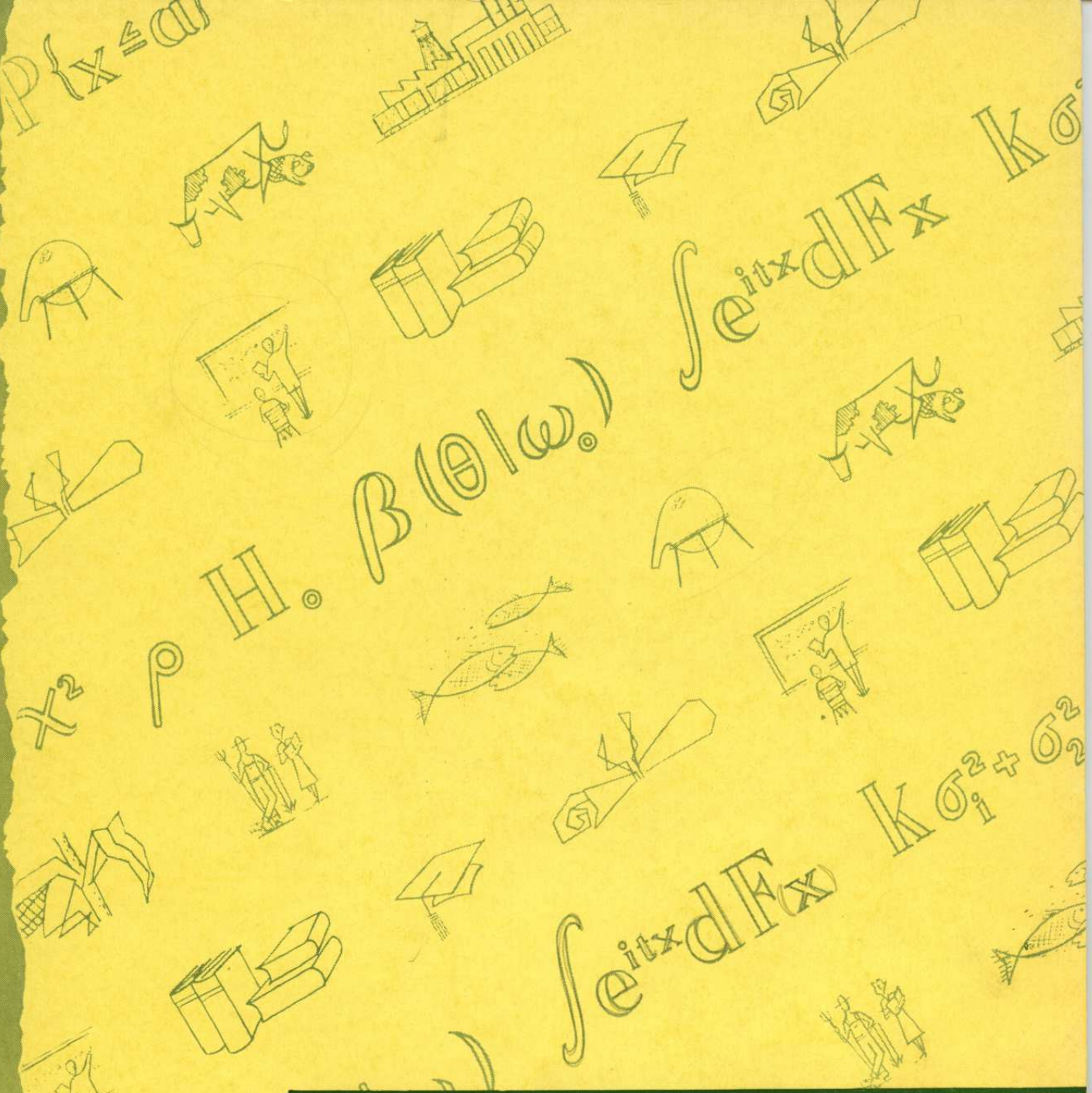
The Statistical Laboratory Established 1933 Iowa State College



ANNUAL REPORT

July 1, 1958 to June 30, 1959

President James H. Hilton
Iowa State University
of Science and Technology
Ames, Iowa

Dear President Hilton:

