

E. D. Ross

THE
STATISTICAL LABORATORY



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THE STATISTICAL LABORATORY
of
the Iowa State College

George W. Snedecor
Director

Harold V. Gaskill
Dean of Science

Charles E. Friley
President



W. G. Cochran, Gertrude M. Cox, George W. Snedecor, C. P. Winsor

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STATISTICS IN THE IOWA STATE COLLEGE

Twenty-five years ago Iowa State College offered its first courses in applied statistics. Statistical methods had long been used in both research and teaching, but not till 1915 did the demand for formal instruction become insistent. The first course offered in Economic Science was described as "Elementary Statistical Methods", while one in Mathematics had the title "Statistical Methods of Interpreting Agricultural Data". During the quarter-century since then interest has grown so rapidly that 20 courses are now needed to accommodate some 350 senior college and graduate students.

The use of statistics in Iowa State College extends to virtually every one of its 54 departments. More than 30 of them employ formal statistical methods in their teaching and research, while others find their needs satisfied by the more usual techniques of tabulating and presenting graphically their collected data. Three departments offer courses of instruction in the subject. Early recognition of this general interest in statistics has led to its development in Iowa State College as a cooperative enterprise.

Such cooperation is an advantage to all. The investigator in his daily use of statistics encounters new problems in which the help of the statistician is required. The research statistician requires the stimulus of practical needs to guide him into useful investigations. The teacher seeks fresh examples and constant familiarity with advancing theory to make his instruction effective. Full cooperation among these workers is the price of their common success.

Because of this cooperation, Iowa State College affords unusual opportunities to those interested in studying statistics and its uses. The mathematical statistician and the experimental scientist, whether graduate student, teacher or research worker, meet on the common ground of statistical problems. Each learns the attitudes, methods and difficulties of the other. Consequently they avoid the two extremities of theory without practice and of application without theory.

Statistics in Iowa State College is decidedly oriented toward the practical. Even the investigation and teaching of theory is evaluated in terms of utility. This at once requires and explains the mutual interests of the statistician and of the investigator who makes use of statistics. The College motto, "Science with Practice", well characterizes its aims in statistics.

The Statistical Laboratory is a department of the College devoted exclusively to statistical affairs. Of the total time of its staff members a majority is spent in helping experimenters with their statistical problems. Teaching and research occupy the remainder. The contacts of the Laboratory are made by conferences with other members of the College staff as well as with workers both within and beyond the borders of the state, by extensive correspondence and by publications.

A BIT OF HISTORY

Chiefly responsible for the first course in agricultural statistics was Professor John M. Evvard of the department of animal nutrition. He was concerned about the significance of his experimental results at the time when it was not clear how "Student's" small sample theory could be applied to group comparisons. Enthusiastic and farsighted, he challenged statistical research and directed many graduate students into the early classes.

In the spring of 1924 a group of some 20 faculty research workers met on Saturday afternoons to study multiple regression under the guidance of Dr. Henry A. Wallace, then assistant editor of "Wallaces' Farmer", now Secretary of Agriculture of the United States. Assisting Dr. Wallace was Dr. Charles F. Sarle who was stationed at Des Moines in the Division of Crop and Livestock Estimates. Such an arrangement was made possible by the leadership of President R. A. Pearson, Dean S. W. Beyer and the head of the Department of Mathematics, Professor E. R. Smith. An immediate result of this venture was the publication of the bulletin, "Correlation and Machine Calculation" by Wallace and Snedecor, a pamphlet which promptly attained worldwide distribution.

Two other landmarks in the developing statistical life of the College were the visits of Professor R. A. Fisher who was a summer session lecturer in 1931 and again in 1936. Graduate students and research workers came from India, Australia and China, from the Argentine and Canada, and from all sections of the United States to study under this great leader. The stimulating contacts with these men served to enhance the profound impression which Professor Fisher has made on statistical thinking in Iowa State College.

Many statisticians of international fame have visited the campus for longer or shorter stays. Some of them require special note. The summer quarter of 1934 brought Professor John Wishart as lecturer from Cambridge University. His help in our covariance problems came at a time when the technique was almost untried. In the fall and winter of 1937-1938 Dr. F. Yates of the Rothamsted Experimental Station was in residence as lecturer on the design of replicated experiments. Dr. J. Neyman, then of the Galton Laboratory in the University of London, now at the University of California, visited us in the spring of 1938. His counsels on the general problem of sampling were most opportune.

