer at the earth's surface (Tanner)
Chemistry of water as affected by soil (Chesters, Corey, Jackson)
Geochemistry and geomorphic processes of soil development (Jackson)

Granting agencies supporting this work included the AEC, Dept. of Defense, NIH and NSF. The paper proposed that the department structure coursework to include emphasis on "the mounting soil/food/population crisis," develop "environmental science programs" in cooperation with other departments, and strongly integrate international programs and activities into ongoing department undertakings.

By the early 1970s the growth and diversification in fundamental research had been accompanied by growth in new applied research projects, resident courses and extension programs in waste disposal in and on the soil, nutrient and other elements in the environment, pesticide residues in the environment and land use and management. The era of operating a department with a substantially more comprehensive scope of faculty and student interests and backgrounds, sources of funding, and programs of research, teaching and extension was at hand.

Emil Truog

Emil Truog was born March 6, 1884 to Swiss immigrant parents on a farm near Independence, WI. He was the youngest of 10 children. Truog received his early education at a country school and small high schools in Independence and Arcadia, WI graduating from the latter as valedictorian of a class of nine boys. He came to the University of Wisconsin, received his BS degree in agriculture in 1909, and his MS degree in chemistry in 1912.

He was offered positions in both the English and the Soils departments. He chose the latter, but continued to hone his skills with the written and spoken word throughout his career. His students often felt as if he were giving rigorous instruction in both Soils and English as they prepared theses and papers for publication and watched as he methodically replaced many of the words they had labored over so long with his own. More than one of his students returned to the laboratory to tell fellow graduate students with a grateful wave of some pages of thesis, "There are four words here he didn't change!"

When he joined the faculty as Instructor in 1912, Truog took up residence in the University Club, where he developed enduring friendships with faculty colleagues, still unmarried, who later became powerful leaders in the College and University, just as he did. His paid career in the department spanned 42 years, and he remained actively involved and present in the department for another 10 years after he retired.

Truog embodied and exemplified many of the traits for which the Swiss are noted. He was methodical, logical, orderly, organized, tenacious, and had as a goal the betterment of farmers, farming and the soil. His standards and expectations were high, and his loyalty and support for those in whom he believed were fierce and strong. One of the memories that his students and colleagues carry is of the large table in his office which was completely covered with stacks of reprints and publications to a depth of 12 to 15 inches each. As discussion of research would touch on a topic that Truog recalled in the literature, he would get up, walk to the table, sometimes circling it once while concentrating on the

E. Truog, probably about 1950. *Department files.*

great mass of paper before him, and then reach into one of the 30 or so stacks of publications and retrieve the exact piece he wanted—usually on the first try.

Truog was short, probably about five feet three or four, but any disadvantage of his short stature was more than made up by the force of his personality. Wherever he was and whatever he was involved in, he brought to it an aura of decisive thought, forceful advocacy and immense persistence. This approach applied to everything from the athletic teams of the UW to state and national politics and the entire field of soil science and its applications.

In the field of soil science he was a leader of enormous significance. Not only did he have a knowledge of chemistry which surpassed that of most of his early contemporaries, but he started to augment his own knowledge and activities through the training of graduate students earlier than almost any other soil scientist in a U.S. university. His development of the first practical and effective test for soil acidity and the national and international recognition which this brought made him the person to whom the best and the brightest graduate students were directed for advanced degrees. These men came to a stimulating and challenging setting. The University of Wisconsin, now the University of Wisconsin–Madison, was unlike most Land Grant Colleges and Universities in having all fields of knowledge located in one institution, so

graduate students had ready access to first-rate departments in the basic sciences such as bacteriology, chemistry, botany, geology, physics and mathematics which would have been unavailable at many institutions. Truog had been a colleague of many of the faculty in these departments, both as a student and as a faculty member, so informal as well as formal working relationships for his graduate students were readily arranged.

Truog's leadership in professional societies was characteristically far sighted, forceful and persuasive. The best analogy from today's era is that of a truly effective lobbyist. When he seized upon an issue he informed himself thoroughly, marshalled all the arguments that supported his position, sized up the opposition, sounded out colleagues, developed an array of supporters and then used every opportunity that emerged, or that he could create, to press his views with vigor until he prevailed.

For example, Truog was instrumental in having the headquarters of the American Society of Agronomy located in Madison and in having a former student appointed as Executive Secretary. When the need for a larger headquarters building became apparent about 1960, then ASA President B.R. Bertramson appointed a building committee to evaluate sites in and around Madison which the Society could purchase to build a permanent headquarters. As it met to evaluate potential building sites, the committee learned that Truog and outgoing ASA Executive Secretary Larry Monthey had picked out the site they thought should be purchased, and, to insure that it wasn't sold to someone else while the committee deliberated, had purchased it themselves and were ready to sell it to the ASA at cost. Truog, who never left any stones unturned when he took on an issue, was left with a commercial building site on his hands when the committee selected a headquarters site other than the one he and Monthey had selected and purchased. It was one of the few times he lost.

Truog's vigor extended to his vigorous support of students and colleagues. Charles E. Kellogg told of Truog's generosity during the 1930s depression. Kellogg stopped in Madison to visit his former colleagues in the Soils Department and the WGNHS en route from Michigan to North Dakota where he was to be interviewed for a permanent position as leader of the state soil survey—a really good job in those lean days. During Kellogg's visit with Truog it was apparent that Kellogg's suit was a bit worn and that he had no money for a better one; so Truog reached into his billfold and gave Kellogg money for a new suit, shirt and shoes, and would never accept repayment from a grateful Kellogg, who got the job and later went on to be the leader of the soil survey program in the United States Department of Agriculture.

Probably Truog's most important support for his students came when it was time to find a job. Many, many of his students who had endured weeks of his rigorous, and sometimes scathing, revisions of their thesis were absolutely overwhelmed to read the glowing descriptions of their knowledge, accomplishments, abilities and potential in letters of recommendation which he wrote on their behalf. He followed up the letters in characteristic fashion with personal contacts to the potential employer, often one of his former students, on behalf of the newly minted PhD. In all of this Truog was an astute observer and evaluator of people. The positions for which he supported his students were ones well suited to their training, talents and interests.

One of the reasons for Truog's great contributions to soil science was his prodigious ability to put things into proper perspective—and to communicate that perspective in memorable ways. Graduate students in his research meetings in the Pine Room never forgot his critiques of students who emphasized items of data which had little significance and overlooked some big finding. Truog would tell about the man who went elephant hunting in Africa and who became so preoccupied with the mice running through the grass that he failed to see the elephants. Then he would look at the offending graduate student over his glasses and say, "There you go again, _____, looking at the mice when the elephants are trampling all over you!"

Truog used the opportunity of his presidential address before the American Society of Agronomy in 1938 to bring a broad and practical perspective on the role of soil science in American society to his fellow members. He highlighted the work of Edmund Ruffin, a Virginia farmer who pioneered in the use of lime, to illustrate ways in which scientific advances can occur and the pressing need for agronomists in general to become far more concerned with the depleted, acid and eroded soils of the United States. He said, "It is the duty of all agronomists to preach the doctrine that the major plant nutrient elements removed from the soil by crops must be returned, pound for pound, in the form of crop residues, animal manure, or commercial fertilizers, if soil fertility is to be maintained. Any other policy has in the past led to and will in the future lead to, first, soil depletion, then soil destruction by erosion, and finally economic ruin."

Truog's method of administering the Soils Department was one that would never stand the scrutiny of modern faculty governance. No faculty member from that era can recall that there ever was a faculty meeting. Instead, Truog decided policy and then garnered support for his decision by discussing it with faculty members one by one, beginning with

President Emeritus E.B. Fred, Margaret Stitgen, and Mrs. Fred at Margaret's retirement reception in 1967 after 45 years of service to the department. *Department files.*

those who were most likely to agree with him or to be persuaded to his point of view. By the time he discussed it with those who might be inclined to disagree he could say that almost all of the faculty supported his point of view. Only the very courageous chose to resist.

His working relationship with Margaret Stitgen, the department's long-time head secretary, is also instructive. Margaret epitomized the work ethic. She was always at work early, never took a break and expected others to do likewise. Not only was her work done promptly, but with accuracy, thought and neatness. Having thus worked ceaselessly all day, Margaret liked to leave at 4:30 p.m. on the dot to meet her sister and ride home with her. Truog, knowing this well, used to wait until about 4:00 p.m. to call Margaret into his office and dictate several letters. Margaret would stride out fuming, steno pad in hand, and begin to transcribe and type her shorthand so fast that the typewriter fairly smoked. Woe be to anyone who interrupted her then. About 4:25 p.m. she would take the finished letters and march into Truog's office, put them in front of him and say, "HERE!" Truog would sign them, silently hand them back, and Margaret would emerge, put them in the envelopes and take them to the mailbox as she left exactly at 4:30 p.m. No married couple ever had a better ritual in struggling for power.

Conserving and Protecting the Soil Resource from Erosion

Accelerated soil erosion began with the clearing and farming of Wisconsin by settlers from the East or from Europe. Even the early lead miners in southwestern Wisconsin contributed to the problem, as recent studies of valley deposits derived from mine tailing piles in that area show some to be high in lead. The phenomenon of soil erosion was noticed early by the young department. King reported on his studies of wind erosion in central Wisconsin in 1894, and expressed his concern about erosion clearly, both before he left the faculty and after he left the USDA, visited the Orient and returned to Madison to live and write. In his 1895 textbook on soils King stated, "The hills no longer protected by forest foliage, no longer bound by forest roots—were gullied and channeled in all directions. So storm by storm and year by year the old fields were invaded by gullies, gorges, ravines and gulches. Ever increasing in width and depth until whole hillsides were carved away, until the soil of a thousand years growth melted into the streams, until the fair acres were converted into hundreds of badlands, desolate and dreary as those of the Dakotas."

The progressive soil survey and the field work of the State Soil Testing Laboratory put department members and colleagues from cooperating agencies into the field where erosion and its consequences could be observed firsthand. The publication in 1916 of Experiment Station Bulletin 272, "Keep Our Hillsides From Washing," by Whitson and T.J. Dunnewald marked the first comprehensive written treatment of the water erosion problem in the state, its causes and the solutions. They described three classes of soil based on slope, and described rotations suitable for controlling erosion for each. Whitson and Dunnewald estimated that 75% of the land in southwestern Wisconsin and 50% of the land elsewhere in the state suffered from excessive erosion. The language they used makes it clear that they knew soil erosion to be a very serious and widespread problem. They identified rainfall, character of the soil, slope and vegetation as causes of erosion and recommended 11 different

measures to control it. They were: increase surface infiltration, contour plowing throwing the soil uphill, graded waterways, pasture and hay on steep slopes, contour tillage of crops such as corn, sod waterways, contour strip cropping, terracing, gully control and repair, and gradual rather than abrupt clearing of steep woodlands to allow a grass cover to become established. The bulletin had, in qualitative form, essentially all of the elements of the practices which became common in the state when the public program of soil and water conservation emerged about 25 years later. What it lacked was details and specifications of how to design and implement the practices recommended.

It's clear that concern about the erosion problem did not end with the publication of Bulletin 272. In 1922 O.R. Zeasman was summoned to Buffalo County by the County Agent to ascertain the damage caused by massive gully erosion and to propose remedies. He continued this work throughout the decade, and by 1928 had designed and constructed more than 25 gully control structures in cooperation with farmers and with local highway departments. Concern continued to grow. The Agricultural Experiment Station annual report for 1928 begins with a frontpiece by University President Glenn Frank that speaks forcefully to the issue. It's given below in its entirety.

"One cannot touch even lightly the conservation problem without a sense of coming into the presence of one of the nation's really fundamental problems that touches the lives of all of the people of the State.

"The conservation movement is primarily a symbol of the fact that, in Wisconsin specifically and in the United States generally, we are today in the twilight zone between exploitation of the American continent and the enrichment of an American culture, using the term culture in a broad sense of the whole fabric and feel of our common life.

"We must, if we are to do more than play at conservation, substitute stable and scientific agriculture for an unintelligent raping and ruining of the soil; we must substitute intelligent forestry for mere timber slashing; we must dress the land that we have deflowered. To date, we have been little more than salesmen of our natural resources; today we are challenged to become statesmen of our natural resources! This, as I see it, is the real challenge of conservation, and it will involve a sweeping reform of the American mind, as well as reforestation of our denuded areas."

The comments quoted above are the only case in which the president of the university provided a statement on a problem or issue in the annual reports of the Experiment Station. The inclusion of this pronouncement by President Frank, therefore, shows how concerned leaders of the department and the college were about the problems of resource abuse associated with both farming and forestry.

The 1928–29 Annual Experiment Station Report summarizes the problem of excessive sheet and gully erosion in western Wisconsin, and reports on work by Zeasman, E.R. Jones, Whitson, and the Lake States Forest Experiment Station of the U.S. Forest Service. Erosion is described as severe on deforested uplands and gully headcutting as rampant on river terraces. The role of forests in absorbing flood waters is pointed out. The report notes prophetically "The present cooperative study is expected to be only a forerunner of long-term experiments and of statewide demonstrations of the means of controlling erosion while obtaining the highest use of farm lands."

In 1930 the bulletin "Soil Erosion, a Local and National Problem" was published by C.G. Bates and Zeasman. The bulletin was based on Zeasman's gully control work and a study of the problem in southwestern Wisconsin begun in 1929 in cooperation with the Lake States Forest Experiment Station.

Pasture renovation and improvement of bluegrass pastures by fertilization came under study by H.L. Ahlgren while he was a graduate student in Soils, and continued after he moved to Agronomy. The results of this research contributed directly to soil and water conservation as well as to the economic improvement of farmers, since the more productive pastures allowed more water to infiltrate and the farmers had less need to send their cattle into the steep woodlands to search for feed.

In 1931 the Agricultural Experiment Station and three bureaus of the USDA (Chemistry and Soils, Agricultural Engineering and Forest Service) cooperatively established an erosion experiment farm on a ridge just east of LaCrosse. Both Whitson and Zeasman were active in arranging details of the cooperative venture. By 1932 a series of comprehensive terracing and other engineering experiments had been installed on the farm, and by 1933 some definitive results were available to guide the fledgling Soil Erosion Service. Further results were reported in 1934, a year in which strong storms gave the new station excellent opportunities to show differences among both engineering and management practices for erosion control. By 1937 the research team at the station was reporting favorable results, both in terms of crop returns per acre and in reduced soil loss by erosion, from the long term comparisons of crop rotations which had been established with and without erosion control practices. At the same time the Forest Service researchers were reporting on the value of forests as water absorption areas on the steeply sloping land of the Coulee region. In the early 1940s R.J. Muckenhirn continued research at the LaCrosse farm. His work included studies of

A.J. Wojta during field observations of land forming. *A.E. Peterson.*

water loss by runoff and percolation, crop yields and pasture renovation in relation to soil conservation practices.

In the central part of the state Albert was reporting the value of "living snow fence"—his name for windbreaks of pines which he had planted along the roads, beginning in 1926, as a means of controlling both drifting snow and wind erosion of the sandy soils of the area. The department involvement in action programs to control erosion was significant during this New Deal era. In 1935 and 1936 Zeasman served as superintendent of three Civilian Conservation Corps (CCC) camps and as technical advisor of 18 others, all of which were concerned with applying erosion control practices to the land. When erosion control action programs were made the responsibility of the Soil Erosion Service, over Zeasman's vigorous objections, he continued to provide training and advice to the fledgling conservationists and engineers on engineering aspects of the new and rapidly growing program. After passage of the Soil Conservation District Act in 1937, Zeasman's salary was partially funded by the Soil Conservation Service and he devoted a great deal of time and effort to the development of programs of work for the county-based districts as they were organized. He continued this role until his retirement in 1956.

Others in the department were involved in the developing effort. Muckenhirn and Zeasman conducted a reconnaissance study of the extent of erosion in the state and in 1941 published a report that served as the reference on the scope and extent of the problem for many years. Concerns about erosion, and related poor surface drainage in central Wisconsin, which had been studied extensively by Musbach until his untimely death, led to the establishment of a comprehensive field plot study of runoff, erosion and soil fertility on the Clark County farm from 1944 to 1958. Muckenhirn, Jackson and Zeasman selected the area and designed the experiments. Later Attoe and A.E. Peterson assumed leadership of the effort. Concurrently A.J. Wojta conceived and perfected an advanced system of land smoothing wherein surface drainage improvement and erosion control were integrated into a unified design. The system has been widely adopted.

Muckenhirn, Jackson and Peterson led the department's involvement with the Agricultural Research Service in establishing and operating research plots to quantify erosion rates and the effectiveness of control measures for both south central and northeast Wisconsin. Muckenhirn also served on the State Soil Conservation Committee for many years and provided policy leadership to the soil and water conservation program through that body. When I.O. Hembre assumed responsibility for the program of the Committee as Executive Secretary he accepted a joint appointment in the Soils Department. This provided an opportunity for involvement of numerous department faculty in the conservation education programs led by Hembre and his colleagues on the State Committee staff.

Zeasman took modern technology and applied it to conservation education. He planned and conducted conservation air tours that let farmers see erosion damage and conservation practice effectiveness in their own neighborhoods and farms from the air. From 1950 through 1955, 5022 farmers took to the air in such tours. Hole, G.B. Lee and M.T. Beatty were part of a group that prepared a scorecard and publication on land judging for high school aged youth and conducted the State Land Judging Contest annually at Farm Progress Days. A.E. Peterson organized numerous demonstrations on wheel track planting—a forerunner of conservation tillage. Zeasman and Wojta led the technical and organizational part of the state plowing contest—a tool for both training in and publicizing of contour plowing, a practice which had been resisted by many farmers. Department members were regular instructors at the Trees for Tomorrow conservation short courses at Eagle River where both teachers and students learned natural resource conservation and

management in the field. Beatty, Murdock and Walsh developed a series of publications for the extensive soil regions of the state which integrated soil and water conservation practices, yield goals for common crops and recommended rates of lime and fertilizer application—a 1960s version of sustainable agriculture. A.E. Peterson and P.J. Stangel established a long-term rotation study at Lancaster in 1965. This experiment is providing crucial data for establishing recommended levels of nitrogen fertilization with a view toward protecting groundwater quality.

Many department members participated actively in the development and review of technical standards for soil and water conservation and management practices with staff of the Soil Conservation Service, Agricultural Stabilization and Conservation Service and Wisconsin Department of Natural Resources as these agencies worked to keep their programs abreast of changing technology.

As the U.S. Environmental Protection Agency sought to develop programs for control of nonpoint pollution, members of the department became active in a project which involved Washington County, WI. This comprehensive study and development of mechanisms for bringing about reductions in nonpoint pollution included T.C. Daniel, Chesters, L.C. Johnson and E.C. Savage. The two latter faculty members were employed by the State Soil and Water Conservation Committee. From this project emerged new understanding of sources for nonpoint pollution in rural and suburban areas and better methods for control.

With the rapid change in agriculture to cash cropping, big machinery and a panoply of pesticides in the 1970s, soil and water conservation practices of prior times became outmoded and were often abandoned. Daniel responded with an integrated research-extension program to adapt conservation tillage techniques developed for warmer climates to fit Wisconsin conditions, demonstrate their use and train technicians and farmers in the fine points of how to use conservation tillage successfully. This led to a similar approach to the conservation of groundwater quality as Daniel and colleagues studied the rates of pesticide leaching for various soils and farming systems and devised management systems designed to minimize or eliminate it.

Changes in the organization, mandate and program of soil and water conservation districts occurred as agriculture and other land uses changed in the state. Hembre's successor, William Horvath, worked to remove the tie between the State Soil Conservation Committee and the University of Wisconsin so as to achieve separate state agency status for the Committee. The eventual result was a partitioning of the program

and staff between the University of Wisconsin and the Wisconsin Department of Agriculture, Trade and Consumer Protection.

During and after these organizational changes Johnson carried out an active program of education for SWCD supervisors, and after the change in state law mentioned above, the members of Land Conservation Committees. He started a series of annual week-long seminars which included both technical and programmatic topics to give these elected officials more depth of understanding than they could receive through one-day meetings.

At the same time F.W. Madison responded to long-standing concerns about groundwater and surface water pollution from animal manure. His program of research and field demonstrations led to standards that helped to guide technical assistance programs both in Wisconsin and across the nation.

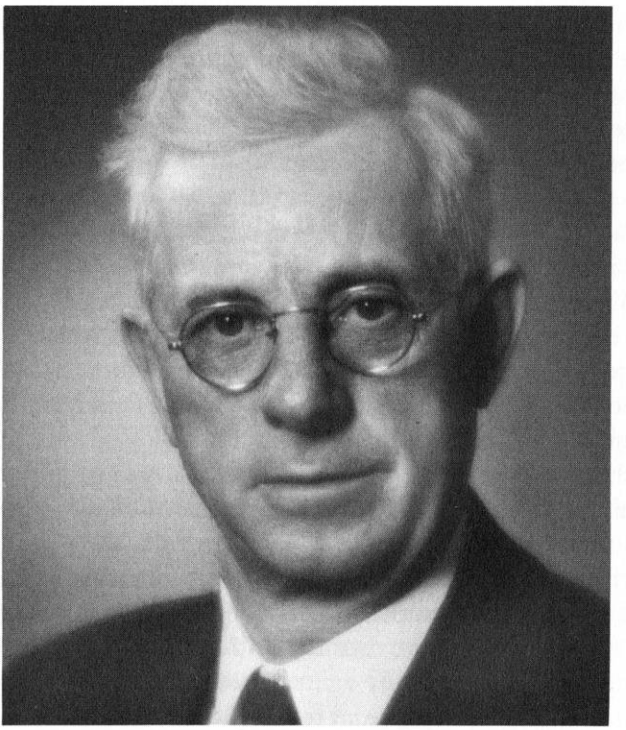
Birl Lowery responded to the need for a definitive understanding of the contemporary relationship of crop yields to soil erosion by establishing long term field plots at the Lancaster Research Station on soils which had experienced various amounts of erosion. The results, together with these of similar studies at other locations throughout the nation, will help to define what has been a rather poorly understood relationship. Lowery has continued his work in applied soil physics by joining Kevin McSweeney in studies of pesticide movement through sandy soils.

Otto Reinhart Zeasman

Otto Reinhart Zeasman was born in Kiev, Russia in April 1886. He and his parents immigrated to eastern Marathon County Wisconsin when he was two. When Zeas was five his father died. By age 12 Zeas was working summers in the lumber mills and on farms. He became a full-time clerk in a general store after finishing the eighth grade and had determined to end his formal education. A local teacher convinced him to join the high school debate team even though he was not enrolled in school. Although he was an outsider his colleagues chose him to lead the team, and Zeasman's love for argumentation was both trained and affirmed. It was a trait that he never relinquished. At an advanced age when he could no longer speak above a whisper, he turned to putting his arguments on paper.

After his debate experience Zeas enrolled at Wayland Academy, supporting himself by working full time as a janitor. After four years of work and study he graduated and received a scholarship to the University of Chicago. Following a year at Chicago and a year of work in a machine shop in northern Minnesota he enrolled at the University of Wisconsin and received his degree in Agriculture in two and a half years. During one semester of his senior year he carried 24 credits, held a job, and courted the woman who became his wife. Upon receiving his degree in 1914 Zeas began work immediately as a land drainage specialist for the University and worked to help farmers by designing and supervising installation of drainage systems. From 1917–19 he worked as Agricultural Agent in Green Lake County, and returned to the campus in 1919 with an appointment in both the Soils and Agricultural Engineering Departments.

Zeas joined the University at a time when relatively few farmers were guided by its recommendations, and those who chose to request help could receive personal service. Zeasman used such requests for drainage surveys and design as opportunities. He designed the drainage system for the University Marsh (now the site of the Nielsen Tennis Stadium, parking lot 60, and intramural fields), but more importantly he surveyed



O.R. Zeasman. *UW–Madison Archives.*

and supervised installation of hundreds of drainage systems for both individual farmers and groups of farmers who were organized into drainage districts. Over the years of making meticulous observations and surveys he came to know all the marshes and wetlands of southern, central and eastern Wisconsin and the people who owned and operated them intimately. If anyone referred to a marsh or wetland in the state, Zeas had been there and could describe its characteristics in detail. He led the transition from drainage as a folk art to drainage as an engineering technology and helped, with his forceful personality and skill in argumentation, to convince skeptical farmers and tilers of the advantages of new technologies, materials and construction systems.