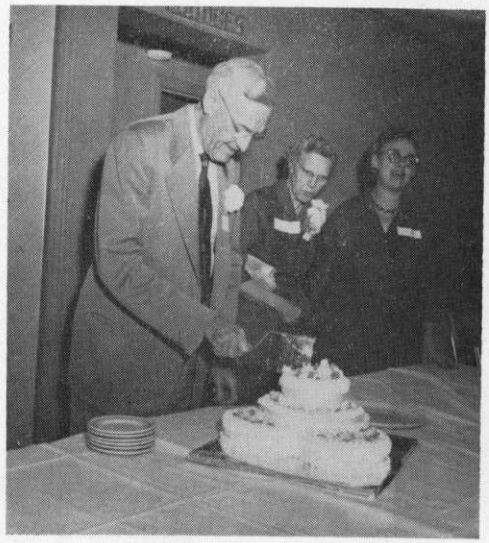
This is the Annual Report of the Statistical Laboratory staff at Iowa State for the period July 1, 1958 through June 30, 1959. It reports on the research, consulting, teaching and operational work of members of the university statistical center as complementary activities of the center's five components: the Statistical Laboratory, established as a research and service institute under the President's Office; the teaching Department of Statistics of the College of Sciences and Humanities (still called the Division of Science in 1958-59); the statistics department of the Agricultural and Home Economics Experiment Station; and the statistics participant unit of the Industrial Science Research Institute; together with the research field office of the Agricultural Estimates Division, Agricultural Marketing Service, U. S. Department of Agriculture, which is located in the Statistical Laboratory. Inasmuch as the statistical endeavors of individuals are carried on through institutions and departments of Iowa State University, this constitutes an annual report from those organizations.

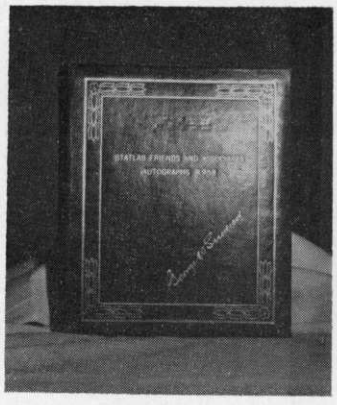
Respectfully submitted on behalf of
the Statistical Laboratory staff,

T. A. Bancroft

Director, Statistical Laboratory, and
Head, Department of Statistics; head,
statistics department, AHEES.