Statistical practice in Iowa State College has always leaned heavily on theory. Professor Smith, Dr. E. S. Allen and Mr. F. A. Brandner of the Department of Mathematics have carried on teaching and research in interpolation, probability and mathematical statistics. Their work has been supplemented recently by the addition of Dr. Gerhard Tintner and Professor W. G. Cochran to the staffs of the mathematics, economics and statistical departments. Dr. Tintner, coming from the University of Vienna and the Cowles Institute, introduces specialized research in economic time series into our statistical activities. Professor Cochran, formerly mathematical statistician of the Rothamsted Experimental Station, leads the research and graduate work in statistics for the Statistical Laboratory and the Department of Mathematics.

The most recent event in our history is the cooperative agreement in statistics between Iowa State College and the United States Department of Agriculture, effective in

1938. In this enterprise, the leaders for the College were President Charles E. Friley, Dean H. V. Gaskill, Director R. E. Buchanan, Professors E. R. Smith, E. W. Lindstrom and T. W. Schultz. Those in the U. S. D. A. taking an active part were Secretary H. A. Wallace, Dr. A. G. Black, Mr. W. F. Callander and Dr. Charles F. Sarle. Dr. Sarle, whose first visit to Iowa State College was with Dr. Wallace in 1924, conceived the idea of an effective union of the statistical endeavors of the College and the Department. The objectives and methods of this cooperation will be described in various paragraphs to follow.

DEVELOPMENT OF THE STATISTICAL LABORATORY

The Department of Mathematics of Iowa State College is noted for its willing and effective cooperation with people having problems in applied mathematics. In statistical applications Professor Snedecor took the lead shortly after joining the staff in 1913. Following the lectures of Dr. Wallace, the demand for professional help in statistics grew so rapidly that in 1927 President R. A. Hughes and Professor Smith instituted the Mathematics Statistical Service with Professor Snedecor and Dr. A. E. Brandt in charge. Calculating and punched card tabulating equipment was installed in the Physics building where direct current electricity was available. The year following, however, larger quarters had to be provided in Beardshear Hall.

The Statistical Laboratory was organized as a department of the College in 1933, and Miss Gertrude Cox was added to the staff. Within a year the need for larger quarters led to the removal of the Laboratory to the old Office Building where it was housed till 1939.

In the fall of 1938, Dr. Brandt resigned to accept the newly created position of Senior Mathematical Statistical Analyst of the Soil Conservation Service. Dr. Charles P. Winsor of Harvard took his place on the Laboratory staff.

Under the terms of the Project Agreement of 1938 the staff and facilities of the Laboratory were increased many fold. Messrs. King, Davis, Harrell, Simpson, Bair, McCarty and Monroe were stationed at Ames as resident



Punched card electrical equipment in the Statistical Laboratory

collaborators in the joint researches. In the Statistical Laboratory six new staff positions were created, and the computing force was correspondingly enlarged. Two regional conferences between Laboratory staff members and U. S. D. A. research men in Iowa and neighboring states have proved mutually advantageous.

The fall of 1939 finds the Statistical Laboratory installed in the new Service Building centrally located on the campus and adequately equipped for the specialized work of the department. Eleven rooms provide space for the staff members, for the student laboratories and for the punched card tabulating machines. One of the rooms is arranged for seminars and conferences.

With the addition of Dr. Winsor and Professor Cochran to our staff the earlier preoccupation of the Laboratory with statistical methods is superseded by a promising union of theory with practice.

FUNCTIONS OF THE STATISTICAL LABORATORY

The functions of the Statistical Laboratory are best explained in the following section of the 1939-1940 Iowa State College General Catalog.

“The purpose of the Statistical Laboratory is to promote and foster the advantageous use of statistics in the teaching and researches of the College.

“RESEARCH. The staff of the Laboratory, together with other interested members of the College staff, seek to develop practical and efficient methods of applying statistical theory to the problems that arise in practice. The results are published in such form as to make them readily available to the layman.

“STATISTICAL COUNSEL. Professional advice in statistical methods is made available to students and members of the College staff. This is directed (a) toward the design of experiments whose results shall be capable of convenient and valid statistical treatment and (b) to the selection of the best available methods for the reduction of data already collected.

“TEACHING. While the Statistical Laboratory is not a department of instruction, members of its staff devote part of their time to teaching statistics in the Mathematics Department. Other members of the College staff teach courses in statistics in the Department of Economics and Sociology. Still others teach courses whose objectives include specialized application of statistics. One function of the Laboratory is to correlate these activities, to promote interest in statistical scholarship and instruction, to prevent duplication of effort, and to assist in organizing such courses in statistics as may be needed in the College.