For many years Zeas served as State Drainage Engineer. This position entailed formal appearances in court on the occasion of any action by legally organized drainage districts, since such districts operated under the supervision of the courts. The formal, systematized court procedures harmonized with Zeas' penchant for clear, definite plans and direct actions. He was the undisputed authority on technical aspects of land drainage, and continued to carry out surveys, plan drainage systems and supervise their installation until he was in his mid 80s when deafness and the

lack of a drivers license ended his field work. He led drainage activities during the period when artificial drainage of wetlands was widespread because of the economic benefits to the owners from crops which they produced after drainage. Land which had been considered a liability before drainage became an asset after drainage.

Zeas was thrust into the front lines of the gully erosion problem in 1922. He added this workload to one already full, and continued to work on design and installation of engineering structures for gully control in western Wisconsin almost singlehanded until the advent of public programs for erosion control a decade later. As late as 1928 his Extension Director questioned Zeas' use of time for such activities. In his forthright fashion Zeas took the skeptical Director on a field tour, showed him horrendous gullies that were devouring whole fields and farms and then asked him if efforts to control the menace were justified. He became the first Extension Specialist in the Upper Midwest to have a significant permanent assignment on erosion control work!

When the extensive public programs for soil conservation emerged as part of the 1930s New Deal the young college graduates who led the programs turned to Zeasman, then nearly 50 and widely experienced in engineering and especially gully control methodology, to get their background information for design and techniques for construction. The manner in which he provided training and leadership earned him enormous respect among this vanguard of soil conservationists. This was true even though Zeas vehemently opposed the manner in which the programs of the Soil Erosion Service and later the Soil Conservation Service were organized and carried out and made no secret of his views.

The archives contain a letter sent to Zeas several years after he retired by more than 40 employees from the Soil Conservation Service, and personally signed by each, which expresses in the warmest way possible how they missed his presence among them and how much they felt indebted for what he taught each of them.

Zeasman's energy and working hours are legendary. Leonard Massie, of Agricultural Engineering, recalls that when he travelled and worked with Zeas between 1961 and 1969 the working day started at sunrise (in the summer) and ended when it got too dark to see in the evening. Zeas at that time was teaching Massie key points about prior work in drainage and soil conservation.

Also legendary are Zeas' views on a wide variety of topics. He was an avid football fan and formed clear judgments on how each play should have been called. When the officiating was not in concert with his views Zeas was bold in the extreme about telling the officials how it should

have been done. He took the same approach to politics. Oldtimers recall a trip to Chicago which included, among others, Zeasman and Truog. Truog, himself a rock-ribbed Republican, enlivened the trip by slyly commenting as they left Madison about the benefits the country was reaping from Roosevelt and the New Deal. As Zeas sat fulminating loudly and profanely in the back seat, Truog sat quietly in front smiling and introducing another piece of bait into the conversation whenever Zeasman's anger showed signs of abating. For Truog it was great sport; for Zeasman it was deadly serious.

Among his many debates, Zeasman carried on a running one with Aldo Leopold. The two were key leaders in the early soil conservation movement and in formulation of the proposal which led to the establishment of the Coon Creek Watershed as the nation's first formally organized watershed program. Zeasman emphasized the engineering and structural approach to erosion and flood control, Leopold the vegetative and land use approach with special emphasis on reforestation and brush planting in gullies. Jack Densmore, State Soil Conservationist (retired) with the Soil Conservation Service, recalls having a crew of CCC men planting trees on a steep and eroding slope in western Wisconsin when Zeasman drove up and informed them all that the practice was useless as an erosion control measure and a total waste of the taxpayers money to boot. The debate ended with Leopold's untimely death in 1948. Zeasman died in 1976. Both men became members of the Wisconsin Conservation Hall of Fame and Leopold the patron saint of the environmental movement worldwide.

Embracing the Environment

As with many other facets of the department's programs it is difficult to pinpoint a distinct beginning for programs that can be characterized as environmental. In one sense F.H. King was already addressing rural environmental issues when, in 1898, he was advocating a rational program of land use which integrated agriculture and forestry within Wisconsin landscapes. Similarly, O.J. Noer and Truog addressed an environmental issue, viz. disposal of urban sewage sludge, in the 1920s.

The first of what has been a sustained effort in environmental matters began in 1950 when the department became involved, jointly with the department of Civil Engineering and the State Laboratory of Hygiene, in a research project on disposal of sewage effluent from the Oscar Mayer Co., a major livestock slaughtering and processing enterprise, of Madison. The project, led for the Soils Department by L.E. Engelbert, involved study of alternatives, such as irrigation, for disposal of slaughter and packinghouse wastes to assist the Oscar Mayer Co. in reducing its sewerage surcharges for disposal of high-strength wastes in the Madison Metropolitan Sewage District. The department may have gained more long-term benefits from the effort than did Oscar Mayer, since irrigation was only practicable for a part of each year and thus did not become a long-term solution for the company's concern. The department learned much about movement of nitrates, other nitrogen compounds and other inorganic constituents of sewage through soils from the research.

A natural outgrowth of this effort was a collaborative research project for land disposal of liquid wastes from the many cheese factories which dotted the rural landscape of America's dairyland at that time. Wastes from the cheesemaking process had for years been discharged into the nearest stream or road ditch. The growth in size of some cheese factories, the frequent fish kills and the smell along roadsides all called for alternative disposal methods. Engelbert, and later A.E. Peterson, pursued alternatives for several years. Disposal on land using spray irrigation or shallow, parallel trenches for infiltration proved to be acceptable alternatives in certain settings. For Peterson this work started a line of research

Injecting municipal sewage sludge on cropland. Departmental research has been crucial to effective and safe sludge applications. *A.E. Peterson.*

on waste disposal which he has pursued throughout his subsequent career in the department.

The department became concerned about and involved in lake water quality early in the 1950s. Berger, in collaboration with limnologist Arthur Hasler, directed studies by graduate student Eldon Zicker of ways to improve the water quality in acid bog lakes of northern Wisconsin by reducing phosphorus release from lake bottom sediments. Traditional agricultural practices such as application of ground limestone to raise the water pH and precipitate the phosphorus were among the remedies studied. Nutrient runoff from agricultural land which could enter lakes began to receive study in connection with classical erosion-runoff plots directed by USDA scientist C.E. Bay and located on the Gugel farm in the university's Hill Farm research area. Jackson and a series of graduates students analyzed runoff collected from the research plots for phosphorus, organic matter, potassium and nitrogen as a means of characterizing the runoff from agricultural lands in terms of its potential for enhancing lake eutrophication. The research entailed work with hundreds of samples, and included extraction of sediments with weak sulfuric acid to determine available phosphorus. The storms which produced the runoff were equalled in magnitude, if not in duration, by the tempest which ensued when Tanner discovered that the acid used for these extractions had

corroded the West Lab drain and created a flood of water in the basement on his desk and papers. It was the first of numerous such events.

These early environmental studies created both an openness and an ability to work on environmental concerns. When Rachel Carson's 1962 book *Silent Spring* brought the environment to everyone's attention, the department moved quickly into a sustained environmental emphasis that continues to grow and interface with more traditional applications such as agriculture.

The burgeoning use of biocides led to a variety of studies by various members of the department on how these synthetic organics reacted in soils, lake sediments and waters. Chesters, while continuing his work on fundamental processes of pesticide degradation in soils, expanded into studies and activities designed to apply the fundamental knowledge in regulatory, educational and other societal responses to pesticides in the environment. This has included a long term of service on the Wisconsin State Pesticide Advisory Council. Extensive work in the regulatory setting has led Chesters to studies on the role of scientific data in the formation of public policy and public decisionmaking. Wilde made studies of the effects of the many biocides used in forest nurseries a component of his research for more than 20 years. J.G. Iyer, who worked with Wilde on many of these studies, has continued this work to the present.

The era of atmospheric tests of hydrogen and atomic bombs created an awareness of radioactive materials, both naturally occurring and artificially produced. Chesters and C.W. Francis studied entry of naturally occurring 210 polonium into plants with special emphasis on tobacco, since the radioactivity of the polonium was postulated to exacerbate the serious deleterious effects of tobacco smoke upon the smoker. The study was then extended to include lead. The study generated interest worldwide, including letters to Chesters from Lyndon Johnson and one unidentified person who sent Chesters a letter with a series of *Playboy* centerfolds enclosed, with the suggestion that "if he (Chesters) was concerned about people's chests he should at least see some good ones."

With the arrival of Keeney on the faculty, research on nitrogen in the environment accelerated. By 1968 he and Chesters were studying the nitrogen cycle within the context of eutrophication of lakes, and by 1970 Keeney and Harris had major projects funded by EPA and NSF on nitrogen transformations in lake sediments, and specifically in Lake Wingra, as a part of the International Biological Program. This work was extended by Keeney with studies of nitrogen transformations in Green Bay, dynamics of the terrestrial nitrogen cycle and nitrates in central Wisconsin soils. In the latter work he collaborated with Tanner, and L.A. Peterson (Horticulture and Soil Science). This work led to major

improvements in management of water and fertilizer on sandy soils of central Wisconsin during potato production.

Characterization, classification and mapping of soils in aquatic environments developed rapidly, with Lee leading work on wetlands and other poorly drained areas that border Wisconsin's lakes and streams. The studies led to improved methods of relating soils and vegetation of wetlands. The work was timed perfectly to give useful information for the sodbuster provisions of the 1986 Food Security Act, in which delineation of wetlands is required.

The department began work on disposal of septic tank effluent in soils in 1959 when the Wisconsin Division of Health requested help in verifying the presence of high groundwater in soils proposed for subdivisions to be served by on-site sewage disposal systems. The Division had encountered a proposed subdivision for which the developer's plat showed no evidence of groundwater within six feet of the surface, but in which water rose to within a few inches of the ground surface in holes dug by an engineer of the Division. Beatty examined this and numerous other plats and proposed that the Division use morphological characteristics of soils such as patterns of color and thickness of soil horizons to determine presence of periodic high water tables in soils. Collaboration with state health officials and training of surveyors, sanitarians, engineers and local officials followed adoption by the Division of the pedological criteria. The department's activity in this sector was greatly enhanced by the arrival of Johan Bouma from The Netherlands. He had been recruited by Francis Hole and appointed to a position jointly funded by the department and the Wisconsin Geological and Natural History Survey, UW–Extension. Bouma began critical studies of the hydraulic conductivity of soils at low tensions, excavated and studied failing soil absorption fields and shortly thereafter he and James Converse, Agricultural Engineering, proposed the mound system for disposal of septic tank effluent on some sites for which conventional systems were inadequate. This work was supported by permanent funding from the state, and it soon embraced study of the fates of pathologic bacteria and viruses, small aerobic treatment systems for home wastes, and the legal and economic implications of potential advances in the technology of household sewage disposal. E.J. Tyler has continued this work and, in collaboration with Converse, J.M. Harkin and others, has developed a family of alternative systems for use in disposal of household sewage.

While the initial work on disposal of household sewage centered on platted subdivisions, the most widespread problems were often in unplatted areas. Beatty and D.A. Yanggen, Agricultural Economics, developed

legal and pedological criteria and methods for using information from both published soil surveys and field examination of soils in developing sanitary ordinances, zoning ordinances and land use plans. Extensive training of local elected officials, county employees and private sector professionals specialized in planning, zoning and sanitation helped to speed acceptance and adoption of these concepts and practices.

Land application of sludges from municipal and industrial sources has been a major research and extension program since the 1960s. Major attention was given early to the fate of toxic heavy metals contained in the sludge, but the work has embraced all aspects of sludge application. Corey, Harris, Helmke, Keeney, Kelling, A.E. Peterson, Schulte, Syers and Walsh have all made significant contributions to these ongoing efforts. Their research results laid the scientific basis for guidelines and regulations, first in Wisconsin and then nationwide, by the Wisconsin Department of Natural Resources and the U.S. Environmental Protection Agency for land application of sludges. By 1989 most cities and sewage districts in Wisconsin were using land application for sludge disposal. Closely related to this work was research by Schulte and Helmke on methods for environmentally safe disposal of flyash. Helmke developed new analytical methods, obtained and introduced new analytical equipment and devised new analytical procedures and standards for heavy metals and other elements in soils and sludges as an integral part of this project. He has continued this distinctive contribution in other projects, including analyses of phosphorus compounds, and contributed to the department's overall advancement in modern inorganic analytical methods at a time when such methodology and equipment is in a state of rapid development and modernization.

Recent concerns about increasing prevalence of excessive levels of nitrates in groundwater have led to additional research and extension educational activities by faculty and staff. This research has its roots in a series of landmark studies by Attoe and a group of graduate students in the 1960s which traced movement and transformation of nitrogen compounds from both animal manure and commercial fertilizers in subsoils under a variety of Wisconsin conditions. Those studies have helped Bundy and students design research which shows the patterns of accumulation of nitrates in subsoils under commonly used farming practices. From this, recommendations for a more environmentally benign fertilizing system and on-the-farm sampling of subsoils for laboratory testing for nitrate accumulations have emerged.

K–J.S. Kung has studied the movement of liquids and tracer compounds through the root zone of sandy soils, and has discovered areas of

preferential flow, a fact which may help to explain pesticide movement to the water table.

J.G. Bockheim has conducted internationally recognized studies of soils in cold regions, especially Antarctica. As a result of these studies, he has proposed changes in Soil Taxonomy to improve the classification of alpine and polar soils. These high latitude regions are important indicators of environmental degradation and global pollution. He has also studied biocycling of plant nutrients in forest ecosystems and demonstrated the importance of chemical weathering and cation exchange in neutralizing acidic deposition in forest ecosystems.

The faculty regard the environmental movement as the most important development in recent departmental history. The rapid legitimation of environmental quality as a major concern of society, together with the extensive prior departmental work which fell under this rubric led faculty and students alike to identify environmental problems and issues as being a major component of the department's program and mission. The departmental initiatives included developing a new course "Soils and Environmental Pollution," numerous seminars on environmental topics and issues, a variety of extension programs and numerous major research projects. This inclusion of the environment as a key part of the department's overall program and mission continues to grow. New problems and issues such as movement of pesticides and nitrates into groundwater, surface water pollution from animal wastes and fertilizers and similar issues have augmented earlier work on issues such as sludge application, on-site waste disposal and land use management.

Teaching the Science

Tracing the changes in courses over a century shows vividly the development of the department, the advances in knowledge and the shifts in emphasis of the department's teaching program. Table 1 highlights curriculum evolution by showing course titles for those years in which significant changes in the courses offered by the department occurred. By considering these sequential points of change one can trace the evolution of a simple curriculum taught by one man to a few students into a comprehensive one designed to meet the needs of a diverse array of students with wide-ranging backgrounds and interests.

When King began teaching in the Agricultural Physics Department in 1889 he taught three formal courses and research—to a very few students. They were: Soil Physics, Meteorology, Farm Engineering, and Original Investigations. These courses were part of a standard curriculum for all students in the College of Agriculture. Electives and specialization came later. By 1905 the course offerings of the department were: Soils (two semesters); Climatology; Advanced and Original Work in Origin and Fertility of Soils; Drainage and Irrigation and a graduate course in Origin and Classification of Soils.

With the rapid growth in enrollment in the four-year Long Course and the major college-wide change in the curriculum in 1907 the department's course offerings were revised extensively by 1908. Introduction of three levels of coursework—introductory, advanced undergraduate and graduate, and graduate—provided a framework for arranging the growing offering of courses. The basic course was retitled Principles of Soil Physics and Fertility and was taught one semester each year. Climatology became Agricultural Climatology and became an advanced undergraduate course. Thesis and Assigned Work and Research Work were introduced. The course in Drainage, Irrigation and Cultivation evolved into two courses: Land Drainage, and Drainage Design, and in 1918 these were transferred to the department of Agricultural Engineering. Five new courses, Soil Physics, Soil Chemistry, Soil Management, Soil Analysis and Plant Nutrition were added. The course in Origin and

Classification of Soils became (briefly) a graduate level course. The new course offerings were made feasible in part by the changes in the overall course work program of the College in which general requirements were reduced, making room for specialized courses and majors in fields such as Soils.

The changing array of course titles given in Table 1 show only part of the evolutionary changes in teaching. As new knowledge was developed through research that knowledge was incorporated into the formal courses even though the course titles often remained unchanged. However, the growth and changes in course offerings reflect the broadening scope of soil science and the evolving interdisciplinary relationships within which soil science operates. The introduction of two courses, Soil Erosion, Causes and Control; and Forest Soils in the 1930s reflect broadening of the curriculum to meet new needs. Physical Chemistry of Soils, introduced in 1948, represents a course based on a new specialty—clay mineralogy. For roughly the past 20 years the department has presented an array of interdisciplinary and service courses designed to meet needs of students with interests beyond the department itself who wish to learn how the discipline of soil science can be related to a variety of contemporary problems and issues. These, individually and collectively, have been a major advance in the department's overall curriculum.

The early start in graduate study described earlier in connection with the research of Truog and others was greatly aided by funding from the Wisconsin Alumni Research Foundation administered by the Graduate School. These funds helped to provide a reliable source of stipends for graduate students and also for key items of research equipment. In the years immediately after World War II when demand for individuals with advanced degrees in soil science was great the money available for stipends to graduate students was strongly augmented by a bequest from the late Professor Musbach (who was killed in an automobile accident in 1939). Funds from his estate helped to support four to six graduate students per year during the mid '40s through the mid '50s.

The striking changes in the curriculum introduced in the 1970s and continuing to 1989 reflect both an expanded view of soil science itself and a comprehensive addition of courses in areas relating to soils as they interact with land use, environmental concerns, meteorology, biochemistry and geography. This broadening of the curriculum in the 1970s coincides with a period of major diversification in the interests and backgrounds of undergraduate students and expansion in undergraduate enrollment and degrees granted by the department. Figure 1 shows this

Table 1. Regular Curriculum Courses by Category in Selected Years

Years	Categories			
	Introductory	Service, Including Middle Course	Advanced Undergraduate, Graduate	Graduate
1898–99	• Meteorology • Soil physics • Farm engineering		• Original investigations in the physical laboratory and field • Research work • Soil journal club	
1903–04	• Soils • Climatology • Drainage, irrigation and cultivation		• Advanced and original work in origin and fertility of soils • Soil physics	
1908–09	• Principles of soil physics and fertility • Land drainage • Thesis and assigned work		• Agricultural climatology • Drainage design • Soil chemistry • Soil management • Plant nutrition • Soil analysis	• Origin, classification and mapping of soils • Research work
1912–13	• Principles of soil physics and fertility • Land drainage • Thesis and assigned work		• Soil management • Soil analysis • Soil physics • Drainage design • Plant nutrition • Origin and classification of soil and agricultural climatology	• Research work • Soil journal club

Continued on next page

Table 1. ***Continued***

Years	Categories			
	Introductory	Service, Including Middle Course	Advanced Undergraduate, Graduate	Graduate
			• Soil physics and cultivation • Advanced soil chemistry	
1918–19	• Principles of soil physics and fertility • Thesis	• Elementary soils • Soil physics and fertility; brief course	• Soil management • Soil analysis • Soil physics • Plant nutrition • Origin and classification of soil and agricultural climatology • Advanced soil chemistry • Field management	• Research • Seminary
1923–24	• Principles of soil physics and fertility • Thesis	• Principles of soil fertility (middle course)	• Soil management • Soil analysis • Soil physics • Soil and land classification and agricultural climatology • Advanced soil chemistry	• Field course • Research • Seminary
1935–36	• Soils and soil fertility		• Soil management • Soil analysis • Soil physics • Soil and land classification; agricultural climatology • Fertilizers and manures	

Continued on next page

Table 1. ***Continued***

Years	Categories			
	Introductory	Service, Including Middle Course	Advanced Undergraduate, Graduate	Graduate
			• Soil science and plant nutrition • Thesis • Seminary in soils • Topical and field work • Soil erosion, causes and control • Forest soils • Research	
1942–44	• Soils and soil fertility		• Fertilizers and soil management • Soil erosion, causes and control • Soil analysis • Soil physics • Forest soils • Soil genesis, classification and mapping • Soil science and plant nutrition • Seminary • Special problems • Thesis	• Research

Continued on next page

Table 1. ***Continued***

Years	Categories			
	Introductory	Service, Including Middle Course	Advanced Undergraduate, Graduate	Graduate
1950–52	• Soils and soil fertility • Fertilizers and soil management		• Soil erosion, causes and control • Soil analysis • Soil physics • Soil bacteriology • Forest soils • Soil genesis, classification and mapping • Soil science and plant nutrition • Seminar • Soil survey methods • Special problems • Thesis	• Research • Physical chemistry of soils
1965–67	• Soils and soil fertility • Fertilizers and soil management	• Science and management of Wisconsin soils	• Soil physics • Soil bacteriology • Forest soils • Soil morphology, classification and mapping • Soil science and plant nutrition • Soil and water conservation • Soil genesis	• Research • Physical chemistry of soils • Seminar

Continued on next page

Table 1. ***Continued***

Years	Categories			
	Introductory	Service, Including Middle Course	Advanced Undergraduate, Graduate	Graduate
			• Soil management experimentation • Soil analysis • Proseminar • Special problems	
1974–76	• Introductory soil science • Independent study	• Man's use of the soil • Soils and land use planning • Soil and environmental pollution • Soils of the world • Environmental toxicology	• Soil morphology, classification and mapping • Soil science and plant nutrition • Soil and water conservation • Forest soils • Colloquium in environmental toxciology • Coordinative internship • Microbial biochemistry of soils and sediments • Microclimatology • Soil analysis • Soil physics • Proseminar • Special problems	• Soil mineralogy • Seminar—Topics in the physics of soil-plant environment • Seminar • Research

Continued on next page

Table 1 *Continued*

Years	Categories			
	Introductory	Service, Including Middle Course	Advanced Undergraduate, Graduate	Graduate
1980–81	• General soil science • Independent study	• Man's use of the soil • Soils and land use planning • Soil and environmental pollution • Soils of the world • Lab and field studies in environmental microbiology • Environmental toxicology • Plant nutrition of horticultural crops	• Soil morphology, classification and mapping • Soil science and plant nutrition • Soil and water management and conservation • Forest soil science • Coordinative internship • Microbial biochemistry of soils and sediments • Special topics in soil science • Microclimatology • Colloquium in environmental toxicology • Soil chemistry • Soil physics • Proseminar • Field study of soil • Soils of Wisconsin field study tour • Microclimatology • Special problems	• Practicum in soil science teaching • Seminars—Soil chemistry and mineralogy; topics in the physics of soil-plant environment; soil fertility and plant nutrition; soil biochemistry and microbiology; forest soil science • Research

Continued on next page

Table 1 ***Continued***

Years	Categories			
	Introductory	Service, Including Middle Course	Advanced Undergraduate, Graduate	Graduate
1989–90	• General soil science • Independent study	• Man's use of the soil • Soils and land use planning	• Coordinative Internship • Application of geoinformation systems to resource management • Pesticides for crop pest management • Environmental monitoring and measurement • Toxicants in the environment: sources, distribution, fate and effects • Physical principles of soil and water management • Soil morphology, classification and mapping • Soil fertility • Soil and water conservation • Field study of soil • Environmental biophysics • Soils of Wisconsin field study tour • Forest soil science	• Kinetics of nutrient availability to plants • Seminars—Soil chemistry and mineralogy; topics in the physics of the soil-plant environment; soil biochemistry and microbiology; soil genesis and classification; soil fertility and plant nutrition; forest soil science • Research

Continued on next page

Table 1. ***Continued***

Years	Categories			
	Introductory	Service, Including Middle Course	Advanced Undergraduate, Graduate	Graduate
1989–90			• Soil chemistry • Soil physics • Soil microbiology and biochemistry • Soil mineralogy and surface chemistry • Special problems • Seminars—Use and abuse of agricultural land; Environmental toxicology colloquium	