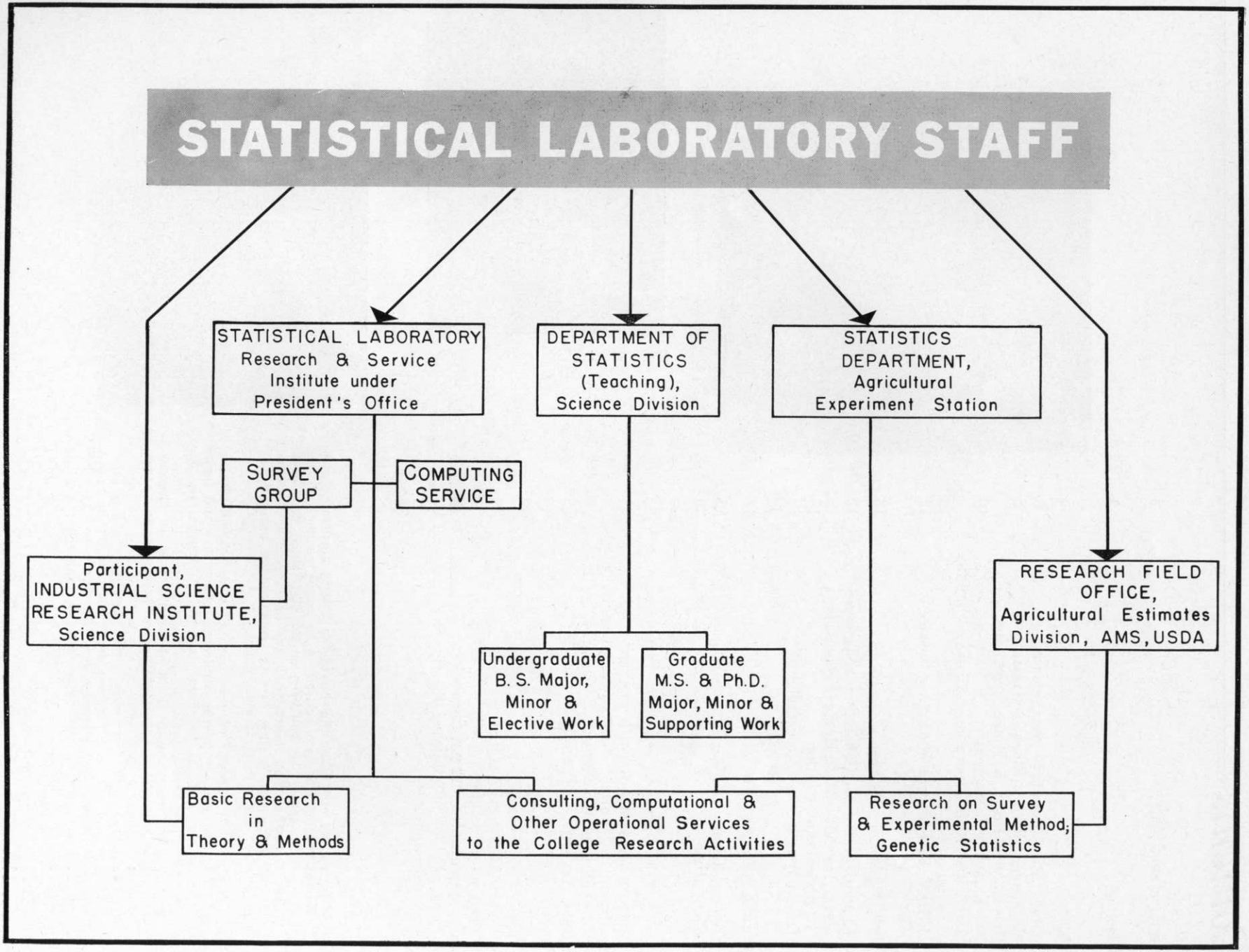
Contents





At the end of the fall quarter of the 1958-59 academic year, George Waddel Snedecor retired as an active member of the Iowa State faculty. He had been on the staff since 1913, first in mathematics, then in statistics, and had served as the Statistical Laboratory's first director and as the agricultural experiment station's first statistician.

Prof. and Mrs. Snedecor were honored at a farewell dinner given by the members of the Statistical Laboratory and their wives or husbands at the Solar Inn on November 12th. As the second photograph indicates, gifts for the California-bound couple were presented by T. A. Bancroft, present director of the Laboratory, on behalf of the group present and other friends and former associates now scattered over the world. The gifts included a monetary gift shaped into a good-luck horseshoe and a book of autographs from some of the many people who have studied under Prof. Snedecor, worked with him here and/or been otherwise closely associated with the development of the Statistical Laboratory.


STATISTICAL LABORATORY STAFF
STATISTICAL LABORATORY Research & Service Institute under President's Office
DEPARTMENT OF STATISTICS (Teaching), Science Division
STATISTICS DEPARTMENT, Agricultural Experiment Station
SURVEY GROUP
COMPUTING SERVICE
Participant, INDUSTRIAL SCIENCE RESEARCH INSTITUTE, Science Division
RESEARCH FIELD OFFICE, Agricultural Estimates Division, AMS, USDA
Undergraduate B. S. Major, Minor & Elective Work
Graduate M.S. & Ph.D. Major, Minor & Supporting Work
Basic Research in Theory & Methods
Consulting, Computational & Other Operational Services to the College Research Activities
Research on Survey & Experimental Method; Genetic Statistics

Personnel

Under the administrative direction of

James H. Hilton, D.Sc. ..... President
Richard S. Bear, Ph.D. ..... Dean, Division of Science[1]; Director, Industrial Science Research Institute (ISRI)
Floyd Andre, Ph.D. ..... Dean, Division of Agriculture; Director, Agricultural & Home Economics Experiment Station (AES)
Theodore A. Bancroft, Ph.D. ..... Director, Statistical Laboratory, and Head, Department of Statistics; Head, statistics department, AES

The five components of the Iowa State statistical center share personnel and facilities, including office space, and have a single director. In fiscal terms this means that each staff member's salary is usually provided from several sources—e.g., the Department of Statistics, the Statistical Laboratory budget (set up under the President's Office), and a statistics project of the Iowa Agricultural & Home Economics Experiment Station or a research contract arranged by the Laboratory and the Industrial Science Research Institute. The relative proportions from each source may then vary from one year to another as the specific detail of his activities varies, even though the general nature of his duties remains unchanged.

The main statistics office and about half of the other offices are in the Service Building. The rest are in buildings N, R and S and in the nearby Cyclone Computer Laboratory building which was completed early in 1959. The members of the statistical center, including its affiliated fellows and graduate students, in the 1958-59 period are listed below.

Staff for the 1958-59 year

Professor:

Theodore A. Bancroft
John Gurland
H. O. Hartley
Paul G. Homeyer (until September 10, 1958)
Oscar Kempthorne
George W. Snedecor (until November 21, 1958; subsequently professor emeritus)
Gerhard Tintner (joint appointment with the Depts. of Economics & Sociology and Mathematics)

Associate professor:

David V. Huntsberger
Emil H. Jebe
Norman V. Strand
C. R. Weaver, visiting associate professor winter quarter

Assistant professor:

Robert J. Buehler
Herbert T. David
Campbell C. Mosier (also manager of the college IBM Service Unit)
William H. Williams (until August 31, 1958)
Leroy Wolins (joint appointment with the Dept. of Psychology)

Associate (or instructor):

Marion R. Bryson
Mary A. Clem
Martin R. Dorff
J. Arthur Greenwood
Howard W. Jespersen
Scott A. Krane[2, 3, 4]
Basilio A. Rojas
Howard L. Taylor
Robert F. White
George Zyskind

Graduate assistant:

Sidney Addelman
Russell A. Altenberger
Harold D. Baker
Neeti R. Bohidar
Aaron H. Booker
Ta-chuan Chen
Herbert Eisenberg (Engineering Experiment Station—Statistics)
John E. Graham
Dale D. Grosvenor
David Hogben
Edwin J. Hughes
Shriniwas K. Katti
Ilbok Lee (Entomology—Statistics)
Roger S. McCullough
Michael H. Miller
José Nieto de Pascual
Mario Paz Misri
J. N. K. Rao
Dale O. Richards[2, 3, 5]
Robert H. Shumway
Donald V. Sisson
Betty K. Stewart
T. Neil Throckmorton

General Electric fellow in statistical methods:

Harold J. Larson

IBM fellow in statistics:

William T. Lewish[2]

National Institutes of Health biometrics trainee:

Roger R. Connelly
Carol B. Edwards
Thomas D. Roseberry

National Science Foundation faculty fellow:

Raymond C. Collier

Rockefeller Foundation fellow:

Burton T. Onate
Quirino Nimes Villaviza

Student assistant (undergrad.):

James Zweifel

Westinghouse scholar in statistics (undergrad.):

Richard W. Hunt
Dale P. Schumacher

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1 Name changes from Division of Science to College of Sciences and Humanities and from Iowa State College of Agriculture and Mechanic Arts to Iowa State University of Science and Technology became effective in July 1959. Since the present report deals with activities of the preceding year, the old names will be used in the sections which follow.
2 graduate assistant in statistics during summer 1958.
3 instructor and/or associate in Dept. of Industrial Engineering September 1, 1958-May 30, 1959.
4 associate in statistics (Industrial Science Research Institute) during summer 1959.
5 instructor in statistics and industrial engineering 1st summer session 1959.

Administrative assistant:

Margaret G. Kirwin

Research helper:

Pedro Altemir, research helper[6]
Helen Ayres, coding & interviewer supervisor
John Burnstrom, temporary field supervisor[6]
Bertha Eastman, chief clerk
Marjorie Mason, clerical supervisor
Jauvanta Walker, technical writer & research helper

Secretarial staff:

Maxine Bogue, stenographer[6]
Audrey Graham, stenographer
Wanda Hollenbeck, clerk-typist, Survey Unit[6]
Anne Leicht, secretary, Survey Unit
Lillian Tordoff, stenographer, Survey Unit
Sue Robinson, typist (part-time)[6]
Margaret Willey, bookkeeper

Statistical clerk:

Jessie Bryan
Mary Jane Kamphuis
Lucile White

Computing clerk:

Mabel Matthews

650 operator:

Rosemary Boles

Key punch or IBM operator:

Eunice Bamrick, key punch operator
Wayne Barkema, IBM operator
Ben Beriskin, IBM operator (part-time)[6]
Karen (Meyer) Bretey, key punch operator
Louise Elliott, key punch operator[6]
Gloria Hildal, key punch operator
Helen Olson, key punch operator[6]
Roger Wilson, IBM operator

Coding clerk:

Grace Boyd
Bill Franzen (part- to full-time)[6]
James Hilton (part- to full-time)[6]
Evelyn Howe
Ava Klopf[6]
Mary McTague[6]
Marie Ostermann[6]
Kenneth Simons[6]
Jeanne Wagaman[6]
Audrey Weiss
Bob Yates[6]

Graduate major student

Postdoctoral student:

Raymond C. Collier
C. R. Weaver

Ph.D. candidate:

Sidney Addelman
Russell A. Altenberger (jt. stat.-economics major)
Neeti R. Bohidar (jt. stat.-animal breeding major)
Aaron H. Booker
Marion R. Bryson
Martin R. Dorff
John E. Graham
David Hogben
Max M. Hoover, Jr. (jt. stat.-crop breeding major)
Edwin J. Hughes
Chester E. Jensen (jt. stat.-forestry major)
Shriniwas K. Katti
Scott A. Krane
Harold J. Larson
Ilbok Lee
William T. Lewish
Roger S. McCullough
José Nieto de Pascual
Burton T. Onate
Jonnagadda N. K. Rao
Dale O. Richards (jt. stat.-ind. engr. major)
Glen P. Roehrkasse (jt. stat.-agr. economics major)[7]
Howard L. Taylor (jt. stat.-economics major)
T. Neil Throckmorton
Izak Mauritz van Aarde
Robert F. White
George Zyskind

M.S. candidate:

Harold D. Baker
Rodney P. Basson
Ta-chuan Chen
Roger R. Connelly
Carol B. Edwards
Herbert B. Eisenberg
Dale D. Grosvenor
Jaime E. Isaacs (FAO and ICA fellow
Hugo E. Mayer, Jr.
Michael H. Miller
James R. Pendleton
Thomas D. Roseberry
Robert H. Shumway
Betty K. Stewart
Quirino Nimes Villaviza

Special student

Pedro R. Altemir (FAO fellow before becoming research helper)
Abdul Jabbar Alwan
Rasela Levi (ICA fellow)
Branko Stojcevski (ICA fellow)

George W. Snedecor retired from active membership on the staff of the Statistical Laboratory and the Department of Statistics effective November 30, 1958, and accepted a position in the U.S. Navy Electronics Laboratory, San Diego, California, as mathematician, i.e., consultant in experimental statistics. He was accorded the status of professor emeritus by action of the State Board of Regents in May 1959.