“COOPERATION WITH UNITED STATES DEPARTMENT OF AGRICULTURE. A project agreement with the Bureau of Agricultural Economics provides for joint research in the statistics of agriculture and the associated statistical theory. The growing demand for agricultural information of greater scope, higher degree of precision and increased detail is emphasizing the need for more

efficient experiments, improved sampling techniques and appropriate statistical methods. These demand intensive research in mathematical statistics and its applications. Under this cooperation a staff is created for the prosecution of such research, with special attention directed toward problems whose solutions will be of immediate utility in agriculture.

“COMPUTATION SERVICE. The Laboratory furnishes such computation as may be required by persons in the College. This computation may be done in one of the regular computing rooms, or, in special cases, in other convenient locations. The equipment in the Laboratory includes a complete set of machines for sorting and tabulating punched cards.

“CALCULATING MACHINES. It is the policy of the College to supply necessary computing machines for all who need them. The Laboratory is responsible for the installation and maintenance of such machines as may be required at various stations in the College buildings. Additional machines are available to those who can arrange to use them in the regular computing rooms.”

THE STATISTICAL SECTION OF THE IOWA AGRICULTURAL EXPERIMENT STATION

Progress in the design and evaluation of certain replicated experiments, such as field plot trials, has been unusually rapid during the last 15 years. Most research workers in agriculture have been too much occupied with their own problems to be able to keep up with developments in statistics. Director R. E. Buchanan, early recognizing the importance of cooperation between the statistician and the experimenter, appointed Professor Snedecor as Statistician of the Agricultural Experiment Station in 1933. Two years later the Statistical Section was organized, the staff including virtually all members of the Statistical Laboratory. Three projects are now set up for research in various phases of the applications of statistics to agricultural problems.

Owing to the utility of the new designs, they have been

readily adopted by research men in our Agricultural Experiment Station. Nowhere else are so many of these complex designs in use. This gives the statistician of Iowa State College the unexampled opportunity to examine the structure itself for efficiency, for applicability, etc., an opportunity which is being successfully utilized by Miss Cox.

Organized as projects in the Statistical Section is the research carried on under the project agreement between the College and the U. S. D. A. which has been described. One project, enlisting the cooperation of both the Agronomy Section and that of Botany and Plant Pathology, outlines investigation of the interrelations among meteorological environment, soil condition, growth response and yield of crops. Another, with the Agricultural Economics Subsection, is designed for the development and testing of techniques suitable for partial census.

INSTRUCTION IN STATISTICS AT IOWA STATE

Statistical methods and theory are both provided in the courses offered in the various College departments. The methods courses require no more than elementary training in mathematics. For those who have or wish to take more mathematics, there are statistical theory courses available in the Departments of Mathematics and Economics.

The Department of Mathematics offers major work for the degrees Master of Science and Doctor of Philosophy in the applied field of statistics. In the Department of Economics, statistics may be chosen for special emphasis by candidates for either degree. Most of the biological departments provide for the election of minor work in statistics. The curricula in statistics are adequately supported by courses in other branches of mathematics, economics and biology, while the Library is well supplied with reference works and journals of statistics.

From five to ten teaching and research fellowships in statistics are provided in the Departments of Mathematics and Economics and the Statistical Laboratory. Candidates for these positions are urged to prepare themselves



in two of the three subjects, mathematical statistics, economics and biology, or in all three.

Computational facilities are adequately developed. Machines for punching and tabulating data in cards are supplied. The College owns more than 175 adding and calculating machines and operates two well equipped computing rooms.

A condensed list of courses in statistics gives an idea of the opportunities which Iowa State College offers the student for instruction in this subject. It may also be found convenient for locating the courses scattered through the College catalog.

Economics 441:	Elementary Economic Statistics	Mr. Dachtler
Economics 537:	Statistical Analysis	Mr. Tintner
Economics 646:	Econometrics	Mr. Tintner
Mathematics 241, 242, 243:	General Mathematics and Statistics	Mr. Tintner
Mathematics 441, 442, 443:	Statistical Methods	Mr. Snedecor
Mathematics 444, 445:	Statistical Laboratory	Mr. Anderson
Mathematics 541, 542, 543:	Mathematical Sta- tistics	Mr. Brandner
Mathematics 545:	Design of Experiments	Miss Cox
Mathematics 599:	Special topics. Messrs. Cochran, Smith, Snedecor, Tintner	
Mathematics 610:	Seminar. Messrs. Cochran, Smith, Snedecor	
Mathematics 640:	Probability	Mr. Allen
Mathematics 641, 642, 643:	Advanced Mathematical Statistics	Mr. Cochran
Mathematics 699:	Research. Messrs. Cochran, Smith, Snedecor	
Vocational Education 552:	Educational Statistics	Mr. Wert