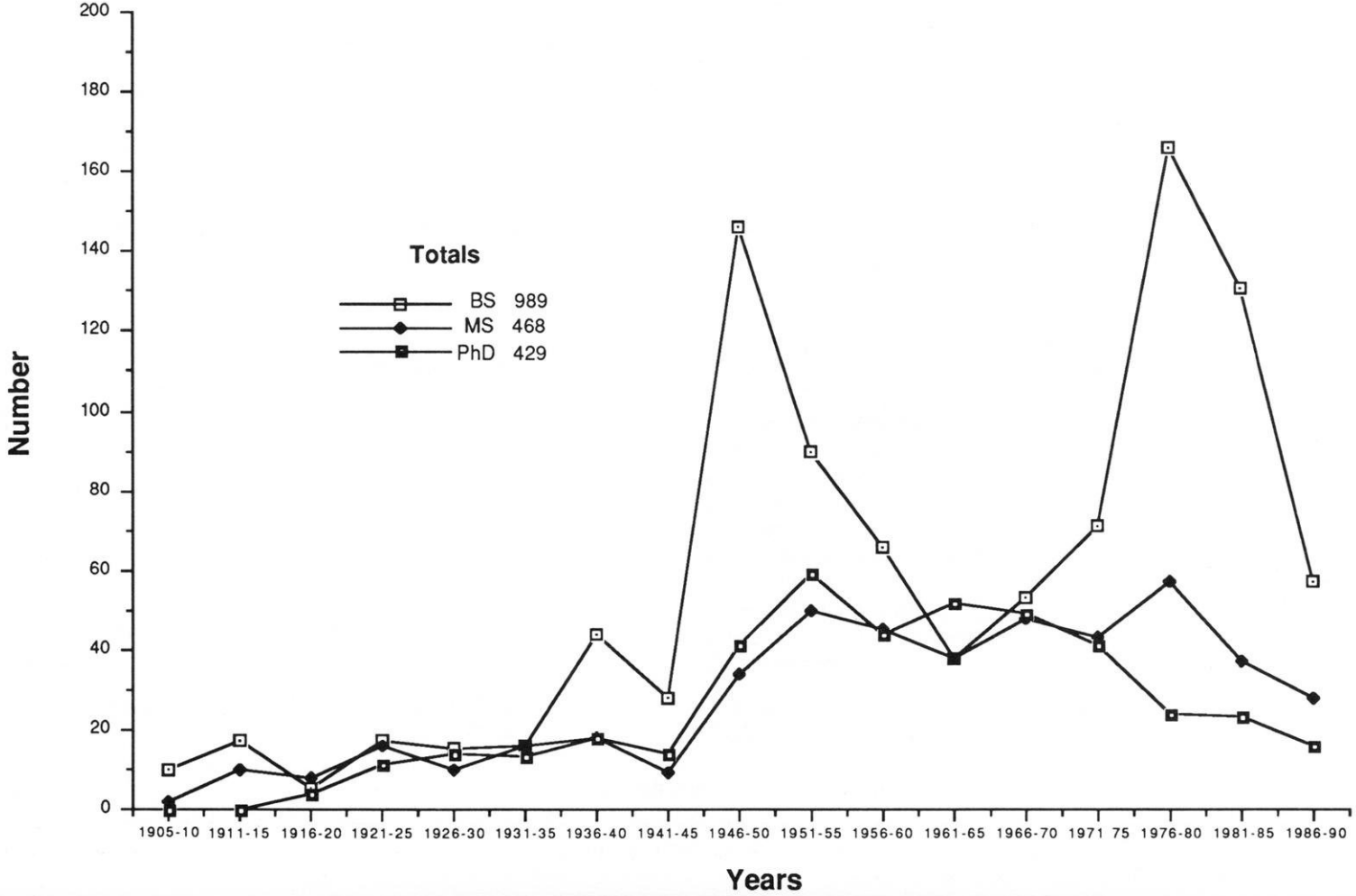


Figure 1. BS, MS, and PhD Degrees Granted, 1905–1990, by the Department of Soil Science, University of Wisconsin–Madison.

expansion within the framework of overall trends in numbers of BS, MS and PhD degrees granted from 1905 through 1989.

The number of BS degrees granted shows a peak in the years around 1950. This peak resulted from the enrollment surge following World War II and the GI Bill of Rights which brought massive numbers of war veterans into higher education. In contrast, the peak in the late 1970s occurred without such an artificial stimulus and was related to the strong surge in interest among college enrollees in understanding and safeguarding the environment and natural resources. Employment opportunities in various environmental and natural resource-related fields helped to stimulate the enrollment growth.

Numbers of BS degrees granted began to increase rapidly in 1976 and continued to range between 29 and 43 through 1982 Since 1984 the highest number of BS degrees granted was 15 in 1989 The abrupt reversal in enrollment late in the 1980s resulted in part from a sharp decline in job opportunities which accompanied the recession of the early 1980s and the de-emphasis of environmental action agency budgets by the federal government.

The decline in numbers of BS degree graduates in Soil Science has been far greater than the overall decline in BS degrees granted in the College of Agricultural and Life Sciences during the mid and latter 1980s. This decline in undergraduate students must also be viewed in the context of increased interest by students in interdisciplinary curricula such as that in Environmental Studies. The broader array of alternatives offered by these curricula, together with the stringent requirements of the Department of Soil Science for mathematics and chemistry, make the Environmental Sciences majors very attractive to many students who might otherwise major in Soil Science because of their interest in soil and water resources in an environmental context.

Figure 1 shows that MS and PhD degrees granted increased gradually from 1905 until the 1970s. The smaller numbers of degrees granted since that time approximate the numbers just prior to World War II. This decline has several causes. Funding to support graduate student stipends and research has not kept pace with the greatly increased costs of research and graduate student stipends. Beginning in the 1950s the source of research funding shifted. Prior to that time state and federal funds administered by the Agricultural Experiment Station had been major sources of funding for research, with external, mostly private grants and WARF providing funds for graduate assistantships. As the competitive grant budgets of the National Science Foundation, the National Institutes of Health, the Environmental Protection Agency, the

Department of Defense and other granting agencies increased, the department sought and gained substantial funding from these sources, especially during the 1960s and 1970s. The access to these funds did not, however, keep up with the increased costs of research and graduate student stipends and the research and graduate training programs of the department have declined relative to the period from 1946 through 1980.

The first men and women to graduate from the department at each of the three degree levels were:

BS—Edward Richard Jones, 1905; Anne Margaret Calvi, 1951

MS—Martin Nelson, 1906; Betty Mabry, 1942

PhD—Harlow L. Walster, 1918; Nadheema S. Kaddou, 1960.

A total of 895 men and 94 women have received BS degrees, 430 men and 38 women have received MS degrees, and 417 men and 12 women have received the PhD degree through December 1990.

Backgrounds of students have changed greatly over the century. Early enrollees were young men from farms or rural communities. Recently approximately 75% of the undergraduate students enrolling in the department come from urban or rural non-farm backgrounds. During the 1980s roughly 10 to 20% of the undergraduate students have been women. With the diversifying backgrounds of the student body, internships and similar workplace experiences have become a key part of an undergraduate student's overall education. Students from other nations have formed a substantial proportion of the graduate enrollment throughout the period of departmental involvement in graduate student training.

In 1889 the new department of Agricultural Physics offered three courses. In 1989 the Department of Soil Science offered a total of 34 courses. As the department completed its centennial year the curriculum was once again under intensive review and revision. Proposed changes in the curriculum of the College of Agricultural and Life Sciences would enable the department to grant BS degrees in Soil Science with options in Agricultural Sciences, Natural Resources, or Natural Science. Figure 2 shows the array of courses under final consideration for the department curriculum as part of the College-wide curriculum revision.

It is clear from that list of degree options and course offerings that BS degree graduates at the beginning of the department's second century will be prepared to enter a society which is vastly different than that entered by Edward Jones and those who subsequently graduated in Agriculture with a special emphasis in Soils early in the 20th century. One specific illustration: the largest single group of undergraduate students in the department in recent years has been those specializing in the area of

(Soil Science Primary Department): Option 1[1]

Advanced Soils Graduate[2]

928 Seminar
727 Adv Soil/Water Management
726 Soil/Plant Relations
725 Soil Genesis

Soils Graduate/Advanced Undergraduate Core

623 Soil Microbiology / Biochemistry
622 Soil Physics
621 Soil Chemistry

Soils Undergraduate Core[3]

329 Captsone (Field-Problem Solving)
399 Coord Intern (Professional Exper.)
328 Seminar (Oral Communication)
327 Soil/Water Management
326 Soils/Plant Growth
325 Soil Inventory/Interpretation
324 Soil Contamination/ Remediation
301 General Soil Science

Special Interest[2] (Soils Primary Dept.)

625 Soil Miner/Surf Chem
532 Environm Biophysics
435 Soils: Landscape/Use
415 GIS/Resource Mgmnt
355 Forest Soil Science

Short Courses

Beginning Soils
Soil/Water Conservation
Advanced Soil Management

Service

315 Soils/Landuse
230 Man's Use of the Soil

1 Does not include cross-listed courses with Soils as the secondary (non-controlling) department.
2 Offered alternate years, except for 928 graduate seminar (offered every semester).
3 Soils 324-327 will be 3-4 cr (3 cr lec/1 cr lab), mission-oriented courses built on specific soil chemistry, physics, microbiology and genesis principles according to individual course needs. For example, Soils 326 will include application of soil chemistry/microbiology principles to plant nutrition and soil physics principles to plant water relations.

Figure 2. Department of Soil Science Instruction Program

turf and grounds management and operations. They generally comprise from 33 to 50% of the graduating class of the department. Placement of these graduates in professional positions has been high.

The department's involvement with the Short Course, now called the Farm and Industry Short Course, covers almost the entire century of departmental existence. As noted earlier, enrollment in the Long Course was slow to develop; whereas, that in Short Course burgeoned to more than 500 students soon after 1900. The department has taught courses as a part of the Short Course curriculum from the program's inception. King's teaching in the program was described earlier in the opening section of this history. His remarkable ability to analyze and rationalize physical phenomena in practical farm setting must have made a great contribution to the popularity of the Short Course program. Whitson developed the department's first year offering into three courses by 1903. They were The Soil, Rural Architecture and Country Roads. The second year courses were Farm Drainage and Irrigation, Farm Mechanics and Principles of Weather Forecasting. After the reorganization which created two departments from Agricultural Physics, the Soils department offerings were reduced to one course per year for each of the

two years of the program, entitled Soil Fertility and Soil Management, respectively. The title of the first year course was later changed to Beginning Soils and that of the second year course to Advanced Soil Management. A third course, first called Farm Conservation and subsequently Soil Conservation, and later Soil and Water Conservation, was added in 1944. The content of these courses has evolved over time even though the titles have remained unchanged for many years.

While the curriculum and the statistics on numbers of graduates may provide the framework or skeleton of the department's teaching program it is the faculty, especially those who specialize in undergraduate advising and teaching, who bring it life. The department and the students have been fortunate to have an array of dedicated and gifted individuals in this role.

Whitson developed and taught most of the core courses in the department from 1901 until nearly the time of his retirement in 1941 He clearly exerted the predominant influence on the department's teaching program during its formative years. A review of the early graduates of the department shows that Whitson was in a position to advise a great many young men who majored in Soils, worked during the summer in the soil survey or in field research of the department and then took leadership roles in the field of soil science as teachers, researchers, leaders of the soil survey and as experts in the soils-related private sector enterprises. He was assisted by a series of excellent instructors, the most well known of whom was E.J "Pappy" Graul, who began teaching as an assistant to Whitson in 1912 By 1921 Graul was teaching the introductory course and continued to do so, as well as advising the undergraduate majors of the department until his retirement in 1955

Graul likewise played a key role in influencing a great many students to major in soil science. Equally as important he made soil science clear and meaningful to untold numbers of students who majored in other fields but who remembered Pappy Graul and the essentials of soil science which he had impressed upon them in his forceful and inimitable ways. His admonition, "It's dangerous not to remember this," hit home with students who wanted to know what was most important of the abundant information Graul revealed in lectures and laboratory sessions. His name is still mentioned by individuals in a variety of occupations around Wisconsin when talking with current faculty members. And he is always described as one who made a strong, positive impression on his students.

J.R. Love continued Graul's tradition of creative and vigorous teaching and advising students. In an era when advising undergraduate students was not a high-profile nor well-compensed activity for faculty,

Love devoted his full energy and attention to these students. He got to know each advisee in depth and cared deeply about their personal and academic development. He taught the basic departmental courses at a time of rapid advances in the soil science field and devoted great time and attention to incorporating new research findings and their application into those courses. Faculty colleagues marvelled at his ability to digest important new research findings and introduce them into his courses with creative illustrations and demonstrations.

F.D. Hole brought distinction to the teaching role of the department and simultaneously to the department of Geography. Francis accepted a joint appointment in the two departments toward the end of his career and developed the course Soils of the World into an offering having wide appeal and a large, diverse enrollment. He used his violin during lectures to dramatize points he wished to emphasize about soil, and led the crusade to have Antigo silt loam declared the official state soil. As a part of this successful effort he composed the Antigo silt loam song, which was enthusiastically adopted by his students and came to adorn tee shirts across the campus and around the state. A local jazz group, the Silt Loam Ensemble, reflects Francis' continuing influence in relating the soil to a wide array of citizens.

L.E. Engelbert shared the role of teaching basic undergraduate courses and advising undergraduate students with Jim Love after having completed assignments as department chairman and as Chief of Party for the College of Agricultural and Life Science's development project in southern Brazil. His contributions came at a crucial time when the number of undergraduate majors in Soil Science was growing each year. He also taught a new course, Man's Use of the Soil, which was designed for students whose major was not in the department. It was a response to the need to bring knowledge of soils to students other than those majoring in the science itself.

A.E. Peterson adapted a technique used by Zeasman for adult farmers and used it in his teaching of Soil and Water Conservation. The air tour which forms a part of the course gives students an opportunity to view first hand both the processes of soil erosion and their results, and also practices which help to control the loss of valuable soil and degradation of water resources.

R.B. Corey has served in many ways like Whitson in teaching across the spectrum of courses in the department. In addition to teaching courses in soil chemistry he has taught General Soil Science, Man's Use of the Soil, Soil Science and Plant Nutrition, Soil Fertility and Fertilizers, Kinetics of Nutrient Availability to Plants, and collaborated in

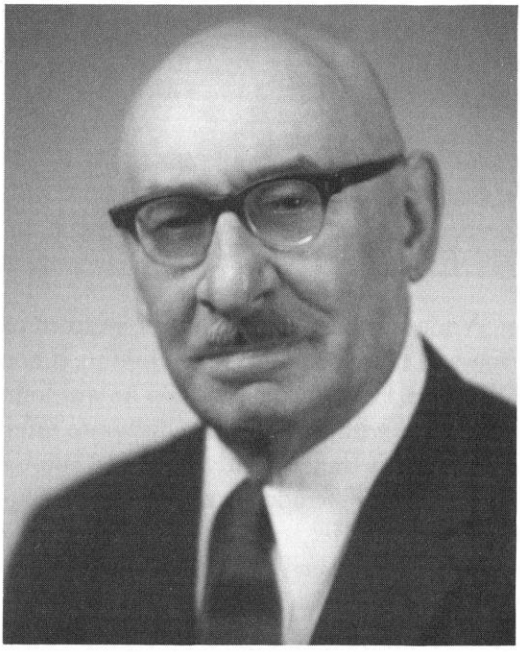
teaching several other department courses. He has that rare ability to teach effectively in a variety of subject matter areas in the discipline. Concurrently he advised with great effectiveness many undergraduate and graduate students.

R.F. Harris has served as chair of the department's teaching committee for many years. This is one of the behind-the-scenes leadership roles which helps to keep departmental teaching efforts focused and in step with rapidly changing times.

Sergei Alexander Wilde

Sergei Alexander Wilde was born in 1898 in the western part of Moscow to parents of Tartar and Dutch ancestry. His childhood home was about a mile from the Kremlin. His father died when he was four. Young Sergei grew up in a home with a plethora of disparate influences. As "Doc" describes them in his transparently disguised autobiography, "Dr. Werner's Facts of Life," they included: a succession of schools, music lessons, student boarders of a variety of political persuasions including some revolutionary activists, poetry and literature, pleasant times with young women musicians, one of whom Doc describes as having "well expressed topographic features," and the outdoor pursuits of fishing and exploring along the banks of the Moscow River. He was introduced early to the boreal forest ecosystems he came to love by spending summers on an estate of a friend of the family where paper birch grew in profusion on "worthless wild land."

Doc graduated from the Imperial Engineering College in Moscow and then became an officer in the Trans-Amurian Horse Artillery. During the course of World War I he was wounded three times and received several awards for bravery, including the Order of Saint George, the highest commendation for the Czar's troops. As the Bolshevik Revolution engulfed the Russian empire and the army began the practice of electing its officers Doc was elected as senior commander of his battery—an honor that he attributed to his part in rescuing the unit's field kitchen during an earlier retreat. After an interval of being caught in the ebb and flow of the Revolution, Wilde landed in Prague where he became a student in forest engineering, graduating cum laude in 1925 His educational program included extensive field work as well as an introduction to the laboratory aspects of the science. Work for a former professor in appraising forest stands and soils introduced him to an aspect of his field that challenged and fascinated him all of his life. Throughout this welter of experiences Doc continued to nurture his loves of music, literature, good food and drink, horses and attractive women. In 1928 Doc received the degree of Doctor of Technical Science from the



S.A. Wilde, circa 1970. *J.G. Iyer.*

University of Prague, received permission to immigrate to the United States, added English to his polyglot array of languages, and arrived at Ellis Island in May 1929.

In that depression-ridden time the United States was far from an easy place to get a job. Doc kept body and soul together working in a stable until a summer appointment with the U.S. Forest Service Lake States Forest Experiment Station at St. Paul, MN materialized. The job took him to an experimental forest in the upper peninsula of Michigan. A succession of similar short-term positions, separated by periods of unemployment, followed until 1934 when he joined the Soils Department of the University of Wisconsin.

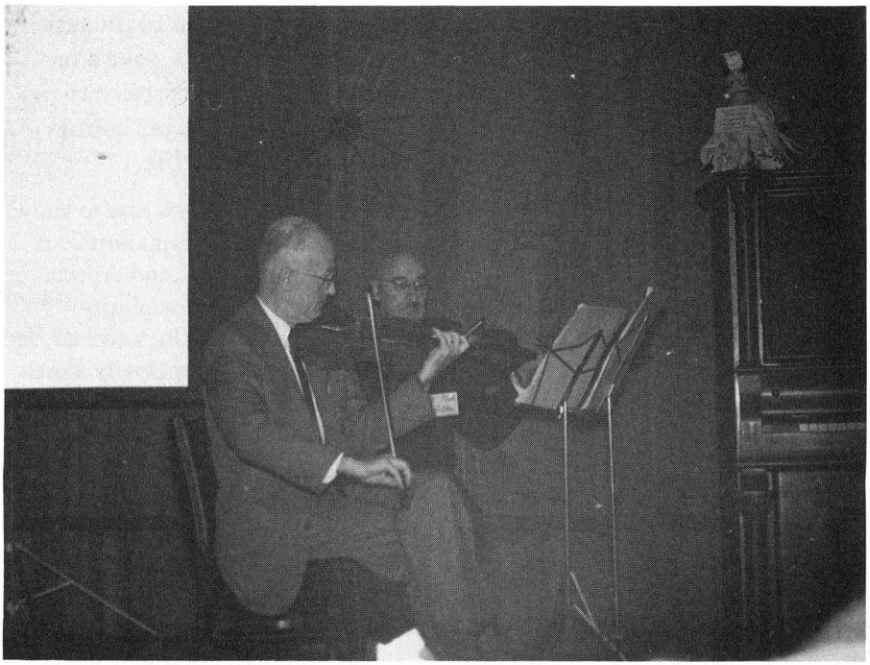
Employment of the liberated, vibrant, exuberant, cosmopolitan Wilde by the Soils Department introduced both a new facet of soil science and a new personality and background in it. Wilde dryly described the department he joined thus: "[W]hen I joined (the department) it had only six professors and about ten graduate students. My professorial colleagues were non-drinking, non-swearing fragments of the Victorian era, dedicated primarily to the production of crops. A conversation usually started with alfalfa and invariably culminated with fertilizers, the omega of the discussions." The process of amalgamation must have been an interesting one.

Doc's ingenuity and adaptability proved more than equal to the task. Garth Voigt, a graduate student of Wilde's in the early '50s, gave a review of how he experienced Doc as a part of the memorial service to pay tribute to this complex man on August 12, 1981 The excerpts quoted below draw together eloquently the many strands of a full life.

"He was, in the final analysis, a very private person who was not easy to know. Seldom were his inner thoughts revealed to anyone although disappointments expressed during his later days indicate that there had been goals and expectations. His inner privacy was to a large degree concealed by his complexity which, I believe, stemmed from his interest in and zest for life. Doc's enthusiasm for living was almost boundless. During the brief years that I was closely associated with him, he was variously immersed in horseback riding, sailing, hunting ducks and upland game birds, fishing, chess, duplicate bridge, woodcarving, woodworking, pen-and-ink sketching, water-color and oil painting, and of course music. The noon-hour halls of the Soils Building were frequently graced with the sounds of the classics generated in Doc's office by quartets, trios or duos that he assembled. On other occasions, when the spirit moved him, he would spontaneously burst into a passage from some obscure German opera. It was seldom clear what triggered these a cappella arias but they were frequently delivered when he arose from his desk to rummage through the sand-filled ash trays for the longest snuffed-out cigarette he could find or to prepare a fresh pot of tea which he consumed in great quantities.

"Doc was a voracious reader and could have very easily sustained a daily book-review column for the local newspaper. He read books of all kinds but returned regularly to the classic works. In all his artistic pursuits his umbilical cord to Europe was never severed. He received sustenance from European music, art and literature all his life. This is not to suggest that American efforts were ignored. Many American writers and a few American artists attracted and held his attention from time to time but there was never any doubt in his mind concerning the absolute superiority in all respects of the European masters over American composers.

"Doc's professional life was influenced strongly by his knowledge of European soils and silviculture, by his association at the University with Emil Truog and Aldo Leopold and by his day-to-day contacts with students and colleagues. He watched with more than paternal interest as his students returned from their scholastic struggles and when he saw application to a problem of current interest, he struggled with them. Usually he did more reading on the subject than even the best of students. Doc never separated his professional from his personal life. He pursued with the same unbridled gusto whatever the goal. Life was life—to be lived to the brim. Colleagues, students and friends were nearly always woven into the tapestry of his life regardless of the time that it happened to be or of previous plans. He was impetuous, persuasive and very hard to refuse and, as a result what was known as the Clear Lake Field Station frequently resembled the Rathskeller or O'Hare airport. These mixtures produced lively encounters and long evenings. And at the center of each vortex was the Professor!



F.D. Hole and S.A. Wilde providing musical accompaniment at a department party. Date uncertain. *A.E. Peterson.*

"My particular association with him spanned a particular segment when his star was in the ascendancy. This was a period capped with tragedy. He was promoted to full professor (though he had never considered himself anything else). His first textbook published by Chronica Botanica was well received and he was already planning the second and the third. His relationships with the Wisconsin Conservation Department were generally smooth and expanding. His regular production of research reports was attracting many good students and his position of leadership in the field of forest soils was rapidly gaining recognition. The Soils Department was flourishing and Doc was making a strong contribution to this increase in stature. Those were the triumphs. The tragedy was the death of his wife, Larissa, his 'lodestar in the voyage across the stormy sea of life'

"His enthusiasm and sensitivity for new ideas and for modifying and revising older accepted principles coupled with his well-developed sense of opportunism frequently took him (and us) into new and uncharted regions of forest soil science. He had an appreciation of the holistic nature of plant-soil systems that enabled him to anticipate by more than three decades present-day concerns with toxic chemicals, soil biology, ground water and the interrelationships of all of these components. Professionally, the soil ecosystem was the center of his universe and his concern with the significance of nursery practice for future forests was with him until his death."

Doc did more than read literature voraciously. He translated a variety of literature from Russian to English—including obscure—often bawdy—poems of Pushkin. John Harkin, who edited the translations for him, recalls that Doc's English vocabulary was spectacular, but noted that it took Doc's idiosyncratic pronunciation of English words to make the lines flow when read aloud. Doc rewarded Harkin for his services with occasional multi-course lunches which were preceded by liberal offerings of Doc's best vodka and followed by his demonstrations at the grand piano of how Paderewski, Rubenstein or Horowitz would be likely to interpret a piece of music.