A half-time appointment as visiting associate professor was granted to C. R. Weaver, Ohio Agricultural Experiment Station statistician and Ohio State U. staff member, for the period December 1, 1958-February 28, 1959, of sabbatic leave from Wooster, Ohio. This appointment suplemented a program of postdoctoral study in statistics he was pursuing here.

Emil H. Jebe was on military leave for the period July 6-20, 1958 for temporary active duty at the Office of Ordnance Research in Durham, North Carolina; N. V. Strand was similarly stationed with the Quartermaster Section, Columbus General Depot, U.S. Army, in Ohio for two weeks starting on November 9.

[6] employed part of the fiscal year.
[7] beginning in June 1959.

Gerhard Tintner was on leave for the period March 1-June 30, 1959 to serve as visiting professor of economics at the Technical U. of Lisbon, Portugal, for three months under the auspices of the International Educational Exchange Service, U.S. State Dept.

John Gurland and Emil Jebe were each granted a short period of leave in order to teach at the Graduate Summer Session of Statistics in the Health Sciences held at the U. of Michigan from June 18 to July 31, 1959, under National Institutes of Health sponsorship. T. A. Bancroft and O. Kempthorne were granted similar periods of leave to join with members of the Dept. of Statistics, U. of Wyoming, in conducting an NSF-sponsored Summer Institute for College Teachers of Statistics held at the U. of Wyoming.

William H. Williams resigned as assistant professor to accept a similar position as of September 1, 1958, in the Mathematics Dept., McMaster U., in Hamilton, Ontario, Canada. Paul G. Homeyer's resignation as professor was effective on September 10 and signified his joining the staff of the General Analysis Corp., Los Angeles, California.

Basilio Rojas' appointment as associate terminated as of the end of September. On October 1 he became a statistician of the Institute for the Improvement of Sugar Cane Production, an organization supported by the Bank of Mexico and the Sugar Producers Association, with headquarters in Mexico City; he also began serving as consultant for the Bank of Mexico. Robert F. White had resigned as associate on August 31 to become an assistant professor in the Dept. of Statistics, U. of Wyoming.

The following associates' departures came after successful completion of Ph.D. programs: George Zyskind left the Laboratory as of August 31st to accept an associateship in the Dept. of Statistics, U. of North Carolina, for postdoctoral research. At the same time Marion Bryson resigned from a half-time Survey Group position in order to work full-time at Duke U. as statistician on OOR contractual research; he had been engaged on the OOR-Duke contract on a part-time basis during the preceding three months at Iowa State College. Howard L. Taylor resigned to join the Gulf Research & Development Co., Pittsburgh, Pennsylvania, beginning on October 1, 1958, as mathematical analyst, Computational Analysis Section.

Don Sisson relinquished an assistantship as of June 30, 1959 after electing to serve as AES statistician and assistant professor of applied statistics at Utah State U. for one year. David Hogben had resigned from an assistantship at the end of May to return to the position of quality control development engineer, Western Electric Co., Kearny, Illinois.

Research

The Statistical Laboratory completed its 26th year in 1959 as one of the several independent research institutes on the campus of Iowa State College. The research program of the Laboratory is closely related to the other activities of its staff members and consequently emphasizes both the development and extension of basic theory and its application in the development of new statistical methods and techniques. One notable development in the 1958-59 period was the number of studies of a fundamental nature which were initiated through the support of research grants and contracts with federal agencies. In most instances these make provision for supervised graduate research on topics proposed by the staff.

Statistical Laboratory Research Projects

Air Force project in theoretical statistics

Research continued on statistical problems of distortion, contagious distributions and functional relationships under an extension of contract No. AF49(638)-43 with the Office of Scientific Research, Air Research & Development Command, USAF. During the 1958-59 year John Gurland, principal investigator, was assisted by Shriniwas Katti and R. S. McCullough.

McCullough continued working on the problem of testing the equality of means in the presence of variance heterogeneity. Some results obtained were written up in Technical Report AFOSR TN 59-177 AD 211317 by McCullough and Gurland. This includes tables of unilateral and bilateral statistics which effectively control the size of the test of equality of means from normal populations. The unilateral statistic is used when it is known *a priori* that the variance of one specified population exceeds that of the other. The bilateral statistic is used when there is no *a priori* knowledge of the relative magnitudes of the population variances.

Also tables were computed for the power of the test using the unilateral statistic at the 5 per cent level. A further table giving the power of an analogous t-test with different but known ratios of the population variances was developed for the purpose of comparison with the power of the test using the unilateral statistic.