OPPORTUNITIES FOR GRADUATES

Numerous calls come for men and women trained in the undergraduate and graduate curricula, but the supply is far short of the demand. Holders of the bachelors degree are needed to take charge of computing rooms in research departments and to assist in actuarial work in the offices of insurance companies. Every year colleges inquire about men with the degree Doctor of Philosophy prepared for teaching and research in mathematical statistics, usually combined with biology or economics. One of the desires of the men setting up the project agreement in statistics was to facilitate the training of men needed for research in agricultural economics, in agronomy and in forestry. Young people of unusual ability in

these fields are invited to investigate the opportunities offered to graduates of Iowa State College.

Here are some examples of the positions held by our former students:

- Acting head, soil and water conservation experiment stations, Soil Conservation Service
- Assistant in statistics, Mayo Clinic
- Manager of the computing room in a poultry department
- Assistant agricultural statistician, Agricultural Marketing Service
- Supervisor of actuarial computation in an insurance company
- Assistant professor in the economics department of a state university
- Five assistants in actuarial departments
- Animal breeder in the Royal Agricultural Society of Copenhagen
- Senior cereal research officer, Department of Agriculture, Melbourne, Australia
- Assistant in Galton Laboratory, University of London
- Tabulating machine operator in another insurance company

Evidence accumulates that most institutions of research in agriculture and biology will establish some kind of statistical unit in the not distant future. Will there be competent men adequately trained for the jobs?

The Laboratory furnishes a computation service for the college



PUBLICATIONS OF THE STAFF OF THE STATISTICAL
LABORATORY

- 1925 Correlation and machine calculation. Iowa State College Official Publication, Vol. 23, No. 35.—H. A. Wallace and George W. Snedecor.
Experiments with small numbers of observations. Proceedings of the Iowa Academy of Science, 32:367.—George W. Snedecor.
- 1926 Breeds of swine and dressing percentages. Monthly Letter to Animal Husbandmen, Armour and Company, Union Stock Yards, Chicago, Ill. Vol. 7, No. 2.—A. E. Brandt.
- 1927 Correlations between daily gains and feed requirements of growing and fattening swine. Proceedings of the American Society of Animal Production.—John M. Evvard, M. G. Snell, C. C. Culbertson, George W. Snedecor.
- 1928 The use of machine factoring in multiple correlation. Journal of American Statistical Association, 23:291.—A. E. Brandt.
Arithmetical changes in statistical constants due to coding and their correction. Iowa State College Journal of Science, 2:229.—A. E. Brandt.
Calculation and use of the standard deviation of partial regression coefficient. Iowa State College Journal of Science, 2:235.—A. E. Brandt.
How many animals per experimental lot? Proceedings of the American Society of Animal Production.—John M. Evvard, C. C. Culbertson, George W. Snedecor.
Uses of punched card equipment in mathematics. The American Mathematical Monthly, 35:161.—George W. Snedecor.
- 1930 A statistical study of industrial science students of the class of 1926. Proceedings of the Iowa Academy of Science, 37:337.—Gertrude M. Cox.
Applications of statistical method to the data of vitamin feeding experiments. I. The percent effect of measured variables. II. How many animals per experimental lot? Journal of Biological Chemistry, 88:449, 461.—M. A. Irwin, A. E. Brandt, P. M. Nelson.
A statistical test of experimental technique. Proceedings of Iowa Academy of Science, 37:279.—George W. Snedecor.
Statistical control of a grading system. Proceedings of Iowa Academy of Science, 37:290.—George W. Snedecor.
- 1931 The use of the individual parts of the aptitude test for predicting success of students. Proceedings of the Iowa Academy of Science, 38:225.—Gertrude M. Cox.
Correlation and machine calculation. Revised Edition. Iowa State College Official Publication, Vol. 30, No. 4.—H. A. Wallace, George W. Snedecor.