Harry Galloway, a student of Doc's from 1936 to 1938, describes an experience with Doc which typifies him perfectly:

"Wilde had a cabin at Clear Lake in Vilas County which he headed for as often as possible. On one trip that summer, Wilde, Lola and I were on our way north thru a sand plains town when a car rammed us from the rear at a stoplight. Doc was out of the car like a flash yelling "you eedioite (idiot)! Why you run into us?" I was in the back seat recovering from the shock when I heard Doc cry, "Gal (short for Galloway) come help me queek." On getting out I saw the problem. The driver was a huge lumberman-like fellow who looked so drunk he could scarcely stand. He towered over us! Doc figured that there was no use talking about insurance or who was guilty. Instead, he asked the fellow's passengers where the Ford garage was. He pointed down the street and we took off for it. Sometimes discretion is the better part of valor.

"The happy ending was that we had a *new* car within a half hour and the old one stayed there in trade. Moral: When there's good fishing and the walleyes are running in the shallows don't let *anything* interfere, not even a car. We were right on time to meet Dick Wittenkamp, Wisconsin State Forester and to go fishing that evening on Clear Lake."

Doc, always the pre-revolution aristocrat, never lost an opportunity to make a point about his distaste for the communist revolution in the USSR. Jaya Iyer related one such incident which occurred when she and Doc and a delegation of Soviet pedologists were examining soils in the field at a series of pits. Doc was having some difficulty getting into and out of the pits, and one of the visiting Russian scientists commented that Wilde was a bit overweight. Doc stopped, looked down at his large midsection, placed a hand dramatically on his convex abdomen, and said, "Don't forget Comrade, that I've been under the pressure of the capitalistic system for nearly forty years." This riposte epitomizes the man who was always able to seize the moment and make something distinctive and wonderful from it.

International Agriculture

by J T. Murdock

The importance of a free flow of knowledge across national boundaries was recognized from the very beginning of the Department of Soil Science. F.H.King, the founder of the department, cashed in an insurance policy and used these funds to travel to the Orient during the last years of his life. The result was a book, *Farmers of Forty Centuries*. King's keen insight in studying traditional agricultural practices may not have been fully appreciated until concerns began to surface about the relationships among modern technology, agricultural sustainability and environmental protection in the '80s. The writings of European scientists and agricultural educators had a tremendous influence on the development of scientific thought of Whitson, Truog and other early leaders of the Department of Soil Science. Their capacity to apply scientific processes to the solution of practical problems was a major factor in gaining international recognition for the department.

Following the First International Congress of Soil Science in Washington, D.C., in 1927, Truog traveled with noted soil scientists from around the world on a post-congress tour of the USA. He played an active role in introducing these scientists to the rapidly developing agricultural research programs of the U.S. Land Grant Universities. The flow of information began to be reversed and analytical procedures, research concepts and production practice developed by our scientists began to find their way into research centers and farm fields around the world.

By 1940 the winds of war had swept across Europe and Asia and the events of December 7, 1941, propelled this nation into a war that irrevocably changed the world in which we live. This tragic era resulted in unparalleled human suffering but it was also an event that opened channels of communication among nations. Systems of production and transportation developed to supply the war effort remained to facilitate social and commercial interaction. In the postwar era, national and international agencies concerned with industrial, agricultural and cultural development were established to counteract the ravages of war and heightened

W.W. Wier, Saidel and E. Truog (left to right) on an International Soil Science Congress field trip in 1927. *Department files.*

international awareness encouraged national independence for peoples who had been under colonial rule for centuries. But independence did not resolve all the problems faced by these emerging nations. On the contrary, severe food shortages and weak economic positions highlighted their need to build or strengthen systems of agricultural production. A major response to this need was to focus on the successes of agricultural production in the USA and on the support provided by the Land Grant system of education, research and extension. The College of Agricultural and Life Sciences, University of Wisconsin, provided an outstanding model of this system. The work of the Department of Soil Science put it at the frontier of soil science and made it a logical source of assistance for other nations.

By 1960 the University of Wisconsin had established an outstanding reputation for its involvement in international activities. In that year the department hosted the quadrennial meeting of the International Soil Science Society. This was a signal honor for the department and a product of sustained vigorous efforts by Truog. He had worked tirelessly toward this goal since his "retirement" in 1954.

Wisconsin was the home of one of the largest groups of foreign students of any university in the world, and the department enrolled its share of international students. In recognition of the important role of the university in international development, the Board of Regents

expanded the "Wisconsin Idea" that "the borders of the campus are the borders of the state" to give it an international flavor. At its meeting in March of 1961 the Board of Regents adopted the following concept:

"With the passing years, the welfare of the people of Wisconsin has become increasingly tied to national and international developments. It is logical, therefore, that the scope of the Wisconsin Idea should be broadened We recognize that the University's first responsibility is to Wisconsin and its residents. But the University must look outward if this obligation is to be fulfilled The interdependence of the world's people, the ease of travel and communications, the rising importance of other cultures and the quest for peace have tended to make the globe our campus."

In 1964, CALS made its first serious move to develop technical assistance activities in international agriculture. Teams were sent to Brazil and Nigeria to study the feasibility of the involvement of the University of Wisconsin–Madison in institution building programs in cooperation with colleges of agriculture in these countries. After the first task force reported back, then Dean of the College, Glenn S. Pound, wrote to the Agency for International Development (AID) expressing interest of the college in participation in overseas assignments as follows:

"For a number of years, fully a third of Wisconsin's graduate students in agriculture have been from other countries. We have emphasized particular areas of scientific subject matter, but we have been increasingly concerned about applying this knowledge to practical problems. Consequently, we are finding it more and more desirable to work in specific overseas locations where there is some promise that our resources can be teamed with those of a host country to make a substantial contribution to challenging problems."

On the basis of this decision the college initiated a program of technical assistance that has become one of the largest in the country. The International Agricultural Programs Office was established in 1963 to give direction to the program. Faculty of the Department of Soil Science were in demand from the outset and played a key role in the development of the international activities as an important function in CALS.

Technical assistance contributions from Soil Science began with requests for services from various agencies. Engelbert worked in Vienna, Austria with the International Atomic Energy Agency, 1963–64. Corey was supported by the Rockefeller Foundation to teach and develop research programs in the Colegio de Postgraduados-Escuela National de Agricultura, Chapingo, Mexico, 1964–65, and A.E. Peterson completed a tour with the Rockefeller Foundation in Egypt and Thailand in 1966–68. By the end of 1964, CALS development projects had been established in Brazil and Nigeria. The Department of Soil Science played a

Corn ears from exhausted land, right, and recuperated part of same land, left. Santa Rosa, Rio Grande do Sul, Brazil. *J. T. Murdock.*

leadership role in these projects and later in the development of a similar project in Indonesia.

Murdock was the first representative of the department to become involved in our long-term institution building efforts to strengthen universities in third-world countries. This work began with cooperation at the

Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, Brazil, in 1964. He first served as soil scientist and then as Project Director, 1966–68, a leadership role in international agriculture he was destined to follow for 22 years before returning to the department as Chair in 1988.

When the Wisconsin team arrived in Porto Alegre there was only 0.5 FTE of faculty time in the Department of Soil Science, UFRGS. The charge given the team was to develop graduate programs within the first two years of the project. The only equipment in the department there was a pH meter and the only reagent was a carboy labeled "Truog's Extraction Solution." It was obvious that more help had to come from somewhere and the logical response was that it must come from the UW Department of Soil Science. The department responded with backstopping help in many ways, including faculty support. Beatty, Kussow, and Al Ludwick (post-doctorate) were sent on long-term assignments and Corey, Engelbert and Walsh on short-term assignments. The graduate program was initiated in 1966. Engelbert returned for a long-term assignment as project director 1969–72, when the project was completed. By this time there were 16 FTE of qualified Brazilian faculty with a growing program of instruction, research and extension.

At present the Department of Soil Science, UFRGS, is one of the strongest departments of soil science in Brazil and maintains close linkage with the UW Department of Soil Science. Wisconsin staff took with them an idea that philosophical as well as technical and scientific transfer was important. The Wisconsin tradition of involvement of faculty and students in laboratory and field work of importance to the agricultural community was an important tool used in the development process. When Wisconsin staff arrived in Rio Grande do Sul, it was fairly obvious that the predominance of acid, infertile soils was a major problem for agricultural production in the state. Immediate steps were taken to gather field information on crop responses to lime and fertilizer applications on major soils in the state and to establish a soil testing laboratory capable of analyzing samples from farm fields. Brazilian graduate students played a key role in this effort. In 1966 they initiated a project to reach out to farmers in the small-farm region of Rio Grande do Sul. Local papers carried headlines "The Federal University Finally Finds the Rural People." The success of this effort encouraged the students to work with faculty and students in other disciplines and to launch "Operacão Tatu" (Operation Armadillo), a soil improvement program that spread to over 35,000 farms and three states by the end of the project in 1972 Not only was Operacão Tatu recognized internationally as

Balinese women hand-harvesting rice. Rice is the staple food of Indonesia, and women traditionally do the planting and harvesting. *L.M. Walsh.*

one of the outstanding examples of working with small farmers, but it was recognized by the UFRGS as an awakening of their commitment to people of the state. In 1969 the Dean of the Faculty of Agronomy, UFRGS, wrote to UW colleagues exclaiming "we are literally planting the flags of UFRGS in every corner of the state"—not far from the Wisconsin Idea!

Shortly after the University of Wisconsin initiated its cooperation with UFRGS, a similar project was begun with the Faculty of Agriculture, University of Ife, Ile-Ife Nigeria. Schulte was the first long-term UW soil scientist to work on this project, 1964–67 and 1971–73, followed by Corey, 1966–71, and M.I. Harsptead, 1968–70, of UW-Stevens Point. In the Nigerian case, the Department of Soil Science had to be developed from its very beginnings. For example, Corey served as Dean of Faculty in 1970–71 The UW Department of Soil Science faculty were involved in teaching, research, and administration while Nigerians were being trained. By the end of the project in 1975, the Department of Soil Science, UNIFE, had 7 senior staff and a full complement of junior and intermediate staff representing soil fertility and plant nutrition, soil chemistry, pedology, soil survey and land use planning and soil microbiology and biochemistry. This new department had established a seven-year study on NPK complete factorial rates for common Nigerian crops; an ecology plot study of the soil effects of continuous cropping to bush

plots left fallow for 25 years and five years, respectively; studies of the effects of different nitrogen fertilizers on soil pH, research on the use of minimum tillage and mulching to control erosion and nutrient runoff; and a nitrogen study on continuous maize and yam cropping.

During the University of Wisconsin's 10 years at Ife student numbers grew from 476 to 4,998, a new campus had been developed and the Faculty of Agriculture had matured to become a major force in Nigeria's agricultural development.

In 1970 the Department of Soil Science became involved in a third institution building project through the Midwest University Consortium for International Activities (MUCIA). The overall project was directed at the development of higher agricultural education in Indonesia, but leadership provided by the University of Wisconsin focused on the Institut Pertanian Bogor (IPB). The Department of Soil Science again provided leadership to the program. Murdock served as project coordinator from 1970–73. This relationship initiated a long-term association that was to conclude with a 5-year assignment in which Murdock served as Project Director for a University of Wisconsin Graduate Education Project, 1980–85. During this period IPB grew from 1200 students studying for their first degree in 1970 to a campus with over 12,000 students and degree programs at BS, MS, and PhD levels in 1985

As it reached its 100th anniversary, the department was beginning to be involved in a CALS project on agricultural research and extension in The Gambia.

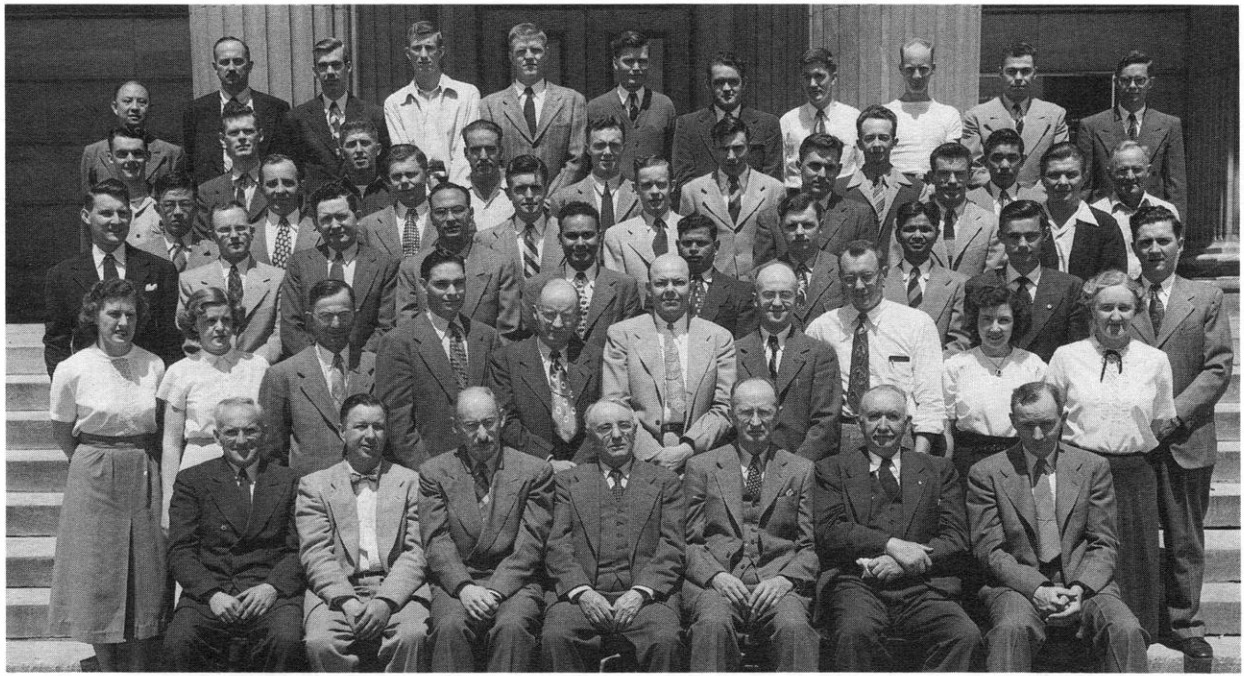
From 1964–89 the Department of Soil Science has provided over 40 person years of the tenured faculty time to institution building activities in universities abroad. These faculty returned to provide leadership for international activities in the department and on campus, and they brought their world views of peoples, lands and soils into the classrooms, seminars and laboratories. Both Kussow and Murdock served as Directors of International Agricultural Programs in the College of Agricultural and Life Sciences, and Murdock served as President of MUCIA during its 5-year stay on the Wisconsin campus.

Evolution of a Comprehensive Department

From its inception until roughly 1958 the department held a preeminent place among soil science departments in the world through its excellence in understanding and teaching the relationships of soils to crop and forest production. For the past 30 years the challenge of being on the leading edge of the science of soils has become much more complex, in part because of the array of new societal concerns in which soil science plays key roles. International agriculture, environmental quality, water quality, toxic and hazardous chemicals, solid and liquid waste disposal, acid precipitation and land use have joined crop production, resource inventory and soil conservation as focal points for departmental programs. Concurrent with these changing influences have been striking changes in the backgrounds and gender distribution of students. Sources of funding for research and graduate student support have changed, grown, and then been strongly reduced, in constant dollar amounts, over this 30 year period.

The self study reports, mission statements and related documents which faculty and staff have prepared over this period of broadening goals, changing student body and shifting financial support provide a series of "snapshots" of departmental thinking and how it has evolved during this period of accelerating changes. They illustrate both the evolving self image of the department itself as seen by its faculty, and a developing collective ability for analysis, synthesis and establishing priorities for future programs, staff and facilities.

The first of several documents that cover the last 30 years of development of the department was a very progressive position paper developed in 1964–65, primarily under the impetus of M.L. Jackson. It opens by proposing that the department name be changed from Soils Department to Department of Soil and Water Science. It is interesting to imagine how the department might have been different if the full change had been accepted by the faculty, rather than the change to Department of Soil Science which was adopted in 1965. This position paper describes



Department of Soil Science staff and graduate students, 1950 (left to right): *1st row*—O.J. Attoe, K.C. Berger, S.A. Wilde, E. Truog, E.J. Graul, C.J. Chapman, R.J. Muckenhirn; *2nd row*—Arline Kaisler, Shirley Herschleber, A.R. Albert, L.E. Engelbert, H.H. Hull, M.L. Jackson, F.D. Hole, C.B. Tanner, Veronica Kennedy, Margaret Stitgen; *3rd row*—Paul Eckern, Paul Kaesberg, John Retzer, Mohamed Shihata, T.M. Rao, D.G. Kelkar, D.L. Hallock, D.K. Patel, D.W. Kolterman, A.E. Peterson; *4th row*—Li-Chuan Wang, R.W. Staroska, E.C. Steinbrenner, C.L. Sarthou, G.J. Oulette, C.I. Rich, R.S. Pierce, J.C. Zubriski; *5th row*—G.E. Wilcox, C.V. Cole, C.M. Geraldson, C.T. Youngberg, D.A. Rennie, J.D. Lancaster, D.W. Rhodes, Tsuneo Tamura, James Asplin; *6th row*—Yi Hseung, D.T. Pronin, J.A. Asleson, G.K. Voigt, W.T. Dible, L.E. Orth, L.D. Whittig, W.H. Anthony, E.J. Evans, C.H. Robinson, R.B. Corey

the department as being "organized in six subject matter areas: physics of soil and water, chemistry of soil, water and minerals, soil fertility, biochemistry of soil and water, soil classification, and soil and water conservation." It states that "[E]ach of these diversified programs includes basic research, resident teaching and extension services to Wisconsin citizens. Each ultimately relates the science of soil and water to basic science as a whole, to plant and animal ecology, and to human environments."

The paper proposed that the renamed department meet growing needs for individuals trained in soil and water science who can effectively deal with growing urban and rural technical problems and world problems of food shortage brought about by population growth. It sets direction with the statement: "Programs in international agriculture, water resources and environmentrics will be given increased emphasis and are expected to become major departmental programs in the years ahead. Food and fiber production research will continue to receive strong attention, but will emphasize fundamental studies such as the efficiency of carbon dioxide assimilation and crop quality as affected by plant nutrient balance." The paper proposed that Extension Specialists be budgeted in part to research and be expected to carry out the studies needed to answer the problems of farmers and industry rather than depending on faculty primarily budgeted to research for such studies. The paper proposed that the department place increased emphasis on soil surveys and their interpretations for nonagricultural uses.

The paper proposed a program of systematic improvements in the teaching program. These included procurement of grant funds for "fundamental, novel improvements in course content and teaching methods." Also proposed was special teaching emphasis on "relating fundamentals of soil and water science to concerns of undergraduate and graduate students in geology, geography, anthropology, bacteriology, botany, civil engineering and the various planning and design fields" while continuing to meet the needs of students in the College of Agriculture who have specialized interests in soils and water broader than those traditionally emphasized.

After delineating a policy for research of "development of basic research programs of an excellence that will command increasing support from major federal granting agencies set up for support of basic research," the paper outlined existing and proposed water research programs, environmental science programs and soil survey programs. This section of the paper was primarily a proposal for systematic development and expansion of a series of programs that were of relatively recent vintage in the department and that showed strong potential for new or

expanded funding. International agriculture programs were given major attention in the paper, not surprisingly, because policy emphasis of USAID at that time emphasized institution building, and building institutions of higher learning was an important component of that program. Also giving impetus to this aspect of programming was the fact that two faculty were on long-term assignment to Nigeria and Brazil and several other faculty had participated in short-term overseas assignments.

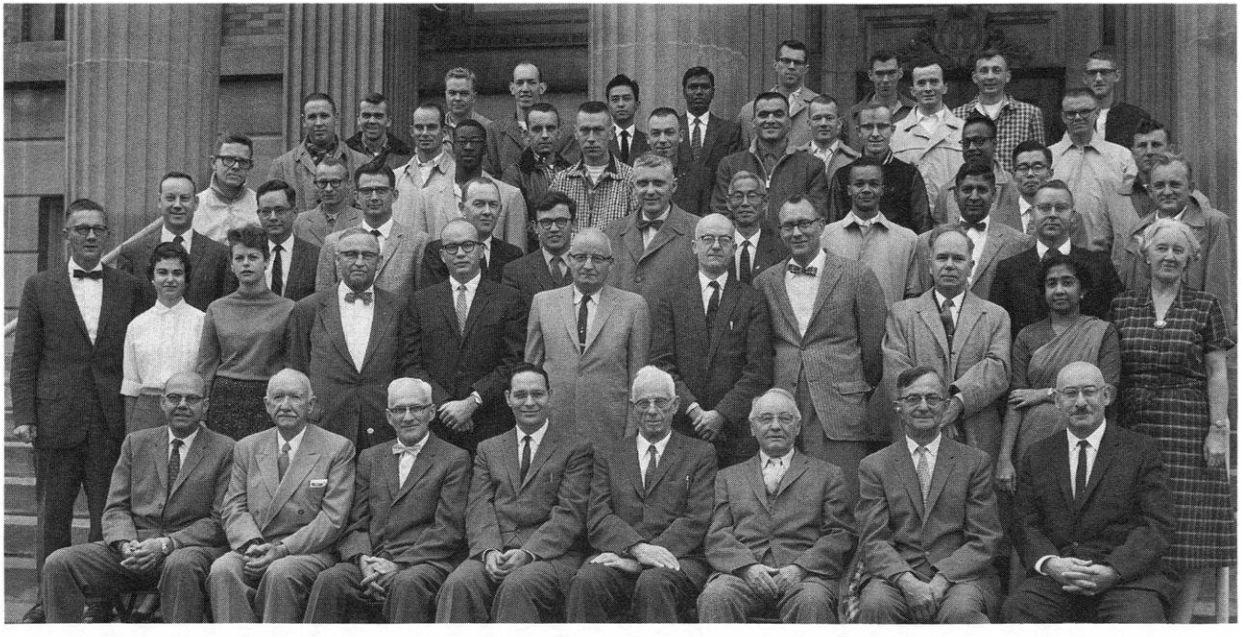
Cooperative programs formed a major heading and point of emphasis of the paper. Not only were the directly obvious interdisciplinary cooperative relationships pointed out but cooperative programs with international, national, regional and state-wide dimensions were each given emphasis.

The 1965 paper was the first to give a systematic treatment to several aspects of staffing. It projected retirements for the subsequent 15 years, proposed preferred ways of filling vacancies created by retirements and proposed adding seven faculty positions. The two highest priority positions/individuals were added and one continues on the faculty at this writing. The paper concluded with a renewed appeal for expanded space and improved physical facilities that was first made formally in a 1961 appeal to the College of Agriculture.

The position paper had important effects on the department. It catalyzed a change in name, even though not to the one originally proposed. It helped to legitimize and systematize incremental changes which had been occurring with increasing frequency. For the first time it projected staffing needs in a new and comprehensive way, thereby catalyzing a great deal of thought and talk about the issues involved. Its emphasis on cooperative programming with an array of other disciplines and organizations sounded a major theme that was not recapitulated in subsequent plans until 1985.

The rapid pace of change and growth during the 1960s and the early 1970s prompted preparation of a decade-long review of growth and changes in the research program of the department from 1964 through 1973. The statement on departmental mission which opened that paper highlighted the striking changes in scope and emphasis which had occurred in research program orientation, and indirectly in all of the other programs of the department, as follows:

"Until the early 1960s, the Department was internationally known for its training, research and extension activities in soil science as related to crop production. More recently, departmental activities have focused on broader problems of environmental science and this change in emphasis reflects itself in all aspects of the department's programs. Research has developed along such problem



Department of Soil Science staff and graduate students, November 1960 (left to right): *1st row*—M.L. Jackson, C.J. Chapman, O.J. Attoe, L.E. Engelbert, O.R. Zeasman, E. Truog, A.R. Albert, S.A. Wilde; *2nd row*—A.E. Peterson, N. Schmitz, D. White, I.O. Hembre, L.M. Walsh, H.H. Hull, F.D. Hole, C.B. Tanner, R.M. DeMuth, J.G. Iyer, M. Stitgen; *3rd row*—J.R. Love, R.B. Corey, J.T. Murdock, G.B. Lee, E.G. Youngs, E.E. Miller, H. Saeki, J.R. Sessing, N.N. Nimgade, J.G. Genys, H.H. Krause; *4th row*—J.D. Hogan, G.W. Olson, C.C. Applewhite, R.E. Doersch, R.J.M. Salem, E.E. Schulte, I.U. Ahmed, K. Wada, J.L. Tuschl; *5th row*—T.H. Schultz, W.J. Sharratt, T.A. Richard, W.E. Janke, J.J. Mortvedt, P.V. Kiely, M.H. Milford; *6th row*—G.R. Hagstrom, J.L. Stroehlein, R.W. Andrew, Jr., H. Tanaka, S.T. Gaikawad, C.R. Willey, J.C. Klacan, D.C. Martens.