Katti gave his attention to various problems arising in the application of contagious distributions. One phase of this research involved an investigation of the relative shapes of a number of families of contagious distributions. Some of the results are included in Technical Report AFOSR TN 59-178 AD 211318 by Katti and Gurland. The skewness, kurtosis, and ratio of first two frequencies were compared for some families of generalized Poisson distributions and generalized Pascal or binomial distributions, subject to restrictions on low-order moments. It was found that for a number of distributions the ratio of first two frequencies had the same ordering as the measures of skewness and kurtosis based on the third- and fourth-order cumulants had.

Another phase of the research focussed on the problem of choosing among a number of simplified methods of estimating the parameters when one has no previous knowledge about the region in which the true parameters

lie. Since the different methods of estimation are more efficient in different regions of the parameter space, it is desirable to set up a rule whereby one may objectively choose one of the methods. A preliminary test criterion, leading to a locally optimal critical region with respect to a certain departure function, was developed. An alternative procedure for selecting methods of estimation is based on a measure of reliability of the statistics employed. The use of the squared coefficient of variation as such a measure of reliability was investigated. Among the recommendations based on this measure are ones concerning the use of the mean, the use of the highest mode, and the preference of counts over ratios of counts.

The problem of evaluating the moments of the absolute difference and the absolute deviation for the following discrete distributions was also considered by Katti: (i) binomial, (ii) negative binomial, (iii) Poisson, (iv) hypergeometric and (v) logarithmic. As explicit expressions for the moments were highly cumbersome, recurrence relations were found to obtain high-order moments, and the algebra was simplified with the help of the generalized hypergeometric functions. A paper on this topic will appear in the March 1960 issue of the Annals of Mathematical Statistics.

In mathematical statistics

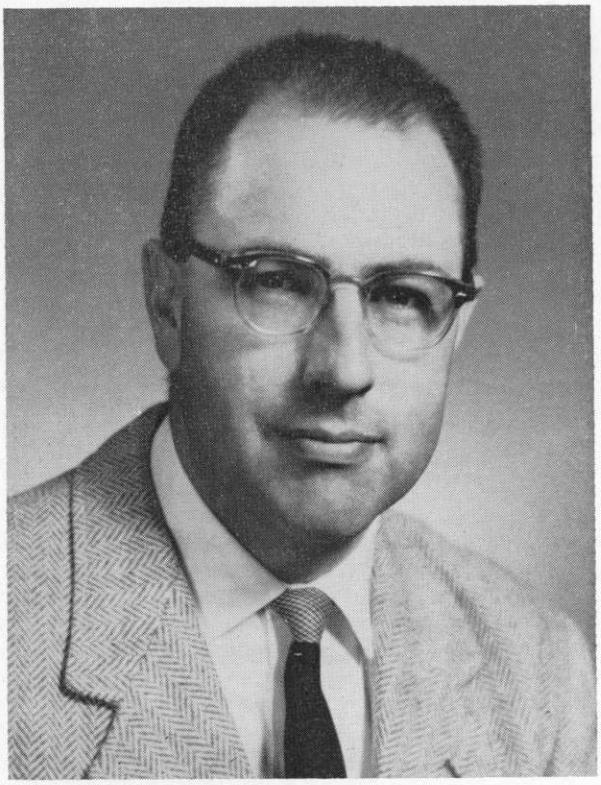
Under Statistical Laboratory Project No. 1, Martin Dorff continued his study of estimators of the parameters of a linear functional relationship between two variables which are both observed subject to error. Attention was given mostly to the situation where there is no replication. A class of estimator of the slope obtained by taking the ratio of two linear forms of the observations was examined for bias and mean square error, and the forms which are optimal with regard to those criteria were found. This work, under John Gurland's direction, parallels research described under the Air Force project in theoretical statistics.

Research in foundations of statistics

R. J. Buehler worked on the foundations of statistics along the following lines. One of the main objectives of statistics is to make inferences having a specified degree of uncertainty. Such inferences have the form: $P(A) = \alpha$; that is, the probability that A is true is equal to α. Here "A is true" is the inference, and α is the confidence level. A framework was described sufficiently general to include: confidence intervals, fiducial intervals, Bayes' estimating intervals, prediction intervals, tolerance intervals and other inferential situations as well. Several criteria of validity were suggested; "weak exactness," for example, generalizes Neyman's usual requirement for confidence intervals. Other criteria were investigated which pointed up essential differences between direct and inferential probabilities. In the theory of direct probabilities an essential feature of randomness in the sense of von Mises is that no rule can be given for selecting a subsequence of outcomes having long-run frequencies different from those of the total sequence. By contrast, for inferential probabilities such subsets can be described in terms of the known observations. Thus if C is a subset of the observation space, the conditional probability $P(A|C)$ may be such that $P(A|C) - \alpha$ has the same sign for all unknown states of nature. Such subsets have been called "relevant." This work, with examples given, will be published in the December 1959 issue of the Annals of Mathematical Statistics.