- A statistical investigation of a teacher's ability as indicated by the success of his students in subsequent courses. A thesis submitted for the degree, master of science, Iowa State College.—Gertrude M. Cox.
- 1932 The hemoglobin content of the blood of the hen: a statistical study of influences and relations. *Science*, 75:25.—H. H. Dukes, L. H. Schwarte, A. E. Brandt.
- An improved design for experiments with groups of animals whose outcome may be estimated. *Proceedings of the American Society of Animal Production*.—G. W. Snedecor, C. C. Culbertson.
- 1933 The scoring of individual performance on tests scaled according to the theory of absolute scaling. *Journal of Educational Psychology*, p. 654.—Clarence W. Brown, Phyllis Bartelme, Gertrude M. Cox.
- The analysis of variance in a $2 \times s$ table with disproportionate frequencies. *Journal of the American Statistical Association*, 28:164.—A. E. Brandt.
- A test for significance in a unique sample. *Journal of the American Statistical Association*, 28:434.—A. E. Brandt.
- * Analysis of variance as an effective method of handling the time element in certain economic statistics. *Journal of the American Statistical Association*, 28:14.—Theodore W. Schultz, George W. Snedecor.
- On the chi-square test for homogeneity. *Iowa State College Journal of Science*, 8:75.—George W. Snedecor, M. R. Irwin.
- 1934 Calculation and interpretation of analysis of variance and covariance. Collegiate Press, Inc., Ames, Iowa.—George W. Snedecor.
- Biological variation vs. errors in measurement. *Science*, 80:246.—George W. Snedecor.
- * The method of expected numbers for tables of multiple classification with disproportionate subclass numbers. *Journal of the American Statistical Association*, 29:289.—George W. Snedecor.
- 1935 * Disproportionate subclass numbers in tables of multiple classification. *Iowa Agricultural Experiment Station Research Bulletin No. 180*.—George W. Snedecor, Gertrude M. Cox.
- * Index number of Iowa farm products prices. *Iowa Agricultural Experiment Station Bulletin No. 336*.—Gertrude M. Cox.
- * Animal and plant breeding; summarizing contest results; uses of the progressive digit method. In *Practical Application of the Punched Card Method in Colleges and Universities*. Columbia University Press, New York, pp. 351, 377, 423.—A. E. Brandt.
- * Analysis of covariance of statistically controlled grades. *Journal of the American Statistical Association*, 30:263.—George W. Snedecor.

- 1936 * Covariance used to analyze the relation between corn yield and acreage. *Journal of Farm Economics*, 18:597.—Gertrude M. Cox, George W. Snedecor.
- A note on dominant white and crest in poultry. Flecks and comb shape make possible identification of heterozygotes. *The Journal of Heredity*, 27:79.—A. E. Brandt.
- Application of punched card equipment to the analysis of complex spectra. *Journal of the Optical Society of America*, 26:83.—J. V. Atanasoff, A. E. Brandt.
- * The improvement of statistical techniques in biology. *Journal of the American Statistical Association*, 31:690.—George W. Snedecor.
- 1937 * Patterns in emotional reactions: I, Respiration. The use of analysis of variance and covariance in psychological data. *Journal of General Psychology*, 16:21.—Harold V. Gaskill, Gertrude M. Cox.
- * Use of a discriminant function for differentiating soils with different azotobacter populations. *Iowa State College Journal of Science*, 11:323.—Gertrude M. Cox, William P. Martin.
- Statistical methods applied to experiments in Agriculture and Biology. Collegiate Press, Inc., Ames, Iowa.—George W. Snedecor.
- Factorial design. *Journal of the American Society of Agronomy*, 29:658.—A. E. Brandt.
- 1938 Tests of significance in reversal or switchback trials. *Iowa Agricultural Experiment Station Research Bulletin No. 234*.—A. E. Brandt.
- * Statistical methods applied to experiments in Agriculture and Biology. Revised Edition. Collegiate Press, Inc., Ames, Iowa.—George W. Snedecor.
- Some principles of sampling. *Proceedings of the 1938 Ohio Conference of Statisticians on Business Research*, Nov. 12. *Ohio State University Publications, College of Commerce Conference, Series No. 5*.—George W. Snedecor.
- 1939 * The multiple factor theory in terms of common elements. *Psychometrika* 4:59.—Gertrude M. Cox.
- * Balanced incomplete block and lattice square designs for testing yield differences among large numbers of soybean varieties. *Iowa Agricultural Experiment Station Research Bulletin No. 257*.—Martin G. Weiss, Gertrude M. Cox.
- * Biostatistical problems involved in the standardization of liquid household insecticides. *Journal of the American Statistical Association*, 34:62.—F. L. Campbell, George W. Snedecor, W. A. Simanton.

* Publications available.