Not appearing in photograph: Beatty, Berger, Chesters, Christoph, Dixon, C. Else, Faber, Hammes, Hays, Jablonic, Muckenhirn, Olsen, Patzer, Sale, Saleh, Suomi, Wang, A. Zimmerman, Beaver, Dahnke, de Vries, Fack, Fanning, Federer, Dudley, Hanna, Hashimoto, Keeney, Kilian, Kunishi, Langton, Milfred, Nielsen, Peck, Puri, Saatci, Sarma, Scholten, Shah, Spyrdakis, Stangel, Stewart, Swan, Thompson, Thurtell, Topp, Valencia, Watson, Waugh, Harris

areas as lake eutrophication, aquatic weed control, water movement, ground water pollution, sludge and effluent recycling, septic tank improvement, use of soil resource inventories for non-agricultural purposes, which is of course a major shift in emphasis."

This statement made clear the large degree to which the changes proposed in the 1965 position paper had become reality by 1973 Factors which induced these changes included the growth in availability of grant funds for research in the environmental areas, changing background of undergraduate students from rural to urban, and the growing awareness of environmental problems, broadly defined, among leaders of governments and the private sector in the state. The result of these factors was most clearly evident in the research funding changes during the decade.

In 1965 extramural funding for research that was agricultural in orientation was $144,000; by 1971 it had reached $179,000, but in 1973 it had declined to $113,000. Extramural funding for environmentally oriented research (which included urban, ecological and health sciences) increased from $192,000 in 1965 to $618,000 in 1973. In addition to the striking change in proportions of extramural research funds directed toward "agricultural" and "environmental" research, the proportion of research funds from extramural sources relative to state of Wisconsin funding for research increased greatly. By 1973 the department was receiving $2.76 of extramural funding for every $1.00 of state funding designated for research. In historical context this represents a major change in source of research funding. With this came an equally significant change in the geographic orientation of the research programs—from being primarily concerned with Wisconsin to having much more comprehensive geographic concerns and applicability. Following an external review in 1972 these changes and growth in program were incorporated into a departmental mission statement in February 1974. That statement summarized the overall mission of the department in undergraduate and graduate instruction, research, extension and international programs. It emphasized the changes which had been occurring during the prior 15 years, noted projected growth in demand for well trained students in soil science as related to both agricultural and environmental problems and issues, and made clear the international involvement and roles of the department. The authors of the mission statement made no effort to analyze the forces which would shape future trends, nor to define the department's niche in the emerging scenario of higher education. It primarily legitimized changes which had already occurred and projected overall growth in demand for undergraduate and graduate students.

The department underwent a cooperative research review in 1979. In preparation for that review the faculty prepared an overview document which laid out eleven attributes of the department which embraced mission, staff, programs, financing and facilities. That status report is both detailed and comprehensive, and thus provides a benchmark against which the department can be compared both now and in future years.

By 1979 the faculty had grown to include 24 individuals, who were collectively budgeted 20.34 full time equivalents (FTE) to the department in proportions of approximately 25 percent instruction, 22 percent extension and 53 percent research. These faculty were supported by 10 academic staff specialists, six classified staff technicians, eight classified secretarial staff, and worked with five postdoctoral appointees. There were 60 graduate students enrolled in the department's program. Eight individuals held adjunct faculty appointments and were budgeted fully outside the department. The overview points out that the department's net assignable space had increased from 22,750 square feet in 1965 to 33,940 in 1979

The 1979 overview included a description of the then current program and a projected future program for the four main components of departmental activity—instruction, research, extension and international programs. The document noted the major improvements in instructional program which had been put into place in the preceding decade in response to the dramatically increased demand for soil science instruction by students oriented toward environmental quality and land use as well as those interested in agriculture. It pointed out that student credits had risen from 760 in 1971 to over 1800 in 1977 and appeared to have stabilized, and that the number of majors in the department had increased from 40 to 111 during the same period. The courses General Soil Science (301) and Soils and Land Use Planning (315) led enrollment with more than 100 enrollees each per semester. The context in which these changes occurred is described in the chapter Teaching The Science. Future directions for instruction envisioned consolidating the major changes that had already occurred, formalization of the laboratory course in soil physics, and possible development of advanced courses in soil-plant interactions and soil genesis. The structure of seminars and special topics courses was noted as having, at least in theory, the potential to "provide advanced level instruction in all of the increasingly more diverse and highly specialized interest areas constituting Soil Science."

In research the department proposed to continue work in basic areas, and to "respond to the major societal needs of the state, region and the nation," as dictated by the funds available. Problems associated with

Department of Soil Science staff and graduate students, 1970 (left to right): *1st row*—A. Iskandar, K. Sridhar, J. Henderson, G. Ojanuga, A. Breider, J. Iyer, B. Schrag, H-C. Shiaw, S.A. Wilde, W.R. Gardner, R.J. Muckenhirn; *2nd row*—S.Y. Lee, N. Burt, S. Friede, C. Wagner, F. Roed, J. Schroeder, A. Aebly, A.E. Peterson, M.L. Jackson, O.J. Attoe, S.G. Dolar; *3rd row*—P. Hodgson, J. Schmelzer, J. Tuschl, O. Osiname, M. Pockar, L.M. Walsh, B. Hoeft, R. DeMuth, D.R. Keeney, P.J. Gous; *4th row*—L. Cajuste, B. Frazier, D. Graetz, M. Browman, R.D. Powell, J.R. Boyle, N.O. Isirimah, F.D. Hole, D. Moore, A.J. Peck; *5th row*—A.A. Millar, W. Adebayo, G. Chesters, L. Sommers, C.J. Milfred, G.B. Lee, L. Jacobs, J.K. Syers, P.A.C. Raats; *6th row*—F. Dalton, M. Wesely, C.R. Amerman, K. Tornberg, D. Nichols, R. Hensler, K.A. Kelling, H. Weaver, D. Mokma, C. Dirksen, G. Waddell, G. Smillie; *7th row*—E.E. Schulte, M.T. Beatty, R.F. Harris, W.R. Kussow, J.R. Love, C.B. Tanner, E.E. Miller, J. Lambert, G. Randall, D. Kinniburgh, T. Evans

increasing urbanization such as conflicting land uses, environmental degradation, non-point pollution, small-scale waste management, sludge disposal, and other solid waste problems were highlighted for special mention. Emphasis on the basic chemistry, biochemistry and physics of processes which occur when wastes are placed in or on the soil were given as the department focus. Irrigated agriculture and the problem of nitrates in groundwater aquifers was also highlighted as an area of both departmental and interdisciplinary research emphasis.

The extension program of the department was described as "providing practical interpretations of soil science research to Wisconsin farmers, urban citizens, industries and governmental agencies," either directly by subject matter specialists of the department, or through county Extension faculty, professionals in the field, staff of governmental agencies or agribusinesses. The two-way interaction of research and extension programs was emphasized. Extension work with governmental units to aid local and state elected officials in their decision-making processes was stressed. In lieu of major future projections the document pointed out the process of annual program planning which is ubiquitous in the extension program planning process.

The international programs of the department were described as embracing technical assistance (generally performed by faculty at an overseas location), graduate training of international students in Madison, and research. The 1979 overview was written six years after the major institution building contracts with universities in Brazil and Nigeria, in which the department was involved, had ended. The overview paper proposed that the department actively pursue participation in the Title XII program of the Foreign Assistance Act, including attempting to add a staff position via the Strengthening Grant available under this title of the Act.

The 1979 overview gave no priorities among the various proposed programs nor did it list contingencies or alternatives for dealing with eventualities such as funding limitations, forced reductions in budgets or staff FTEs, or downturns in enrollment. In essence it proposed continuation of the 1979 department program as it then existed with refinements in selected components. The necessity for setting such priorities arrived in 1980 in the form of mandated base budget and FTE reductions of 5% in research, instruction and extension following substantial cuts in state and federal base budgets for the University of Wisconsin–Madison and University of Wisconsin-Extension.

The department responded to this mandate, which applied to all departments and units in the College, with a statement adopted by the

faculty on a 15 to 7 vote and sent to Dean Walsh in February 1981 It proposed that the mandate be met by changes in restaffing upon the retirements of Jackson and Hole. If only one of the two vacancies created by these retirements could be replaced, the majority view was that the single new position should be a soil physicist with a strong basic background (to replace the expertise lost when Gardner resigned in 1980.) A minority of the faculty felt that the first priority for restaffing if only one position were available should be in soil classification-genesis-land use. Thus the exceedingly difficult leap from overall planning for a department with the assumption of stable or growing funding to mandated reduction of a strongly specialized faculty and staff with only a very few individuals in each specialty was confronted. In actuality some of the issues and alternatives became moot as a result of the availability of staff who could be recruited for the one open position.

In 1984–85 the department again carried out a self study in preparation for a comprehensive review by an external panel. The process and the resulting document represent a distinct advance over earlier efforts, including the bellwether 1965 position paper, which had until then been the most incisive and comprehensive document on the department's program. The 1985 overview was developed after sustained departmental deliberations. The written document that resulted included an 88-page text supplemented by seven appendices.

The section on instructional program devoted its principal attention to the principles on which department's course offerings were based, trends in course enrollments and specific plans for staffing the courses for which new instructors would be needed because of forthcoming retirements. The degree of incisive analysis, treatment of deficiencies in the coursework program and explicit plans for the 1985 to 1990 period represent a major advance in departmental planning efforts.

The department's evaluation of its research efforts and prospects led to a very different written product than did earlier efforts. Limitations, barriers and competitors for funding were acknowledged openly. Then the research of the department was treated by programs rather than by groups of projects as had been done in the past. The three interrelated programs—crop production, soil and water conservation and soil genesis—were each analyzed in detail from a systems perspective (this was particularly true of the crop production section) rather than from a historical project or funding perspective. Computer-aided modelling of systems was explicitly described for the first time in a departmental planning document. What emerged was a coherent and integrated research agenda for the programs, and for the department, that could im-

Department of Soil Science staff and graduate students, 1990 (left to right): *1st row*—O.J. Attoe, L.E. Engelbert, Dick Corey, Art Peterson, G.B. Lee, Champ Tanner, Ed Miller, Marv Beatty, Katim Touray, Cathy Seybold, Kris Lund, John Harkin; *2nd row*—Yingming Liang, M.L. Jackson, Will Bleam, Phil Helmke, Francis Hole, Brian Girard, Mark Janowiak, Rick Wietersen, Paul Ehrhardt, Zhibo Lu, unknown, Dave Kroll; *3rd row*—Keun-Yook Chung, Steve Grant, Terri Kraak, Todd Andrski, Tony Miller, Gary Hart, Tom Sauer, Rahman Azooz, Steve Donohue, Wayne Kussow, John Murdock, Chris Meyer, Fred Matt; *4th row*—Jaya Iyer, Jan Jarman, Will Stites, Kevin Fermanich, Pat Sauer, Chris Johnson, Mike Pelech, Tom Vlach, Susan Sommers, Mary Czynszak-Lyne, Judy Hale, Riyadh Fathulla; *5th row*—Ibrahim Saeed, Phil Speth, Sheri Speth, Carol Duffy, Len Dain, Jim Marshall, Sebastian Braum, Chen-Peng Chen, Carlos Rodriguez, Roger Springman, Jim Vanherwynen, Robert Schmidt, Susan Danforth, Lisa Danforth, Paulette Falk, Phil Hodgson, Sherry Combs; *6th row*—Hyun Park, Keith Kelling, Birl Lowery, Syaiful Anwar, Paul Brake, Gereon Welhouse, Bill Hickey, Gary Jackson, Larry Bundy, Renate Forkel, Joyce Alt, Mike Anderson, Chris Rademacher; *7th row*—Steve Ventura, John Norman, Jim Love, Kevin McSweeney, Wenli Cheng, Baojin Zhu, Dong Wang, Alex Kurakov, Jerry Tyler, Matias Vanotti, Kent Smith, Nyle Wollenhaupt, Gordon Chesters, John Parsen; *8th row*—Emmett Schulte, Kristin Clausen, Merritt Milks, Dick Wolkowski, Jason Garwick, Gary Johnson, Robin Harris, Sam Halaka, Sam Kung, Dan Gustafson.

mediately be perceived to be of significance to society and to the advancement of science. A major theme of the document was interdisciplinary research.

Changing interdisciplinary relationships and changing roles and relationships with state agencies were important facts of life as the department completed its first hundred years. As both the university and society at large change, the pattern of disciplinary and departmental organization no longer fits current problems, issues and opportunities. Within the University of Wisconsin–Madison, creation of formalized interdisciplinary organizations and programs, such as the Water Chemistry Program, the Institute for Environmental Studies and the Environmental Toxicology Center in the early 1970s have had significant impact on the department and its program. The influence of the Institute for Environmental Studies has been broader since its program embraces undergraduate instruction, graduate instruction and research. Both Lee and Keeney provided sustained major leadership to the Land Resources Management Program of the Institute, Madison has been involved in teaching and advising students in the Water Resources Management Program and Harkin has led the Environmental Toxicology Center for several years. Chesters has directed the Water Resources Center of the Graduate School since 1972. All of these new intrauniversity relationships have led to both opportunities and problems for the department, many of the latter still unresolved in 1989.

This chapter describes some of the formal planning documents which came out of a period of strong changes and strains for the department. The department was striving to come to terms with, among other changes, new societal expectations, changes in sources of funding, growth followed by decline in funding for research and extension, and changes in numbers and backgrounds of students. All of these changes existed in a period when the science of soil was growing rapidly and significant new research findings were occurring throughout the nation and the world. In many cases, the way in which research was done and the tools for doing it were also undergoing significant changes.

These conflicting and changing expectations produced debates and disagreements among the faculty along with the plans which finally emerged on paper. Occasionally the disagreements spilled over into the public arena. When Keeney left in 1988 to head the Leopold Center for Sustainable Agriculture at Iowa State University his criticism of inadequate funds for research on sustainable agriculture issues and outmoded research facilities in the Soils Annex received wide coverage in the press.

Such occurrences of public disagreement have been rare. This one may, however, have helped to accelerate changes. As the department reached its 100th year, plans for remodeling the Annex had been approved, and persons selected to fill open faculty positions were bringing a strong scientific and environmental background to the department.

APPENDICES

Several department buildings (left to right): Soils Annex, Soils Building, King Hall and a greenhouse. *UW–Madison Archives.*

Appendix I—Buildings and Facilities

Building	Years Occupied	Architect	Original Cost	Net Assignable Square Feet
South Hall (part)	1889–96			
King Hall*	1896–date	J.T.W. Jennings	$37,000	11,208
Soils Greenhouse (rebuilt in 1954)	1908–date	Arthur Peabody		4,753
King Hall Addition (Soils Building)	1914–date	Laird & Cret	$49,200	15,359
Soils Annex (built in 1909)	1972–date	Arthur Peabody	$20,000	7,955

*When the Soils (then Agricultural Physics) Department first occupied King Hall they shared the building with the Department of Horticulture. After the 1914 addition, commonly known as the Soils Building, was built the Department moved out of the original (1896) King Hall, re-occupying it in part in 1965, and in its entirety following a complete remodelling which began in 1983 and was completed in 1987 under the direction of Miller, Wagner, and Coenen, Architects, at a cost of $2,062,900.

The Soil and Plant Analysis Laboratory was initially located in King Hall and the Soils Building and then occupied rented space at 806 S. Park St., Madison, from 1967 until 1984, when it moved to 5711 Mineral Point Road, Madison. The Marshfield Laboratory has had space at the headquarters of the Marshfield Agricultural Research Station since the lab was opened in 1960.

Appendix II.
Chairs of the
Department of Soil Science

Name	Years
F.H. King	1889–1901
A.R. Whitson	1901–1939
E. Truog	1939–1954
O.J. Attoe	1954–1958
L.E. Engelbert	1958–1969
G. Chesters	1969–1972
L.M. Walsh	1972–1979
D.R. Keeney	1979–1984
C.B. Tanner	1984–1988
J.T. Murdock	1988–

Appendix III.
Directors, State Soil and Plant Analysis Laboratories.

Laboratory	Director	Years
Madison	A.R. Whitson?	1913–1921
	C.J. Chapman	1921–1927
	H.H. Hull	1927–1965
	R.A. Wiese	1965–1967
	E.E. Schulte	1967–1971
	J.J. Genson	1971–1977
	E.A. Liegel	1977–1981
	E.E. Schulte	1981–1988
	S.M. Combs	1988–
Marshfield	C.C. Olsen	1958–1975
	E.A. Liegel	1975–1977
	C.R. Simson	1977–1984
	J.B. Peters	1984–

Appendix IV.
Abbreviations Used

Acronym	Title
AEC	Atomic Energy Commission
ASA	American Society of Agronomy
CALS	College of Agricultural and Life Sciences
CCC	Civilian Conservation Corps (a public employment and public works program of the 1930s)
CSRS	Cooperative States Research Service
EPA	Environmental Protection Agency
FTE	Full time equivalent
GI Bill of Rights	A law enacted by Congress after World War II which included, among other provisions, funding for higher education for war veterans
IPB	Institut Pertanian Bogor (Indonesia)
MUCIA	Midwest University Consortium for International Activities
NIH	National Institutes of Health
NSF	National Science Foundation
SWCD	Soil and water conservation district
TVA	Tennessee Valley Authority
UFRGS	Universidade Federal do Rio Grande do Sul (Brazil)
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WARF	Wisconsin Alumni Research Foundation
WGNHS	Wisconsin Geological and Natural History Survey

Appendix V.
Department of Soil Science Faculty, 1889–1989

Year Hired	Name	Year Resigned	Specialty
1888	King, F.H.	1901	Soil physics, soil chemistry, meteorology, rural engineering
1897	Jeffery, J.A.	1899	Soil fertility
1899	Wells, F.J.	1903	
	Whitson, A.R.	1941	Soil fertility, soil survey, land use
1903	Stoddart, C.W.	1910	Drainage, soil fertility, soil acidity
	Haskins, L.P.	1904	Cranberry production
1905	Jones, E.R.	1918	Drainage (to Agricultural Engineering)
1906	McLeod, A.F.	1907	Nitrogen depletion in cultivated soils
1909	Walster, H.L.	1919	
1910	Peterson, P.P.	1912	Phosphorus status of soils
	Sievers, F.J.	1912	Development of wet and sandy soils
	Weir, W.W.	1919	Soil acidity and liming, soil fertility
1911	Ullsperger, H.W.	1925	Management of sandy soils, drainage
1912	Graul, E.J.	1953	Soil testing, soil fertility, nitrogen fixation
	Musbach, F.L.	1939	Soil fertility, Marshfield, Ashland
	Truog, E.	1954	Soil chemistry, soil fertility, soil testing
1913	Finner, E.R.	1914	Drainage, soils laboratories
1914	Goodhue, R.S.	1915	
	Zeasman, O.R.	1956	Drainage, soil conservation
1915	Stewart, H.W.	1927	Water use by crops
	Albert, A.R.	1958	Soil fertility, sandy soils, muck
	Geib, W.J.	1929	Soil survey
	Hanson, L.P.	1918	
1919	Harmer, P.N.	1921	
	Richards, G.	1929	Soil physics
1920	Mallory, E.J.	1921	
1921	Chapman, C.J.	1960	Soil testing, soil fertility
	Bartholomew, R.P.	1926	
1927	Hull, H.H.	1965	Soil testing

Year Hired	Name	Year Resigned	Specialty
1931	Austin, R.H.	1932	
1933	Ahlgren, H.L.	1934	Pasture renovation
1934	Wilde, S.A.	1968	Forest soils, forest nurseries
1936	Muckenhirn, R.J.	1973	Soil conservation, soil genesis
1941	Attoe, O.J.	1970	Soil fertility
	Berger, K.C.	1965	Soil fertility, micronutrients
	Turner, F.H.	1946	TVA Test-Demonstration Program (to Agronomy)
1942	Jackson, M.L.	1986	Soil chemistry, clay mineralogy
	Nelson, L.B.	1943	Soil fertility
1946	Wojta, A.J.	1959	Water management and drainage
	Robinson, G.H.	1950	Soil survey
1950	Hole, F.D.	1983	Soil genesis, morphology, classification
	Ekern, P.G.	1955	Soil conservation, meteorology
	Engelbert, L.E.	1982	Soil fertility
1951	Tanner, C.B.	1988	Soil physics
	Voigt, G.K.	1955	Forest soils
1952	Peterson, A.E.		Soil fertility, soil and water conservation, waste management
	Lee, G.B.	1988	Soil morphology, mapping, classification; land resources
1954	Miller, E.E.	1986	Soil physics
	Suomi, V.E.	1986	Meteorology
	Corey, R.B.		Soil chemistry
1955	Murdock, J.T.		International agriculture, soil fertility
1956	Love, J.R.	1986	Turf management
	Hembre, I.O.	1967	Soil and water conservation
	Beatty, M.T.	1988	Soil survey interpretation, land use
1958	Chesters, G.		Soil biochemistry, water resources, pesticides
	Hays, O.E. (adjunct)	1963	Soil and water conservation
1959	Walsh, L.M.		Soil fertility
	Wang, J.Y.	1962	Agricultural meteorology
1962	Massie, L.R.	1964	Soil and water conservation (to Agricultural Engineering)
1961	Wiese, R.A.	1967	Soil fertility, soil testing

Year Hired	Name	Year Resigned	Specialty
1964	Harris, R.F.		Soil microbiology and biochemistry
	Olsen, C.C.	1975	Soil testing, liming
	Schulte, E.E.		Soil fertility, soil testing
	Stangel, P.J.	1966	Soil fertility, TVA-Test Demonstration Program
1965	Keeney, D.R.	1988	Nitrogen biochemistry, aquatic ecosystems, environmental science
	Peterson, L.A. (adjunct)		Soil fertility
	Raats, P.A.C. (adjunct)	1968	Soil physics
	Thurtell, G.W.	1968	Micrometeorology
1967	Harkin, J.M.		Organic chemistry, water resources
	Kussow, W.R.		Soil fertility, turf management
1968	Boyle, J.R.	1973	Forest soils
	Ludwick, A.E.	1970	Soil fertility
	Milfred, C.J.	1970	Soil survey
	Powell, R.D.	1975	Soil fertility
	Syers, J.K.	1972	Soil chemistry
	Horvath, W.J.	1972	Soil and water conservation
1969	Dirksen, C. (adjunct)	1973	Soil physics
	Amerman, C.R. (adjunct)	1973	Soil and water conservation
1971	Bouma, J.	1975	Soil morphology and physics
	Gilmour, J.T.	1972	Soil biochemistry
	Konrad, J.G. (adjunct)		Water quality
1972	Daniel, T.C.	1989	Soil and water conservation, pesticides
1973	Helmke, P.A.		Soil chemistry, analytical methodology
	Madison, F.W.		Water resources, pedology
1974	Bockheim, J.G.		Forest soil science, pedology of alpine and cold regions
1975	Tyler, E.J.		Soil genesis, morphology, mapping, waste disposal
1977	Kelling, K.A.		Soil fertility
	Johnson, L.C.	1985	Soil and water conservation
1979	Fixen, P.E.	1981	Soil fertility
1980	Lowery, B.		Soil physics
1982	Bundy, L.G.		Soil fertility
	Clark, D.R.		Climatology

Year Hired	Name	Year Resigned	Specialty
1983	Beaver, A.J. (collateral)		Soil genesis
	McSweeney, K.		Soil morphology and genesis
1985	Iyer, J.G.		Forest soils
1986	Kung, K-J.S.		Soil physics
1988	Bleam, W.F.		Surface chemistry, mineralogy
	Norman, J.M.		Soil and atmospheric physics
1989	Ventura, S.J.		Remote sensing