In survey methodology

J. N. K. Rao and H. O. Hartley have started on a new approach to the problem of sampling with unequal probability and without replacement. While most workers in this field have tried to tackle the problem sequentially by specifying the selection probabilities at *each* draw, the approach adopted here made use of a well-known simple method, frequently employed by survey practitioners, in which the sample units are all drawn as one



Robert J. Buehler, assistant professor of statistics, divides his time between research and the training of statisticians. He has written several research articles and technical reports on topics in mathematical statistics and on development of an equation of state for gases and liquids. Prof. Buehler teaches a graduate sequence in theory for the M.S. core program in statistics. He has also taught a more advanced course in distribution theory and more elementary courses in general statistical theory and methods. Since 1958 he has been part of the research team working on theoretical problems for the Army Ballistic Missile Agency, Office of Ordnance Research, Huntsville, Alabama.

Dr. Buehler received his academic training at the U. of Wisconsin, with an undergraduate major in chemistry and advanced degree programs in mathematics. For over three years he worked for the Sandia Corp., Albuquerque, New Mexico, on mathematical problems in atomic weapons design. Then from 1955 until his coming to Iowa State in 1957, he was employed at the U. of Wisconsin as a Naval Research Laboratory project associate, under the Chemistry Dept., and an instructor in mathematics. He is president of the Central Iowa chapter of the American Statistical Association for its second year.

group. The reason why the theory of this simple method had not been developed in the past has undoubtedly been the difficulty of obtaining formulas for the probabilities that two specified units are both in the sample. These probabilities have now been evaluated exactly for special cases of small samples and populations and asymptotically for large samples and populations. The result is a sampling scheme in which the estimator of the population mean has a precision which is higher than the estimator resulting from sampling with unequal probabilities and with replacement. The reduction in variance is in the nature of a "finite population correction" of a special kind.

Following up from a problem which was sketched in Howard L. Taylor's Ph.D. thesis (summarized on p. 33), Jack Graham, N. V. Strand and H. O. Hartley examined the possibility of obtaining improved estimators of the proportionate area of a particular soil type in a specified land usage category. The immediate task relates to the Statistical Laboratory's work for the Soil Conservation Service in connection with a National Inventory of Soil and Water Conservation Needs (a project mentioned further on p. 12). The task is to obtain, for each county in the survey, estimates of the area of some 20 to 30 different soil types within each of four different land usage classes: namely, Crop land, Pasture, Woodland and Other. If such estimates are made from the sample survey units which fall into the particular county, the estimates for certain of those 80 to 120 categories will be of very low precision. It was therefore suggested that only the four areas of Crop land, Pasture, Woodland and Other would be estimated from the survey units in the county, while the "split up" of, say, the Cropland into the 20-30 soil types would be accomplished by employing also the survey units in "neighboring" and comparable counties. This procedure may result in considerable reduction in the variance of the estimates but is, of course, subject to the possibility of bias which may be serious if the area proportions of the soil types for, say, Crop land, do in fact vary from county to county. Work is in progress to use the data from the National Inventory as far as is suitable to examine the feasibility and effectiveness of the new method.

Work by José Nieto de Pascual on regression estimators is discussed on p. 12 under Project 1207. Investigations on correlations involving sample means, quasi-ranges and quasi-midranges were undertaken by J. N. K. Rao jointly with Dr. Bernard Ostle of Sandia Corporation.

In computational methodology

The details of programs developed by members of the Statistical Laboratory for the IBM 650 during the year, to implement its use as an all-college computing facility, will be found in the next progress report (No. 2) of the Scientific Computing Group. However, a few special areas of endeavor will be mentioned here. The programs discussed below were all written in the fixed-decimal or basic system.

Howard Jespersen and H. O. Hartley have now developed a standard program for analysis of variance covering practically "equal number" designs. For each particular design it is only necessary to punch a few code cards specifying such design and analysis details as the number of factors (or pseudo factors) involved, the number of levels for each factor, pooling instructions for the sums of squares of the factorial analysis to obtain various analysis of variance summaries appropriate to the design. The 650 program is essentially based on the analysis of variance calculus developed by Hartley in a paper published in Biometrics (12:2, June 1956, "A plan for programming analysis of variance for general purpose computers") and makes provision for the computation of individual error residuals (or indeed residuals of any other component if desired). Initial variate transformations are being incorporated, and the facility of tabulating error residuals obtained from various variate transformations should be of interest in investigations concerned with finding appropriate metameters. The program will be extended to analysis of covariance.