Appendix VI. Degrees Granted in Soil Science by Year

Compiled by Sheri Speth

1905
Jones, Edward Richard, BS
Nelson, Martin, BS

1906
Nelson, Martin, MS

1908
Jones, Edward Richard, MS
Walster, Harlow Leslie, BS
Weir, Wilbert Walter, BS

1909
Lassetar, William Casper, BS
Musbach, Frederick Ludwig, BS
Ruzek, Charles Vladis, BS
Truog, Emil, BS

1910
Sievers, Fred John, BS
Wolf, George Paul, BS

1911
Dunnewald, Theodore John, BS
Funchess, M., MS
Graul, Edward John, BS
Meyer, Alfred Henry, BS
Ostrander, Ward Adelbert, BS
Schoenmann, Leroy Adolph, BS

1912
Buser, Alfred Leo, BS
Dunnewald, Theodore John, MS
Everett, Benjamin Bryan, MS
Noer, Oyvind Juul, BS
Truog, Emil, MS
Ullsperger, Herman Wenzl, BS

1913
Post, Clinton Blaine, BS
Tang, Tsic Yee, BS
Wolf, George Paul, MS

1914
Boardman, William Clayton, BS
Chapman, Clinton Joseph, BS
Henning, Erwin Lloyd, BS
Ostrander, Ward Adelbert, MS
Pan, Chu Chi, BS
Tang, Tsic Yee, MS
Zeasman, Otto Reinhard, BS

1915
Albert, Arthur Robert, BS
Goodhue, Robert Shield, BS
Henning, Erwin Lloyd, MS
Pan, Chu Chi, MS

1916
Sand, Chitaman Vishun, MS
Sykora, James, BS

1917
Bailey, Ernest Hayden, BS
Foster, Guy Kenneth, MS
Hopkins, Edward Stanely, MS
Machlis, Joseph Arthur, BS
Pettis, Charles Semple, BS
Weir, Wilbert Walter, MS

1918
Graul, Edward John, MS
Pettis, Charles Semple, MS
Reid, Dwight Logan, MS
Walster, Harlow Leslie, PhD

1920
Bauer, Frederick Charles, PhD
Brant, Howard Jonathan, BS
Clevenger, Clinton B., PhD
Gibbs, William Mariett, PhD
Sykora, James, MS

1921
Casis, Pedro Antonio, BS
Hamerski, John A., BS
Kubier, Julius, BS
O'Connell, Francis J., BS
Parker, Frank Wilson, PhD
Pierre, William Henry, BS
Tang, Yang Yu, MS
Tosterud, Martin, MS
Voskuil, Walter Henry, BS

1922
Bailey, Ernest Hayden, MS
Bryan, Ollie Clifton, PhD
Edwards, Max, BS
Juday, Dean, BS
Magistad, Oscar Conrad, BS

Matteson, Lynn B., BS
Opgenorth, Louis T., BS
Samuels, C. D., MS
Tiedjens, Victor Alphons, MS
Voskuil, Walter Henry, MS

1923
Bartholomew, Robert Perc., MS
Chapman, Homer Dwight, BS
Duley, Frank Leslie, PhD
Foster, George Henry, MS
Harper, Horace James, PhD
Magistad, Oscar Conrad, MS
Millar, Charles Ernest, PhD
Pierre, William Henry, MS
Sievers, Fred John, MS
Templin, Edward Henry, BS

1924
Ford, Marion C., BS
Laird, David Gordon, MS
Magistad, Oscar Conrad, PhD
Norling, Sven Albert, PhD
Scarseth, George D., BS
Stewart, Harold Wilson, PhD
Tosterud, Martin, PhD
Volk, Norman James, MS

1925
Chapman, Homer Dwight, MS
Fudge, Joseph Franklin, MS
Luttrell, Cassius D., BS
Osborne, Oliver Martin, MS
Pierre, William Henry, PhD
Roberts, Edward J., BS
Smith, Alfred, PhD

1926
Austin, F. Reed, BS
Bartholomew, Robert Perc., PhD
Geib, Horace V., MS
Hammen, Edwin Andrew, BS
Hull, Harold Haight, BS
Noer, Oyvind Juul, PhD

1927
Baldwin, Ira L., PhD
Chapman, Homer Dwight, PhD
Chucka, Joseph A., BS
Ford, Marion C., MS
Frost, Harold G., MS
Hull, Harold Haight, MS
Kerr, Henry William, PhD
Meyer, Alfred Henry, PhD
Peng, Chien, MS
Rentschler, Fred M., BS

1928
Ableiter, Kenneth J., BS
Chucka, Joseph A., MS
Fudge, Joseph Franklin, PhD
Heck, Arthur Floyd, PhD
Nelson, John Henry, BS
Thomas, Royle P., PhD
Weyker, Lawrence M., BS
Wheeting, Lawrence C., PhD

1929
Birdsall, Benjamin J., BS
Cook, Harold Waldo, BS
Ford, Marion C., PhD
Keller, Theon Jay, BS
Midgeley, Alvin Rees, PhD
Mitchell, John, MS
Ruzek, Charles Vladis, MS
Towers, Lewis, BS
Weyker, Lawrence M., MS

1930
Chucka, Joseph A., PhD
Fink, Delmar Simon, BS
Laird, David Gordon, PhD
Nichols, John Levi, BS
Peng, Chien, PhD
Rothermel, Arlow William, BS
Tsuji, Seiichiro, MS

1931
Bergh, Otto Ingman, MS
Chang, Nai-Feng, MS
Cowart, Roland, PhD
Elwell, John Ambrose, MS
Fink, Delmar Simon, MS
Keller, Theon Jay, BS
Mitchell, John, PhD
Pavlak, Ray L., BS

1932
Ableiter, Kenneth J., MS
Dean, Lyman Arnold, MS
Drosdoff, Matthew, MS
Fiskett, Francis J., BS
Hill, William Walter, MS
Hull, Harold Haight, PhD

Larson, Olaf F., BS
Leahy, Alfred, PhD
Lubratovich, Mirko D., BS
Muckenhirn, Robert John, BS
Pierre, Joseph J., BS
Rothermel, Arlow William, MS
Quackenbush, Forrest Ward, BS
Swalm, Harris Amos, BS
Thompson, Alfred M., BS
Thor, Alfred Uhno, MS
Tyner, Edward Henry, MS
Volk, Gaylord Monroe, BS
Volk, Norman James, PhD

1933

Butman, Burel Stark, BS
Clark, Charles Leach, BS
Larson, Olaf F., MS
Mehlich, Adolf, BS
Muckenhirn, Robert John, MS
Sell, Otto Edwin, MS
Volk, Gaylord Monroe, MS
Wright, George LaFollette, BS

1934

Cook, Ray L., PhD
Dean, Lyman Arnold, PhD
Doughty, Jesse L., PhD
Drosdoff, Matthew, PhD
Fink, Delmar Simon, PhD
Larson, Harold W.E., PhD
Matelski, Roy Peter, BS
Tyner, Edward Henry, PhD
Volk, Garth William, BS

1935

Ahlgren, Henry Lawrence, PhD
Longwell, Thomas Jackson, BS
Lovejoy, Delmar Boynton, MS
Volk, Garth William, MS
Wing, Gordon Nye, BS

1936

Benzmann, Arlo Frederick, BS
Galligan, Robert James, BS
Jeffries, Charles Davis, PhD
Kavanaugh, James Nicholas, BS
Kliman, Stephen, MS
Leopold, Aldo Starker, BS
Mehlich, Adolf, PhD
Muckenhirn, Robert John, PhD
Sell, Otto Edwin, PhD
Torrance, Stuart William, BS
Volk, Garth William, PhD
Weeks, Martin Edward, MS

1937

Bay, Clyde Edward, BS
Berger, Kermit Carl, BS
Hsieh, Shen, MS
Jolivette, James Peter, BS
Jones, Randall Jeffrice, MS
Kahlenberg, Robert Otto, BS
Kindschi, Clifford J., BS
Ledvina, Louis Vincent, BS
Millar, William Dow, BS
Ohlrogge, Alvin John, BS
Phillips, Sidney J., MS
Schafer, George M., MS
Schaller, Frank Willard, BS
Shipman, Gordon Edward, BS
Taylor, John R., PhD
Weeks, Martin Edward, PhD
Wyss, Orville, BS

1938

Batson, Davis Monroe, MS
Boyd, Frederick Tilghman, PhD
Cady, John Gilbert, MS
Galloway, Harry Merrill, MS
Gregory, Isaac Coles, MS
Hirsch, Donald Everett, BS
Johnson, William Martin, MS
Kletzien, Ronald William, BS
Kliman, Stephen, PhD
Kronenberger, Russell Carl, BS
Pearson, Robert Watt, PhD
Peter, Hollis William, BS
Simonson, Roy Walter, PhD
Steingraeber, Joseph Anthony, BS
Zucollo, Bruno Arthur, BS

1939

Bonnet, Juanet Amidee, PhD
Gallatin, Melvin H., BS
Gavre, Vincent M., BS
Higbee, Edward C., MS
Jackson, Marion LeRoy, PhD
Jones, Randall Jeffrice, PhD
Kopitke, John Charles, MS
Merwin, Henry D., MS
Oberts, David G., BS

Rehling, Carl John, PhD
Schmeichel, Norman E., BS
Thorson, Leo E., BS
Vogt, Alvin F., BS

1940

Batson, Davis Monroe, PhD
Bartelme, Robert J., BS
Berg, Nicholas J., BS
Cohen, Morris, BS
Delwiche, Thomas J., BS
Dregne, Harold, MS
Ferris, Howard J., BS
Henkel, Richard H., BS
Kilmer, Victor J., BS
Kluge, Carl T., BS
Monthey, Lawrence George, BS
Nelson, Lewis Bailey, PhD
Norteman, Louis H., BS
Pedersen, Edwood John, BS
Puhr, Leo Francis, PhD
Rich, Charles Irvin, BS
Slotwinski, Bronislaus V., MS
Stone, Earl Lewis, MS
Strelow, Harvey V., BS
VanWinter, Gerald H., BS
Walsh, Arthur J., BS
Walsh, James E., BS
Wells, Max K., BS
White, Donald P., MS

1941

Berger, Kermit Carl, PhD
Bower, Charles Arthur, PhD
Buran, Harold A., BS
Carlsen, Kenneth V., BS
Coleman, Russell, PhD
Fine, Lawrence Oliver, PhD
Fisk, Charles C., BS
Ihlenfeldt, Stanley W., BS
Krome, Stanley H., BS
Krueger, Harold O., BS
Schaller, Charles W., BS
Spencer, Francis M., BS
Terman, Gilbert Leroy, PhD
Voss, Alvin M., BS
Westin, Frederick Charles, BS

1942

Asleson, Johan A., BS
Attoe, Osborne James, PhD
Bailey, Thell Arthur, PhD
Dion, Henry George, PhD
Engelbert, Lincoln E., BS
Giesen, Robert J., BS
Glissendorf, Wilmar E., BS
Green.Joseph Edward, BS and MS
Hellman, Nison N., BS
Johnson, Lewis Rockwell, MS
Kindschi, Clifford J., MS
Knox, Howard E., BS
Kraemer, Elmer F., BS
Laird, Reggie James, MS
Lovvorn, R. L., PhD
Luther, Vernon Virgil, BS
Mabry, Betty, MS
Mackey, J. Mitchell, BS
Mullendore, Daniel W., BS
Olson, Raymond Verlin, MS
Rendig, Victor Vernon, BS
Rozansky, Harold I., BS
Sachtschale, Robert J., BS

1943

Aldrich, Daniel Gaskill, PhD
Brooks, Gilbert Norman, BS
Buchholz, John Rudolph, BS
Kilmer, Victor J., MS
Mackie, Wallace Zilisch, BS
Momsen, Keith Warren, BS
Rosendahl, Russell Otto, PhD

1944

Gerhard, Lee Edward, BS
Grunewald, Armin Robert, BS
Hellman, Nison N., PhD
Pitner, John Bruce, PhD

1945

Axley, John Harold, PhD
Dirks, Hellmut George, MS

1946

Borgen, John Obed, BS
Dahlstrand, Nils Peter, BS
Monthey, Lawrence George, MS
Peterson, Willard James, BS
Takahashi, Harold Haruya, BS
Urban, Joseph Paul, BS
Volk, Gaylord Monroe, PhD

1947

Allen, Seward Ellery, MS

Asleson, Johan A., MS
Brandt, Carl Stafford, PhD
Carlisle, Frank Jefferson, PhD
Christensen, Raymond P., PhD
Docter, John Christian, BS
Engelbert, Lincoln E., MS
Evans, Chester Evan, PhD
Foth, Henry Donald, BS
Goates, Rex James, PhD
Hanson, Aaron Julius, BS
Hanson, Spencer Richard, BS
Harder, Roger W., MS
Jones, Ulysses Simpson, PhD
Kahn, Abdur Rahim, MS
Katz, Yale H., BS
Kehrein, Robert Benjamin, BS
Krahn, George William, BS
McLeod, Lois Lucille, MS
Moyer, Byron Clyde, MS
Odell, Robert Waldo, BS
Olson, Raymond Verlin, PhD
Peterson, Arthur Edwin, BS
Rieger, Samuel, MS
Rom, Roy Curt, BS
Rud, Orvin Elwood, BS
Sasman, Robert Thomas, BS
Schallock, Donald Allen, BS
Sires, Melvin King, BS
Weis, Paul Lester, BS
Westin, Frederick Charles, MS
White, Joe Lloyd, PhD
Willis, Arthur Leslie, MS
Yu, Teh-Ming, MS
Zubriski, Joseph Cazimer, BS

1948

Abrams, Eugene, BS
Amundson, Arthur John, Jr., BS
Berg, John Wilmer, BS
Bieri, Peter Oral, BS
Bourbeau, Gerard Auguste, PhD
Brynildson, Clifford Levern, BS
Czehno, Richard John, BS
Davis, William Keith, BS
Fischer, William Robert, BS
Flemming, Herman Joseph, BS
Fosberg, Maynard Axel, BS
Foth, Henry Donald, MS
Gerloff, Gerald Carl, PhD
Hackbarth, Robert Louis, BS
Hamilton, Harry Lemuel, PhD
Horehled, Anton Michael, BS
Huber, Joseph Louis, BS
Jen, How-yan, PhD
Kaudy, John Clement, BS
Klingelhoets, Ambrose John, MS
Kubota, Joe, PhD
Lee, Gerhard Bjarne, BS
Lutz, Jacob Andrew, Jr., MS
Mortensen, Walter Peter, BS
Nelson, Lowell Gordon, BS
Peterson, Arthur Edwin, MS
Peterson, Kermit H., BS
Post, Arthur Herman, PhD
Preator, Rodney Earl, BS
Sims, Billy Lynn, BS
Smolen, David Adolph, BS
Thomas, Delbert Davis, BS
Tomlinson, James Robley, BS
Voigt, Garth Kenneth, BS
Walgenbach, Eugene Aloysius, MS
Wiberg, Morris Clifford, BS
Yoder, Emmitt William, BS
Zicker, Eldon Louis, BS
Zubriski, Joseph Cazimer, MS

1949

Abrams, Eugene, MS
Allen, Seward Ellery, PhD
Barrett, Grant Leroy, BS
Bendrick, Benjamin Donald, BS
Bott, Albert Willis, BS
Church, Ronald Paul, BS
Corey, Richard Boardman, BS
Crabb, James Arnold, BS
Dean, Arnold Miller, PhD
Dinauer, Richard Charles, BS
Duckart, Richard Henry, BS
Eckart, Frederick George, BS
Evenson, Eldon Howard, BS
Fitzgerald, Warren Joseph, BS
Fosberg, Maynard Axel, MS
Fribourg, Henry A., BS
Garvey, Glenn David, BS
Gerbitz, Eugene Richard, BS
Gerlach, Robert Walter, BS
Gilmour, Campbell M. Morrison, PhD

Gorr, Duane Richard, BS
Grimm, William Nelson, BS
Gulson, Lennes Osmar, BS
Hallock, Daniel Leroy, BS
Heinkel, Howard Earl, BS
Higgins, Richard Anthony, BS
Huber, Joseph Louis, MS
Jensen, Arthur Ovette, BS
Jensen, Edwin Harry, BS
Jensen, LaVerne Robert, BS
Kaudy, John Clement, MS
Klages, Murray George, MS
Klein, Wayne Carter, BS
Lamba, Prithvi Singh, PhD
Lee, Gerhard Bjarne, MS
Link, Victor George, BS
Mackie, Wallace Zilisch, PhD
Marcial, Bolivar-Ing L., MS
Marini, Antonio Charles, BS
Menn, James Paul, BS
Meshnick, James Charles, BS
Mezera, Harold Joseph, BS
Mitchel, Robert Filip, BS
Mueller, John Joseph, BS
Pennington, Roy Platt, PhD
Randall, George William, BS
Rendig, Victor Vernon, PhD
Sachtschale, Robert J., MS
Schoewe, Robert Henry, BS
Schwoegler, James Edward, BS
Seay, William Albert, PhD
Sims, Billy Lynn, MS
Singh, Ranbir, PhD
Slota, Robert William, BS
Spencer, Donovan Worden, BS
Swallow, George Brenton, BS
Ten Haken, Irwin John, BS
Ustruck, Russell Larry, BS
Voigt, Garth Kenneth, MS
Whittig, Lynn Daryl, BS
Wilcox, Gerald Eugene, BS
Willis, Arthur Leslie, PhD
Woehler, Eugene Earl, BS

1950

Anderson, Frank Lucien, BS
Barndt, Roland Frank, BS
Beardsley, James Merl, BS
Bernet, Marvin Lloyd, BS
Birdsall, Raymond Perry, BS
Brumm, Gilbert Vern, BS
Buehl, Willis George, BS
Burger, Ambrose W., PhD
Carbon, Edward Henry, BS
Cole, Carroll Vernon, PhD
Disrud, George Roman, BS
Drozdowicz, Edward, BS
Ekern, Paul Chester, PhD
Engelbert, Lincoln E., PhD
Ensign, Arthur Robert, BS
Evans, Edward John, MS
Felly, Alfred Earl, BS
French, Richard Louis, BS
Gielow, Arthur Charles, BS
Grady, Grover Quention, Jr., BS
Grimes, Myron Francis, BS
Haszel, Orville Louis, BS
Hedlin, Robert Arthur, PhD
Hettrick, Harold David, BS
Hoague, Raymond Elmer, BS
Hoene, Robert William, BS
Hoveland, Carl Soren, BS
Johnson, Robert Lief, BS
Johnson, Sidney V., BS
Kehlenbrink, George Walter, BS
Klecker, Paul Hugo, BS
Lamb, Daniel Aloysius, BS
Lovett, Dorain Curtis, BS
Luetscher, Bruce Dunlap, BS
Marx, Russell Kenneth, BS
Massey, Herbert Fane, MS
Matel, Stanley Eugene, BS
Menzel, Ronald George, PhD
Merk, Joseph William, BS
Miller, Merlin Kenneth, BS
Moldenhauer, Robert Eldon, BS
Myhre, Donald LaVerne, BS
Novakowski, Lloyd Stanley, BS
Ouellette, Gerard Joseph, PhD
Pellett, Paul William, BS
Peterson, Arthur Edwin, PhD
Peterson, Frederick Forney, BS
Peterson, Merle Arnold, BS
Peterson, Stanley Forney, BS
Prins, Edward Bert, BS
Redmann, Kenneth Paul, BS
Retzer, John Leonard, PhD
Rhodes, Donald Walter, PhD

Rich, Charles Irvin, PhD
Richgels, Carl Edward, BS
Riederer, James Aidan, BS
Robinson, Glenn Hugh, PhD
Rooney, William Robert, BS
Sarthou, Charles Lawrence, PhD
Schallock, Donald Allen, MS
Schoenemann, John Alfred, BS
Schultz, Thomas Harold, BS
Shields, Leo George, BS
Starostka, Raymond Walter, PhD
Sulaiman, Mohammad, MS
Tanner, Champ Bean, PhD
Taplin, Bert Charles, BS
Toussaint, Emile Fadala, BS
Vindedahl, Howard P., BS
Vithalrao, Tanjore Mahadev, PhD
Volkmann, Walter Paul, BS
Wang, Li-Chuan, MS
Watson, Bruce George, BS
Watt, Robert Engels, BS
Watters, William John, BS
Whittig, Lynn Daryl, MS
Wiechman, Donald Earl, BS
Wilms, Robert David, BS
Wuestenberg, Ernest Carl, BS
Ziebell, Martin Gustav, BS

1951

Anthony, Warner Hale, PhD
Ash, Cecil Grant, PhD
Barritt, Donald Theodore, BS
Beardsley, James Merl, MS
Beckman, Robert Milo, BS
Bourget, Sylvio Joseph, MS
Branson, Roy L., MS
Buck, Clifford William, BS
Calvi, Margaret Anne, BS
Corey, Richard Boardman, MS
Crehore, Thomas Richard, BS
Davis, Grant Clark, BS
Engdahl, Henry Claire, MS
Gagnon, Calvin Theodore, BS
Geraldson, Carroll Morton, PhD
Grundahl, Henry Morris, BS
Hanks, Ronald John, MS
Hawks, Keith Merwin, BS
Hseung, Yi, PhD
Jensen, Albert Henry, BS
Kaudy, John Clement, PhD
Kelkar, Dattatraya Gajanan, MS
Kenefick, Donald Gene, BS
Kittrick, James Allen, BS
Kobussen, Leland Paul, BS
Lafond, Andrew Maurice, PhD
Link, Victor George, MS
Luckow, Russell Laverne, BS
Ludwig, William Lowell, BS
Manser, William Denis, BS
McCabe, John Patrick, BS
Mennen, Marlyn Clement, BS
Mitchell, Harold Dean, BS
Moldenhauer, William Calvin, MS
Newbury, Raymond Lawrence, BS
Nichols, Elonzo Frederick, BS
Nimlos, Thomas John, BS
Orth, Leo Everett, PhD
Patel, Dayaram Kunverji, PhD
Pomerening, James Albert, BS
Prosser, David Burbey, BS
Reilly, William Jerome, BS
Schoephorster, Dale Byron, BS
Shihata, Mahmoud Mostafa, MS
Smith, Harley Dewain, BS
Sorensen, Douglas Dale, BS
Steege, Donald Harold, BS
Steinbrenner, Eugene C., MS
Tamura, Tsuneo, MS
Thull, Robert W., BS
Toppen, Spencer Leroy, BS
Urguidi, Rene, MS
Voigt, Garth Kenneth, PhD
Volkmann, Walter Paul, MS
White, Donald P., PhD
Wilcox, Gerald Eugene, MS
Wishau, Clifton Howard, BS
Youngberg, Chester Theodore, PhD
Zubriski, Joseph Cazimer, PhD

1952

Bartz, James Fredrick, BS
Carey, Rex Lincoln, BS
Corey, Richard Boardman, PhD
Davey, Charles Bingham, MS
Dible, William Trotter, PhD
Diers, Richard W., BS
Diez, Fernando Balbino, BS
Evans, Edward John, PhD

Evans, James Ornette, MS
Gibbons, John David, BS
Glover, Everett Dow, MS
Grunewald, Richard Otto, BS
Hallock, Daniel Leroy, PhD
Hilden, Lester Blaine, BS
Hoveland, Carl Soren, MS
Jensen, Edwin Harry, PhD
Johnson, Leonard Charles, BS
King, Kenneth M., MS
Kittrick, James Allen, MS
Kolterman, Delbert Wayne, PhD
Kubly, Alvin Raymond, BS
Langdon, James Benjamin, BS
Larsen, Grant Sylvin, BS
Love, James Ramon, MS
Massey, Herbert Fane, PhD
Moldenhauer, Robert Eldon, MS
Pierce, Robert Stanley, MS
Pinter, Julius Robert, BS
Post, LeRoy George, BS
Radl, George Albert, BS
Rennie, Donald Andrews, PhD
Schultz, Thomas Harold, MS
Sorenson, Douglas Dale, MS
Swendsen, David Herbert, BS
Tamura, Tsuneo, PhD
Toussaint, Emile Fadala, MS
Vanden Heuvel, Richard Cornelius, MS
Vezina, Arthur John, BS
Wang, Li-Chuan, PhD
Westin, Frederick Charles, PhD
Westin, Paul Robert, BS
Wishau, Clifton Howard, MS

1953

Aguilera, Nicolas Herrera, MS
Angle, Robert Forrest, BS
Boykin, William Baynard, PhD
Branson, Roy L., PhD
Brockmiller, Victor Robert, BS
Brown, George Franklin, Jr., BS
Cochrane, Thomas Orton, BS
DeByle, Norbert Valentine, BS
Dionne, Jean-Louis, PhD
Doll, Eugene Carter, PhD
Galarowicz, John Joseph, BS
Garrow, Franklin Lee, BS
Hanks, Ronald John, PhD
Heikkinen, Toivo, BS
Henry, Clifford Dennis, MS
Marriott, Lawrence Frederick, MS
Moore, Duane Grey, BS
Nashold, Raymond Duane, BS
Nelson, Lowell Gordon, PhD
Peterson, Donald R., PhD
Punwar, Jalanasinh Kalyansinh, PhD
Quader, Muhammad Abdul, PhD
Romo, Luis Armando, PhD
Schmitt, Herbert Henry, BS
Sharett, Warren James, BS
Shihata, Mahmoud Mostafa, PhD
Sillanpaa, Mikko, MS
Timmons, Donald Ralph, BS
Weber, Roland Carl, BS
Wilcox, Gerald Eugene, PhD

1954

Andreis, Henry Jerome, BS
Brown, Bruce Elliott, MS
Bourget, Sylvio Joseph, PhD
Doell, Dean Dell, BS
Ellis, Roscoe, PhD
Gile, Leland, Jr., MS
Halstead, Ronald Lawrence, PhD
Hammes, Jack Kevan, BS
Hewedi, Mahmoud Abdelgawad, PhD
Holmes, Wallace Edward, MS
Inda, William Shaw, BS
Knoll, Donald Walter, BS
Kramer, Verne Chester, BS
Lancaster, James D., PhD
Lebhan, Arthur Clarence, BS
Link, Ernest George, MS
Mader, Donald Lewis, MS
Mortensen, Walter Peter, PhD
Myhre, Donald LaVerne, PhD
Noel, Wesley Allen, BS
Opgenorth, Kenneth Louis, BS
Richard, Thomas Arthur, BS
Schwartzbeck, Richard Arthur, BS
Seaborg, Albert Donald, BS
Sims, Billy Lynn, PhD
Valencia, Iluminado Gana, MS
Vanden Heuvel, Richard Cornelius, PhD

Wengel, Raymond William, BS
Whittig, Lynn Daryl, PhD
Wood, John Bates, BS
Zufall, Jack Floyd, BS

1955

Andreis, Henry Jerome, MS
Banerjee, Somir, PhD
Beatty, Marvin Theodore, PhD
Cain, John Manford, BS
Craddock, Garnet Roy, PhD
Dana–Bashian, John, MS
Davey, Charles Bingham, PhD
DeMumbrum, Lawrence Edgar, PhD
Elrick, David Emerson, MS
Fleischfresser, Marvin Harry, BS
Freitag, Gerald Albert, BS
Gallardo-Pichardo, Lauro, MS
Gehrke, Frederick Edward, BS
Greiten, Roger Allan, BS
Hodgson, Joseph Frederick, PhD
Holmes, Wallace Edward, PhD
Janulis, Alphonse, BS
Johnson, Norman Leighton, BS
Kaufman, Abraham, PhD
Kittrick, James Allen, PhD
Klacan, George Robert, BS
Krokowski, Dennis Joseph, BS
Lee, Gerhard Bjarne, PhD
Loewenstein, Howard, PhD
Marriott, Lawrence Frederick, PhD
Martinson, John Leslie, MS
Moore, Duane Grey, MS
Murdock, John Thomas, PhD
Noel, Wesley Allen, MS
Rennie, Wayland Walden, PhD
Ruhde, Richard W., BS
Schmid, Wilbert Adolf, BS
Schwartzbeck, Richard Arthur, MS
Shields, Leo George, MS
Swindale, Leslie Denis, PhD
Zicker, Eldon Louis, PhD

1956

Buol, Stanley Walter, BS
Cain, John Manford, MS
Chang, Shou Ching, PhD
Chesters, Gordon, MS
Dubrovin, Kenneth Paul, PhD
Forest, David Lawrence, BS
Hanson, Russell Vroman, BS
Horn, Merlin Edwin, BS
Kilian, Kenneth Clarence, BS
King, Kenneth M., PhD
King, Sanford MacCallum, PhD
Leonard, Charles Fredrick, BS
Love, James Ramon, PhD
Mader, Donald Lewis, PhD
Martinson, Albin Herbert, BS
Moldenhauer, William Calvin , PhD
Nimlos, Thomas John, MS
Patzer, Robert Arthur, BS
Peterson, Lloyd Allan, MS
Phillips, John Joseph, BS
Pollack, Sidney Solomon, PhD
Quast, Richard Neil, BS
Slagel, Donald Edward, MS
Thompson, Stanley Oswald, MS
Trainor, Richard Phillip, BS
Truog, John Rayne, BS
Voth, Evert Eugene, BS
Wehrli, Eugene, MS
Wengel, Raymond William, MS

1957

Asleson, Johan A., PhD
Bartz, James Fredrick, MS
Brown, Bruce Elliot, PhD
Cole, Dale Warren, MS
DeByle, Norbert Valentine, MS
Drozd, Edmund Michael, BS
Eck, Paul, PhD
Elrick, David Emerson, PhD
Franz, Jerome Harold, BS
Heikkinen, Toivo, MS
Hidalgo, Emilio, MS
Hilliker, Cleitus James, BS
Hobson, Edwin Louis, PhD
Horn, Merlin Edwin, MS
Johnson, Bruce Neil, BS
Kaul, John Herbert, BS
Keller, Theodore, PhD
Lawton, Richard Raymond, BS
Leaf, Albert Lazarus, PhD
McIntyre, Donald Sidney, PhD
Nelson, Kenneth Charles, BS
Oliver, Ramon, BS
Peck, Theodore, BS

Pierce, Robert Stanley, PhD
Rades, Robert John, BS
Richard, Thomas Arthur, MS
Sawhney, Brij Lal, PhD
Schmude, Keith Orville, BS
Timmons, Donald Ralph, MS
Wallis, Gordon W., MS
Walsh, Leo Marcellus, MS
Wengel, Raymond William, PhD

1958

Ahmed, Iaj Uddin, MS
Bartelt, Glen Orlen, BS
Bonsack, Alan Clarence, BS
Breska, George Joseph, MS
Buol, Stanley Walter, MS
Dahnke, William Clarence, BS
Dixon, Joe Boris, PhD
Doersch, Ronald Ernest, BS
Formali, Mehrabbuddin, BS
Hammes, Jack Kevan, MS
Immega, Gerhardt Dallas, BS
Klebesadel, Leslie Jospeh, PhD
Mamaril, Cezar P., MS
Melville, Ronald Dean, BS
Nesbit, Rolland, BS
Palmer, Michael B., BS
Peck, Theodore, MS
Pelton, William Lawrence, PhD
Peterson, Lloyd Allan, PhD
Redd, John Paul, MS
Rom, Roy Curt, PhD
Sessing, John Roy, MS
Sharratt, Warren James, MS
Shivers, Stanley Michael, BS
Spangenberg, Donald George, BS
Sparr, M. C., MS
Straehler, Jack LaFond, BS
Stroehlein, Jack Lee, MS
Tilo, Santiago Nanat, MS
Timm, Gerald Elmer, BS
Tomac, John Martin, BS

1959

Albright, David Dean, BS
Applewhite, Clyde Carlton, MS
Bartz, James Fredrick, PhD
Bos, Harmannus Jurrien, BS
Chesters, Gordon, PhD
Christoph, Charles Donald, BS
Fleischfresser, Marvin Harry, MS
Formali, Mehrabbuddin, MS
Francois, Leland Emil, BS
Glenn, Rollin Copper, PhD
Haberland, Franklin Paul, BS
Hashimoto, Isao, MS
Jankus, James Walter, MS
Klacan, George Robert, MS
Krueger, James Frederick, BS
Mehra, Om Prakash, PhD
Nimlos, Thomas John, PhD
Orth, Paul Gerhardt, PhD
Otterson, Gordon Edward, BS
Pederson, David Martin, BS
Reynolds, Charles Arthur, BS
Scholten, Arnold Gerhard, MS
Schmude, Keith Orville, MS
Spyridakis, Demetrios Emmanuel, MS
Than, Salai Tun, PhD
Vollbrecht, Howard Albert, PhD
Walsh, Leo Marcellus, PhD
Waugh, Donovan Lloyd, BS
Wells, Carol Glenn, PhD

1960

Beaver, Albert John, BS
Bhure, Nilkanth Dulischandra, PhD
Blader, Richard Alfred, BS
Brenckle, Robert Lorenz, BS
Buol, Stanley Walter, PhD
Burns, William Waggoner, BS
Cole, Arthur David, BS
Dahnke, William Clarence, MS
Decker, Larry Richard, BS
Disch, Dennis Dean, BS
Fack, Hans Jurgen, PhD
Gilliland, Duane Lyman, BS
Haberland, Franklin Paul, MS
Hammes, Jack Kevan, PhD
Haskew, Henry Charles, MS
Heikkinen, Toivo, PhD
Horn, Merlin Edwin, PhD
Hsu, Pa Ho, PhD
Jablonic, Randall Thomas, BS
Kaddou, Nadheema Salih, PhD
Killingstad, Karl Paul, BS
Krause, Helmut Horst, PhD
Martens, David Charles, BS

Mason, Eugene Nelson, BS
Milfred, Clarence James, BS
Moore, Duane Grey, PhD
Mueller, Carl Harry, BS
Nielsen, Gerald Alan, MS
Otter, Augustine John, BS
Potterton, Paul Everette, MS
Prine, Eugene Darwin, BS
Radke, Jerry Keith, BS
Schille, Frederic Henry, BS
Skrede, Gordon Kenneth, BS
Sparr, M. C., PhD
Sprengeler, Ronald James, BS
Whitney, Allan Vincent, MS

1961

Demo, Owen Robert, BS
Doersch, Ronald Ernest, MS
Dolezal, George, BS
Gaikawad, Shankar Tulshiram, MS
Genrich, Martin Ross, BS
Hanna, Augustine Booya, PhD
Hashimoto, Isao, PhD
Hock, Kenneth John, BS
Hoefs, Charles Richard, BS
Hogan, Jerry Don, MS
Keeney, Dennis Raymond, MS
Kilian, Kenneth Clarence, MS
Korth, Irving L., MS
Kussow, Wayne Robert, BS
Olsen, Conrad Christian, MS
Petersen, Gary Walter, BS
Radtke, Sherman Alfred, BS
Schulte, Emmett Elmer, MS
Sessing, John Roy, PhD
Sharratt, Warren James, PhD
Tanaka, Hirofumi, MS
Watson, Bruce George, MS
Waugh, Donovan Lloyd, MS

1962

Ahmed, Iaj Uddin, PhD
Bichler, David William, BS
Ciolkosz, Edward John, BS
Collins, Thomas Michael, BS
Dahnke, William Clarence, PhD
de Vries, Maarten Louis, PhD
Federer, Charles Anthony, MS
Iyer, Jaya Ganpathi, MS
Janke, Wilfred Edwin, PhD
Klacan, George Robert, PhD
Kiely, Patrick Vincent, MS
Kunishi, Harry Midio, PhD
Looman, Jan Patricia, PhD
Martens, David Charles, MS
Milford, Murray Hudson, PhD
Milfred, Clarence James, MS
Mortvedt, John Jacob, PhD
Nimgade, Namdeo Marotrao, PhD
Olson, Gerald Walter, PhD
Peck, Theodore, PhD
Rusch, Donald Harold, BS
Salem, Rafi M. Mukhlis, MS
Schultz, Thomas Harold, PhD
Shah, Kanaiyalal Manilal, MS
Stroehlein, Jack Lee, PhD
Valencia, Iluminado Gana, PhD
Zufall, Raymond Howard, BS

1963

Armstrong, David Edwin, MS
Beaver, Albert John, MS
Doersch, Ronald Ernest, PhD
Fosberg, Maynard Axel, PhD
Gottschalk, Robert Louis, BS
Hadley, Donald Gene, MS
Helling, Charles Siver, MS
Jha, Kali Kant, PhD
Joy, Donald Nathan, BS
Kittams, Harry Arthur, PhD
Kussow, Wayne Robert, MS
Madison, Frederick William, MS
Manhart, Lewis Gene, BS
Nielsen, Gerald Alan, PhD
Owens, Donald William, BS
Petersen, Gary Walter, MS
Pionke, Harry Bernhard, BS
Pritzl, Donald Edward, BS
Radke, Rodney Owen, BS
Ramsden, Alan Gene, BS
Sarma, Vedabandhu Ananthakrish, PhD
Staidl, George John, BS
Stangel, Paul Julius, MS
Turner, Curtis Edward, BS
Waugh, Donovan Lloyd, PhD
Weber, Roger Joseph, BS
Willey, Cliff Rufus, PhD

1964
Ashby, David Lawrence, MS
Barnard, Enos Eugene, PhD
Borchardt, Glenn Arnold, BS
Ciolkosz, Edward John, MS
Daniels, Lewis Arthur, BS
Dix, Eugene Earl, BS
Doperalski, John William, BS
Fanning, Delvin Seymor, PhD
Federer, Charles Anthony, PhD
Francis, Chester Wayne, MS
Gaikawad, Shankar Tulshiram, PhD
Graetz, Donald Alvin, BS
Hagstrom, Gerow Allen, PhD
Harris, Robin Frank, PhD
Kiely, Patrick Vincent, PhD
Kilian, Kenneth Clarence, PhD
Langton, John Edward, MS
Liebhardt, William Charles, MS
Ludwick, Albert Earl, MS
Martens, David Charles, PhD
O'Donnell, Jerry Lee, BS
Payne, Steve Wilfred, BS
Ranney, Richard Willard, BS
Schulte, Emmet Elmer, PhD
Stangel, Paul Julius, PhD
Stewart, John Allen, PhD
Swan, James Byron, PhD
Topp, George Clarke, PhD
Wildung, Raymond Earle, MS

1965
Dix, Peter Carl, BS
Eckert, William Edward, BS
Fanning, Carl Douglas, PhD
Giordano, Andrea, MS
Graven, Earle Holm, PhD
Isensee, Allan Robert, MS
Miess, Joseph C., BS
Moeller, Henry Thomas, BS
Petersen, Gary Walter, PhD
Radke, Jerry Keith, PhD
Radke, Rodney Owen, MS
Raman, Kavesseri Venkata, PhD
Richard, Thomas Arthur, PhD
Scholten, Arnold Gerhard, PhD
Shaw, Byron Herbert, BS
Spyridakis, Demetrios Emmanuel, PhD
Thompson, Stanley Oswald, PhD
Thurtell, George, PhD
Wenzel, David Lee, BS

1966
Armstrong, David Edwin, PhD
Ashby, David Lawrence, PhD
Beaver, Albert John, PhD
Beestman, George Bernard, MS
Behmer, Dale Edward, PhD
Dixon, Robert Morton, PhD
Dolcater, David Lee, MS
Erhardt, Wilfred Henry, PhD
Fedkenheuer, Alvin William, BS
Fenster, William Ernest, MS
Frazier, Bruce Edwin, BS
Glocker, Carl Leonard, MS
Gonske, Robert George, BS
Helling, Charles Siver, PhD
Hensler, Ronald Fred, BS
Huang, Pan Min, PhD
Jagodinsky, Gregory, BS
Koli, Stephen Essah, MS
Liebhardt, William Charles, PhD
Lorenz, William Frederick, BS
Maeglin, Robert Riemeyer, MS
Milfred, Clarence James, PhD
Mueller, Carl Harry, MS
Pierce, Thomas Lee, BS
Pionke, Harry Bernhard, MS
Ranney, Richard Willard, PhD
Retzlaff, Dean Gilbert, BS
Seip, William Taylor, BS
Sharpee, Kenneth Wayne, BS
Shaw, Byron Herbert, MS
Tanzer, Christiaan, MS
Trautmann, William Lester, MS
Volk, Veril Van, PhD
Watterston, Kenneth Gordon, PhD
Wenninger, Thomas A., BS

1967
Allan, Roderick James, MS
Barndt, Wayne David, BS
Borchardt, Glenn Arnold, MS
Buchholz, Terry Lee, BS
Cain, John Manford, PhD
Ciolkosz, Edward John, PhD

Comella, Vincent Alan, BS
Davies, William Edward, BS
Fenster, William Ernest, PhD
Francis, Chester Wayne, PhD
Gonske, Robert George, MS
Graetz, Donald Alvin, MS
Gundlach, Howard Francis, BS
Isensee, Allan Robert, PhD
Konrad, John Grey, MS
Kussow, Wayne Robert, PhD
Ludwick, Albert Earl, PhD
Meehan, John Leo, BS
Miller, William Lewis, BS
Moniz, Antonio Carlos, MS
O'Donnell, Jerry Lee, MS
Pionke, Harry Bernhard, PhD
Radke, Rodney Owen, PhD
Rasson, Farag Lietto, MS
Smith, Randall Jay, BS
Torres, Carlos, MS
Tripp, Donald James, MS
Wiese, Thomas Edwin, BS
Wildung, Raymond Earle, PhD

1968

Black, Thomas Andrew, MS
Brakken, Kent T., BS
Browman, Michael G., MS
Cattanach, Allan Wayne, BS
Fedkenheuer, Alvin William, MS
Fernandez de Cordoba, Fernando, PhD
Fuchs, Marcel, PhD
Henderson, James Henry, MS
Hensler, Ronald Fred, MS
Iyer, Jaya Ganpathi, PhD
Kaap, James Delbert, BS
Kerr, James Patterson, PhD
Kissinger, Everett Jacob, BS
Kukachka, F. Robert, BS
Leet, David Leverett, BS
Lipas, Erkki Johannes, MS
Miller, Monroe Stephen, BS
Nelson, Neil Douglas, MS
Owens, Donald William, MS
Parker, Dale Edward, MS
Rudesill, Clinton Lewis, BS
Schwarzmeier, Jerome Anthony, BS
Sharpee, Kenneth Wayne, MS
Torgerson, Oliver Arnold, BS
Wesely, Marvin Larry, MS

1969

Al-Rawi, Amin Hamad, PhD
Beestman, George Bernard, PhD
Berger, Peter Christian, BS
Black, Thomas Andrew, PhD
Byrnes, Bernard Harry, BS
Cash, Francis Joseph, BS
Dancer, William Stetson, MS
Dirks, Glenn Richard, BS
El-Attar, Hatim Abdelwahab, MS
Frazier, Bruce Edwin, MS
Gjertson, Mary Elizabeth, BS
Isirimah, Nnaemeka Ogu, MS
Jacobs, Lee Wilburt, MS
Jacobson, Alan Edward, MS
Jung, Phillip Edward, BS
Kanemasu, Edward T., PhD
Konrad, John Grey, PhD
LaCroix, Richard Lee, MS
Lesczynski, David Bernard, MS
Murphy, William Michael, MS
Nelson, Charles Henning, BS
Newland, Leo W., PhD
Oinonen, Phillip Edward, BS
Ojanuga, Abayomi George, MS
Rand, Robert Erwin, MS
Roth, Charles Barron, PhD
Saleh, Saleh Mihsen, PhD
Salem, M. Zarif, PhD
Scotter, David R., PhD
Shaw, Byron Herbert, PhD
Sommers, Lee Edwin, MS
Viaene, Robert M., MS

1970

Anderson, James Leonard, BS
Aspiras, Ruben B., PhD
Baxter, F. Paul, PhD
Chapman, Stanley Lane, PhD
Chevis, Bruce Anthony, BS
Cowan, Emily Selden, BS
Dalton, Francis N., MS
de Gaubeka, Josu, MS
Dolcater, David Lee, PhD
Eisele, Joseph Nels, BS
El-Attar, Hatim Abdelwahab, PhD
Foth, Laten Fritz, BS

Frazier, Charles A., BS
Graetz, Donald Alvin, PhD
Hanson, Leo David, BS
Hendrickson, Larry Lee, BS
Hensler, Ronald Fred, PhD
Lambert, John L., PhD
Manoch, Bamrung, MS
McGuire, Patrick Earl, BS
Millar, Augustin A., PhD
Olsen, Robert James, PhD
Panke, Frederick Wayne, BS
Parker, Dale Edward, PhD
Seibel, Harold David, MS
Stamm, Douglas Ray, BS
Turk, Goksel, MS
Tuscher, Donald Wayne, BS
Walker, William Gordon, BS
Weaver, Robert M., PhD
Wesely, Marvin Larry, PhD
Wordell, Carsten Bernard, BS

1971

Adebayo, Adewale Ayo, MS
Bates, William Jackson, BS
Bellemore, John Clement, BS
Brooks, Allan G., BS
Browman, Michael G., PhD
Cantlon, Patrick Richard, BS
Chen, Rex Long-Shun, MS
Dobberstein, Dennis Lee, BS
Dube, John S., MS
Evans, Timothy David, MS
Henderson, James Henry, PhD
Imsmuth, Sant, MS
Irish, Michael Lee, BS
Jung, Phillip Edward, MS
Kirkham, Mary Beth, PhD
Kleiber, William A., BS
Lee, Che-Cherng, PhD
Miller, Charles Frank, BS
Mokma, Delbert Lewis, PhD
Norman, John M., PhD
Ojanuga, Abayomi George, PhD
Roof, Allan Duane, BS
Sanders, James E., BS
Smillie, George Winston, MS
Sommers, Lee Edwin, PhD
Thorp, Dennis Ozora, BS
Trautmann, William Lester, PhD
Walther, Donald L., BS

1972

Amman, Theodore J., BS
Anderson, James Leonard, MS
Andre, Steven John, BS
Byrnes, Bernard H., MS
Cajuste, Lenom J., PhD
Dalton, Francis N., PhD
Dancer, William Stetson, PhD
Dancker, Robert Charles, BS
Daniel, Tommy Curtis, PhD
Genson, Jerry James, MS
Goltz, Stewart M., PhD
Hendrickson, Larry Lee, MS
Hoeft, Robert Gene, PhD
Howell, David Dickinson, BS
Iskandar, Iskandar Karam, PhD
Jensen, Jeffrey Jon, BS
Kelling, Keith Arnold, MS
Kinniburgh, David George, MS
Lang, Dennis Raymond, BS
Larsen, Richard L., MS
Laux, David Richard, BS
LeMahieu, Patrick Jon, BS
Lewis, Douglas Larry, BS
Lynch, Daniel James, BS
Madison, Frederick William, PhD
Nichols, Dale Stephen, MS
Osiname, Olumuyiwa, PhD
Pavlik, Hannah Flora, BS
Randall, Gyles W., PhD
Ryden, John C., MS
Sayin, Mahmut, MS
Shukla, Surendra Shanker, PhD
Steevens, Dale Russell, MS
Tedesco, Marino J., PhD
Van Rooyen, Daniel Johannes, MS

1973

Adebayo, Adewale Ayo, PhD
Agin, Mark, MS
Beld, Julian John, BS
Chalk, Philip M., PhD
Corlett, Alan H., BS
Denning, Joseph LaVern, MS
Desnoyers, John Robert, BS
Fischer, Susan E., BS

Frerichs, William Wayne, BS
Goedert, Wenceslau J., PhD
Isirimah, Nnaemeka Ogu, PhD
Jacobs, Lee Wilburt, PhD
Kaatz, Dean Myron, BS
Kadeba, Olatunji, MS
Karlen, Douglas Lawrence, BS
Klamt, Egon, PhD
Komarneni, Sridhar, PhD
Lee, Suck Young, PhD
May, Howard M., MS
Mielniczuk, Joao, PhD
Nass, Alan Thomas, BS
Parsen, John David, BS
Quast, Lynn Leslie H., BS
Roberts, David Charles, BS
Vandervelde, Dirk Andrew, BS
Van Rooyen, Daniel Johannes, PhD
Volkweiss, Sergio Jorge, PhD
Walker, William Gordon, MS
Westphal, Joanne Dobron, MS
Wettstein, Carol Ann, BS
Yapp, Douglas Allen, BS

1974

Austin, Howard Leroy, BS
Baughn, John Wayne, PhD
Bell, Roger Clair, BS
Chen, Rex, Long-Shung, PhD
Coppo, Catherine Margaret, BS
Cunningham, James Daniel, MS
Downs, James Michael, BS
Ewald, John Scott, BS
Hill, Gregory Alan, MS
Jacobson, Richard David, BS
Kelling, Keith Arnold, PhD
Kempen, Barbara Mary Zenas, BS
Kinniburgh, David George, PhD
Kluess, Steven Kenneth, BS
Konwinski, Gary Robert, BS
Larson, Joseph Alan, BS
Liberty, John Bruce, BS
Liegel, Edward Alan, MS
Lobaugh, Stephen John, BS
Maharjan, Purna Lall, MS
Mayer, Diane Elizabeth, BS
Nichols, Dale Stephen, PhD
Pavlik, Hannah Flora, MS
Petersen, Bruce Kay, BS
Riopel, Yves Eugene, BS
Roberts, David Warren, BS
Romano, Richard Ralph, BS
Sagher, Aga, MS
Setijono, Slamet, MS
Shadis, David Alan, BS
Simsiman, Geronimo Vivit, PhD
Simson, Craig Roger, BS
Strenger, Steven Henry, BS
Sukandar, Djokosudardjo, MS
Thorson, Thor Darrell, BS
Unluturk, Adnan, MS
Van Patten, Douglas James, BS
Wagner, Richard Harvey, BS
Wendt, Robert Carlton, MS
Wilson, Bruce Edward, MS
Zien, Steven Morse, BS
Zitzer, Stephen Frederick, BS

1975

Abdel-Hafeez, Mahgoub Eltayeb, MS
Baker, Fred G., MS
Barager, Jack Raymond, BS
Bent, Mitchell Gordon, MS
Carlson, Jan Edward, BS
Dirks, Glenn Richard, MS
Erdahl, Robert John, BS
Falayi, Obafemi Omotayo, MS
Frazier, Bruce Edwin, PhD
Gandar, Paul Weston, PhD
Hansen, Wolcott Brown, BS
Knapton, Isaac William, BS
Kornblau, Mark Lewis, BS
Larson, Alan Clark, BS
Lewis, Lee Steven, BS
Maki, Wayne Francis, BS
McGuire, Patrick Earl, MS
Otting, Andrew John, BS
Rice, Richard Francis, BS
Robarge, Wayne Philip, PhD
Sayin, Mahmut, PhD
Simpson, Glen George, BS
Van Susteren, Peter James, BS
Veneman, Petrus L.M., MS
Vepraskas, Michael John, MS
Wiedenbeck, Susan E., BS
Zwirlein, Gary Michael, BS
Zoroofchian, Gholam Reza, BS

1976

Aide, Michael Thomas, BS
Anderson, James Leonard, PhD
Bauman, Bruce John, BS
Clay, David Edward, BS
Dong, Allen, MS
Griffin, Richard Gay, BS
Harder, Sharon Marie, MS
Honeck, Kristy Ann, BS
Huettl, Peter Joseph, MS
Jawson, Michael David, MS
Kessenich, Joseph John, BS
Kienert, Mark Alen, BS
Koons, Robert Dey, MS
Lesczynski, David Bernard, PhD
Magnin, George Ernest, BS
Meland, John Russell, BS
Meyer, Kevin Gerard, BS
Mitchell, Robert Douglas, BS
Murray, Ronald Patrick, BS
Nevins, Peter Alan, BS
Reich, Lee Alan, MS
Roberts, David Warren, MS
Rojas, Luis Felipe, BS
Saffigna, Paul Gio, PhD
Sagher, Aga, PhD
Samdahl, Diane Marie, BS
Scallon, John Robert, BS
Schloesser, Lynn Lee, BS
Schoenemann, Mark Richard, BS
Sebree, Donald James, BS
Simson, Craig Roger, MS
Syverud, Thomas Dean, BS
Tikalsky, Susan Mary, BS
Wagner, Duane Alan, BS
Walworth, James L., BS
Warner, Barbara A., BS
White, Michael Oliver, BS
Wolkowski, Richard Paul, BS
Worm, Jeffrey F., BS
Wright, Thomas Hoesly, BS
Yule, Donald Franklyn, MS
Zimmerman, David William, BS

1977

Adel, Rodney James, BS
Ainsworth, Calvin Carney, BS
Avenius, Robert Charles, BS
Bloomfield, Nathaniel Jose T., MS
Brantmeier, Thomas E., BS
Brown, Marilyn K., BS
Corning, Gary Wayne, BS
Dardak, Abu, PhD
Dorsey, Joseph L., BS
Elder, William Edward, BS
Fauerbach, Gregory Alan, BS
Gast, William August, BS
Genson, Leslie George, BS
Hardy, Paul Andrew, BS
Hendrickson, Larry Lee, PhD
Huebner, Paul Myron, BS
Huibregtse, Kent Stephen, BS
Hunt, Thomas Charles, BS
Johnston, Carol Arlene, MS
Kasa, Marilyn Louise, BS
Lake, Patricia L., BS
LeMasters, Gary Skeeles, BS
Marlett, William Paul, BS
McAneney, Kevin John, MS
Ogunlana, Francis Afolabi, MS
Orr, Blair D., BS
Pastene, Alexander James, BS
Pastor, John Joseph, MS
Peshoane, Nephtali Tlhabeli, BS
Reese, Frances Ann, MS
Schwengel, William Henry, BS
Smith, Margaret Mary, BS
Steingraeber, Ita M., BS
Suthatorn, Pornchai, MS
Tellier, Paul Lyman, BS
Unluturk, Adnan, PhD
Vargas, Milton Alexandre T., MS
Veneman, Petrus L.M., PhD
Villars, Thomas Ross, BS
Wilkie, John David, BS
Westphal, Joanne Dobron, PhD
Wright, Ronald Glenn, BS

1978

Allen, Christopher William, BS
Almeida, Jeronimo Cunha, MS
Anderson, Kim Marie, BS
Arogun, Joash Olabode, MS
Belinskas, Alan Anthony, MS
Bruns, Brian D., BS
Bunyolo, Anos Mwape, MS
Cemashko, Margaret, BS
Dowse, Carlton Scott, BS

Drew, Robert William, BS
Dzantor, Emmanuel Kudjo, MS
Egre, Laurie Beth, BS
Esser, LaVerne W., BS
Fillery, Ian Robert P., PhD
Frolking, Tod Alexander, MS
Gibneski, Helen Kirkpatrick, BS
Hahn, Robert William, BS
Haupert, Terry August, BS
Jaynes, Dan Brian, MS
Jepsen, Edward Andrew, BS
Koerner, Keith Terry, BS
Koons, Robert Dey, PhD
Leide, James Earl, BS
May, Howard M., PhD
Nwadialo, Bernard-Shaw Emeje, MS
Olotu, Michael Ukponmwan O., MS
Paulow, Terry Daniel, BS
Peters, John Bruce, MS
Pittner, Joseph Gerard, BS
Pronold, Michael Joseph, BS
Puls, Robert William, BS
Rattunde, Henry Fredrick, BS
Redders, Jeffery Scott, BS
Rem, Paul G., BS
Sarin, Peter, BS
Schellentrager, Gregg William, BS
Schoenfield, Myles Bruce, MS
Senst, Gregory Alfred, BS
Sequera Bello, Ronal Wladimir, MS
Shammas, Abdallah Toufic, PhD
Sinukaban, Naik, MS
Stam, Alan Christie, MS
Stellato, Joseph John, BS
Stensby, David George, MS
Storke, Jerold Michael, BS
Stougaard, Robert Norman, BS
Van De Bogart, Clay Aaron, BS
Wendt, Robert Carlton, PhD
Wilson, Scott Clare, BS
Wolkowski, Richard Paul, MS
Yule, Donald Franklyn, PhD

1979

Abitz, Peter Robert, BS
Anderson, Michael Paul, BS
Andraski, Brian Joseph, BS
Beno, David Raymond, BS
Berthlein, Dale George, BS
Brown, Paul Warren, MS
Brunette, David Leigh, BS
Checkai, Ronald Thomas, MS
Dickey, Mark Thomas, BS
Dunn, Dawn Maria, BS
Fagbenro, John Adeniyi, MS
Fiore, Christine M., BS
Fitzgerald, Charles Joseph, MS
Franz, Linda Jennifer, BS
Grosenick, Catherine Jean, BS
Hanson, Glenn David, MS
Helke, David Charles, BS
Huibregtse, Kent Stephen, MS
Ilozumba, Innocent C., MS
Jansky, Leroy Gerald, BS
Johannsen, Stephen D., MS
Kalenak, Jeffrey Ward, MS
Kirkpatrick, Kim Louise, BS
Klingelhoets, Paul A., BS
Kochhann, Rainoldo Albert, PhD
Koehler, Thomas J., BS
Koenig, Joel Clark, BS
Krupinski, Mark Andrew, BS
Laszewski, Virginia Ann, BS
Liska, Robert Joseph, BS
Lunder, Terry Ann, BS
Marx, Gerald Paul, BS
McAneney, Kevin John, PhD
McCown, Deborah D., PhD
Moore, Isabel Christina, MS
Mueller, Dwight Hamilton, MS
Nelson, Carol Ann, BS
Ohm, Robert Scott, MS
O'Leary, Michael Ambrose, BS
Omen, David Harold, BS
Parks, Jeffrey Allen, BS
Rathbun, Gary John, MS
Ray, Norman Robert, BS
Reardon, Michael William, BS
Reiser, Kenneth Theodore, BS
Repka, Rita Theresa, BS
Robl, Daniel John, BS
Rodencal, Jeffery John, BS
Russell, Bradley Jay, BS
Schellentrager, Gregg William, MS
Schumacher, Susan Jane, BS
Selner, Glenn Daniel, BS
Shields, Walter Joseph, PhD
Stoerzer, Lois Jean, BS

Syverud, Thomas Dean, MS
Taylor, David Scott, BS
Vanden Brook, James Paul, BS
Vlahakis, Mark Stephen, BS
Westropp, Lillian Carol, BS
Williams, Linda Maria, BS
Youngdahl, Randall Lyle, BS
Zucollo, Robin Sue, BS

1980

Borg, Heinz Jakob, MS
Backus, Michael Robert, BS
Beyer, Sherrie Louise, BS
Bullington, Scott W., BS
Carlson, Mary Ellen, BS
Cashell, Margaret Marie, MS
Clark, Eleanor Fitzhugh, BS
Cook, Mari L., BS
Crawford, James G., BS
Dollase, Diane Kay, BS
Dong, Allen, PhD
Dusault, Allen John, BS
Dzantor, Emmanuel Kudjo, PhD
Endres, Cathlin Mae, BS
Erickson, Thomas William, BS
Esser, Jacqueline Marie, BS
Ferreira, Maria De Graca, PhD
Green, Jeffrey Allen, BS
Grissom, Danny L., BS
Hanefeld, Linda Susan, BS
Hansen, Mark John, BS
Johnson, Neal Yngve, BS
Jones, Stephen Hickson, MS
Karow, Mary Elizabeth, BS
Lang, Brian Joseph, BS
Leide, James Earl, MS
Malik, Urooj, BS
McGinley, Paul Michael, BS
Murphy, Thomas Richard, BS
Norton, Patrick James, BS
Osterdyk, Kelly Lee, BS
Pastor, John Joseph, PhD
Patterson, Rebecca, BS
Pekowsky, Robert Carl, BS
Polacheck, Joe Reading, BS
Rademacher, Christine Johanna, BS
Riordan, Michael James, BS
Romero, Stephen Paul, BS
Sattell, Robert Richard, BS
Schaefer, Robert William, BS
Schloesser, Andrew Victor, BS
Schlosser, Mark John, BS
Schoenemann, Mark Richard, MS
Silva, Fernando F., MS
Skopp, Joseph Michael, PhD
Smith, Matthew David, BS
Sterrett, Jeffery William, BS
Stieber, Joe M., BS
Stroick, Jule Ann, BS
Udoh, Dominic Johnson, MS
Walter, Holly Michele, MS
Walworth, James Lawrence, MS
Zappi, Eduordo Augusto, BS

1981

Al-Hajjar, Bashar Jamil, MS
Anderson, David Lee, PhD
Anderson, Kim Marie, MS
Bertelsen, Alan Michael, BS
Bieganski, Ronnie Joe, BS
Birrenkott, Gary Lee, BS
Brown, Paul Warren, PhD
Comfort, Steven Douglas, BS
Counihan, Richard F., BS
DeMeurisse, Anne Marie, BS
Fox, Dean Stanley, BS
Gallagher, Theresa Lee, BS
Ghodrati, Masoud, BS
Joshi, Jaya Raj, MS
Kisow, Charles Edward, BS
Klitzkie, Theodore Charles, BS
Krueger, Gary Leigh, BS
Lesavich, Stephen, BS
Lim, Chin Huat, PhD
Mack, Walter Donald, BS
Milner, Maribeth, MS
Miron, Mary Josephine, BS
Moncrief, John Frazeur, PhD
Moore, Donna Lee, BS
Munz, Paul Guenther, BS
Myrland, Brian Edward, BS
Oliveira, Manuel Teles de, MS
Olund, Cynthia Lynn, BS
Pastene, Alexander James, MS
Ploetz, Susan Tira, BS
Rinelli, Linda Louise, BS
Russell, Dean Scott, BS
Schwab, Thomas Gerard, BS

Sinukaban, Naik, PhD
Spillane, Kevin Michael, BS
Suthatorn, Pornchai, PhD
Taylor, David Scott, MS
Taylor, Edwin Allen, BS
Teo, Leng, MS
Tikalsky, Susan Mary, MS
Wagner, Robert Mark, BS
Zenk, Jodi Lynn, BS

1982

Balogh, Joan Irene, MS
Barnes, William James, BS
Danforth, Lisa Ellen, BS
Davison, James Walker, BS
Deneen, Daniel Joseph, BS
Drugan, Michael Kent, BS
Fries, Marcos Rubens, MS
Garvey, Maureen H., BS
Gehr, Kathryn Marie, BS
Hess, Brian George, BS
Huettl, Peter Joseph, PhD
Hundt, Sarah Rose, BS
Johnston, Carol Arlene, PhD
Kaisaki, Frederick Mikio, MS
Karlen, Daniel J., BS
Khatri Chhetri, Tej Bajadur, PhD
Kivlin, Paul Thomas, BS
Kladivko, Eileen Joyce, PhD
Kluz, Mary Ann, BS
Lampert, Jordan Keith, PhD
Lange, Richard Martin, BS
Lowry, Patricia A., BS
Madden, Mark Steven, BS
Meyer, John Carl, BS
Mohamed, Yousif Yagoub, MS
Moore, Thomas Glen, BS
Murdock, John Richard, BS
Nummilien, Bruce, BS
O'Brien, Harry, BS
Ocker, Susan Renee, BS
Patterson, Michael Dale, BS
Proost, Richard Thomas, BS
Rhude, Trygve Alan, BS
Rogers, Seth Palmer, BS
Royal, Daniel Brian, BS
Schmoock, Fred Dale, BS
Schulz-Crolius, Teresa Ann, BS
Shadel, Elizabeth A., BS
Stangel, William Daniel, BS
Staubli, Randy Joseph, BS
Stippich, Herman Carl, BS
Trudell, Kathryn, BS
Vale, Rui Ramos Do, MS
Weber, Jane Ann, BS
Werlein, Steven Robert, BS
Wilberg, Robert Johnston, BS
Wilhelm, Roy Dennis, BS

1983

Bidwell, Ann Marie, MS
Cates, Kim Johnson, MS
Cates, Richard Lyman, PhD
Checkai, Ronald Thomas, PhD
Conder, Paul, BS
Dahl, Robert A., BS
DeLeo, Steven P., BS
Dlamini, Michael Gija Benzey, BS
Edwards, Richard Brant, BS
Eichelkraut, Greg, BS
Fujii, Roger, PhD
Ghodrati, Masoud, MS
Goodroad, Lewis L., PhD
Handrich, Michael William, BS
Hargett, David L., PhD
Hegge, Jon, BS
Hoger, Michael L., BS
Hommerding, James Joseph, BS
Huang, Joyce Chao-Yong Lu, MS
Johnson, Michael D., MS
Kakuk, Michael Stephen, BS
Koepsell, F. Scott, BS
Lekena, Nkareng, MS
Lunze, Lubanga, MS
Marshall, James Grant, BS
Masterpole, Daniel, MS
Mleziva, Michael A., BS
Ndlovu, Leonard Sive, BS
Nettesheim, Denise G., BS
Newbold, Kathryn Jean, PhD
Olson, Gail L., BS
Patlak, Margaret Ellen, MS
Perry, James Jennings, MS
Ploetz, Susan Tira, MS
Rogers, William Joseph, BS
Schlecht, Sarah Jane, BS
Semler, Michael R., BS
Staudenmaier, Louis William, BS

Tabinsky, Olga, BS
Tolkacz, Thomas Robert, BS
Wander, Michelle Mary, BS
Wietholter, Sirio, PhD

1984

Adamczak, Denise Mary, BS
Al-Dossari, Abdullah K., BS
Anamosa, Paul Robert, MS
Andraski, Brian Joseph, MS
Andraski, Todd Walter, BS
Apfel, Richard Alex, BS
Baker, William Robert, BS
Birrenkott, Brian Anton, BS
Bland, William Lehman, PhD
Boyce, Jean Ellen, BS
Boyle, Elizabeth Lynn, BS
Connolly, Bernard Thomas, BS
Dahl, Glenn Alan, BS
Daoud, Deifallah Mohammad, PhD
DeLuca, Thomas Henry, BS
Dietrich, Diane Mary, BS
Esser, Jacqueline Marie, MS
Francone, Stuart Lee, BS
Gibas-Kreft, Dawn R., BS
Griffin, Michael J., BS
Hung, Jia-Jang, PhD
Jefferson, Jill, BS
Johnson, Kelly M., BS
Klingberg, Kevan Mark, BS
Meese, Brian George, BS
Motavalli, Peter Parviz, MS
Mulder, Thomas Alvin, BS
Mutschler, Peter John, BS
Nyberg, Scott F., BS
Pepe, Steven Joseph, BS
Pittman, Michael John, BS
Postle, Jeffrey Kemerer, MS
Scallon, Gregory Sean, BS
Schlegel, Jon Peter, BS
Schweiger, Bruce Robert, BS
Stieber, Tim David, BS
Weissbach, Marjorie Ruth, BS
Welsh, Margaret O., MS
Zwaska, Paul Curry, BS

1985

Cox, James David, BS
Ertman, Christopher Todd, BS
Feng, Yongsheng, MS
Frolking, Tod Alexander, PhD
Grzan, Jerry George, BS
Hagan, Henry, BS
Heng, Lee Kheng, MS
Herman, Kris Dean, BS
Jacobson, Renee D., BS
Krismer, Michael George, BS
Lato, Leon Julian, BS
Lennert, Larry Louis, BS
Loesch, Jean Marie, BS
Oberle, Steven Lyle, MS
Persson, Lynn Anne, MS
Ruark, Gregory A., PhD
Sauer, Thomas John, MS
Scannell, Thomas Francis, BS
Simmons, Karen Elizabeth, MS
Tomlinson, Karen Ruth, BS
Zeinert, Philip Darwin, BS

1986

Al-Darby, Ali Mohammad, PhD
Amerson, Robert Scott, BS
Barrett, Mark Daniel, BS
Benzel, Tracy Conrad, MS
Condron, Margaret Anne, BS
Doering, David Paul, BS
Gessler, Paul Edward, BS
Hamilton, Thomas William, BS
Hildebrand, Gail Lynn, BS
Hilfiker, Ruth Emily, MS
Malone, Elizabeth Sue, MS
Marquardt, Kendall Lee, BS
Mazursky, Mark Gregory, BS
Nicholls, Kerry Herbert, BS
Schlesinger, Cathleen Marie, BS
Schmidt, Carole Louise, MS
Schuetze, John Wayne, BS
Slavik, Randy Thomas, BS
Van Hierden, Mark Henry, BS

1987

Appelt, Dan Robert, BS
Bauer, Thomas Lee, BS
Berchem, Margaret Rose, BS
Combs, Sherry Margaret, PhD
Erickson, Thomas William, MS
Esser, Kjell Bjorgen, PhD
Heshaam, Ajmal A., MS
Huebsch, Catherine Ann, BS
Hurtenbach, John Anthony, BS

Jacobson, John C., MS
Kehrmeyer, Staci Rose, BS
Kidd, David Michael, BS
Leclerc, Scott A., MS
Lee, Michael Joseph, BS
McGuire, Michael John, BS
Pilz, Jeffrey Craig, BS
Ripp, Lora Mae, BS
Roth, David Carol, BS
Shen, Yuan, PhD
Wipperfurth, Arthur John, BS

1988

Arrington, Roderick T., MS
Comfort, Steven Douglas, PhD
Fathulla, Riyadh Najeeb, PhD
Fermanich, Kevin John, MS
Gould, Catherine Linn, MS
Grunke, Gary Lee, BS
Habecker, Melinda Ann, MS
Hautot, Charles, BS
Jackson, Edward Jonathan, MS
Jepsen, Edward Andrew, MS
Kasper, Pamm J., BS
Kluz, Mary Ann, MS
Kopecky, Mark John, MS
Liang, Yingming, MS
Madden, Mark Steven, MS
Markham–Nitz, Linda M., BS
Millies, Daniel R., BS
Mlynarek, Michael J., MS
Oberle, Steven Lyle, PhD
Raifsnider, Jeffery Glen, BS
Ransome, Lorraine Susan, PhD
Rasmussen, Mary Katherine, BS
Seils, David Edward, BS
Soda, Kevin Kenneth, BS
Stites, Wilbur D., Jr., MS
Trudell, Kathryn, MS
Ward Good, Laura, MS

1989

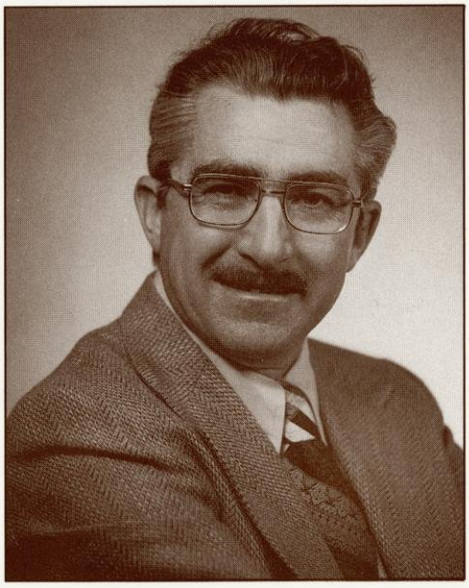
Bahr, Jeffery James, BS
Datiri, Benjamin Chumang, PhD
Guthery, David Eugene, BS
Hargis, Kevin Zackary, BS
Hoffman, John Scott, BS
Horman, Wayne G., BS
Iribarren, Jacqueline A., BS
Janzen, Roy Marvin, BS
Jefferson, Jill, MS
Jensen, Daniel Patrick, BS
Kadir, Abdul, MS
Karim, Anwar Mustafa, BS
Koscik, Kenneth Joseph, BS
Lyons, Michael Edward, BS
Marquardt, Keith A., BS
McCarthy, Ronald Brian, BS
Milner, Maribeth, PhD
Monge, Todd A., BS
Morrison, Robert Daniel, PhD
Smart, Alexander John, BS
Solomon, Michael, MS
Sturgul, Scott John, MS
Vanotti, Matias, MS
Wolkowski, Richard Paul, PhD

1990*

Donohue, Stephen Vincent, MS
Eberhardt, Chad D., BS
Jennrich, Karl Eugene, BS
Khan, Yousaf H., PhD
Kraft, George, PhD
Kuczmarski, Rodney Allen, BS
Lennert, Larry L., MS
McCurdy, Michael Gordon, BS
McGuire, Patrick Earl, PhD
Miller, Anthony Wheaton, BS
Saeed, Ibrahim A.M., PhD
Smith, Kent F., BS

* completion of the 1989–90 year

INDEX



Marvin T. Beatty is a professor emeritus at the University of Wisconsin-Madison, Department of Soil Science, and an associate dean emeritus with the University of Wisconsin–Extension. He joined the Department of Soil Science and the Wisconsin Geological and Natural History Survey in 1956 as an assistant professor and extension specialist in soil survey interpretation. He was an associate dean of UW-Extension, Cooperative Extension, and a professor of soil science when he retired in 1988.