Dale Grosvenor rewrote the ISC (Grosvenor-Hartley) program for linear programming on the IBM 650. Some of the additional features and improvements of the program are as follows:

(1) It will operate in any of four modes. Mode 1 uses a variant from the conventional criteria of linear programming. Instead of selecting the incoming column by scanning the entire matrix for the column with the most negative element in the objective row, this mode brings into the basis every column for which the element in the objective row is negative. The method is much faster than using the conventional criteria because it reduces the amount of card reading required. Mode 2 is linear programming using the conventional simplex criteria. Mode 3 is variable resource programming. It enables one to find optimal solutions for all nonnegative levels of a given resource. Mode 4 is variable price programming. It enables one to find optimal solutions for all prices of interest of a given activity or resource.

(2) Provision is made to make more efficient use of the general storage area of the IBM 650. The specific usage of the general storage area is determined by an extensive initialization. This initialization considers the mode of operation and the dimensions of the input matrix in order to make the most efficient arrangement of the general storage area.

(3) Provision is made to use the program to solve simultaneous equations with as many as 99 variables. Provision of the inverse of the coefficient matrix is optional.

A work program was written by Jespersen which takes a regression output matrix, allows for arbitrary deletions of variables and augmentations, and then produces an output ready for use as the input of a standard matrix inversion program.

Two programs had been developed in 1957 and 1958 by H. O. Hartley and William T. Lewish for statistical graduation of rainfall data from Project 26 of the North Central Region Technical Committee on Weather Information for Agriculture. The first of these programs, "Fitting the gamma distribution to rainfall data," was incorporated in IBM's Program Library. The second program, in the nature of a sequel to the other, was described briefly in the 1957-58 Annual Report. Both programs have now been rewritten in more general form and incorporate certain improvements which make them more nearly optimum. A limited number of multilithed copies are available as 650 Program No. 6.008 ISC, "Fitting of data to the two-parameter gamma distribution with special reference to rainfall data," and 650 Pro-

gram No. 6.007 ISC, "Determining probabilities from a fitted gamma distribution." These programs are to be released in the IBM Program Library under File Nos. 6.0.029 and 6.0.040, respectively.

A program was written by Lewish and Hartley for the inversion of a 98 × 98 matrix of a Leontief type and was first used in connection with productivity studies in economics. This program utilizes the large diagonal coefficients in matrices such as the above and consists of an adaptation of the relation

$$(I-A)^{-1} = I + A + A^2 + \ldots$$

but does not require the storing of the full matrix inside the machine. In fact, sections of the inverse are produced in separate runs producing 10 lines of up to 100 elements each in each run with the original matrix (I - A) to be inverted filing through the machine. The speed depends on the number of iterations required, i.e., on the magnitude of the elements in A.

Other

The Statistical Laboratory cooperates with other research institutes and experiment stations on the campus in arranging certain programs of statistical research and obtaining financial support through grants or contractual awards. Progress made in the 1958-1959 period under joint sponsorship of the Laboratory and the Industrial Science Research Institute or the Iowa Agricultural & Home Economics Experiment Station is described further in the sections which follow.

Gerhard Tintner continued research on econometric models, operations research, stochastic linear programming and tests of significance in the variate difference method. An investigation is underway on Carnap's theory of probability and its application to operations research, including application to inventory problems; a paper on this work has been accepted for publication in the Spanish journal, Trabajos de Estadistica. A study of general aspects of the United States' economic development since 1870 from the standpoint of gross national product was completed during the year.

Industrial Science Research Institute

Programs of research described in this section were arranged as joint projects of the Industrial Science Research Institute of the Division of Science[1] and the Statistical Laboratory. The Air Force project reported on in the preceding section also came under ISRI auspices.

ABMA project in statistical methodology

A contractual agreement was entered into by the Army Ballistic Missile Agency (OOR), Huntsville, Alabama, and Iowa State College's Industrial Science Research Institute and Statistical Laboratory effective May 1, 1958. This provided initially for two research studies in statistics with support for 14 months. Under a supplementary agreement the project will be continued through June 1960. Research staff have been H. O. Hartley as leader-in-charge, Herbert T. David, Robert J. Buehler, J. Arthur Greenwood, Scott A. Krane and (assigned to the research team for two months for help in computations) Mario Paz.

The Phase I study concerned generalization of Edgeworth's and Charlier's series and the Pearsonian curves for several dimensions; Phase II, correlation and regression for nonlinear cases. In the course of the work up to July 1, 1959, 14 technical reports and parts of two others were prepared. Copies of these reports are not obtainable from the Statistical Laboratory, but the subject-matter of most of them will be published in journal articles. Report No. 1.13, "Distribution theory of some angular variates," in its long form represents the Ph.D. thesis of J. Arthur Greenwood submitted for the degree in statistics at Harvard U. and summarized in more detail in the September 1959 Statlab Review (Vol. 13, No. 1).

Although the research program for Phase I was formulated as a general statistical study of multivariate distributions, it was recognized that the sponsors of the study were particularly interested in the application of the results to wind distributions. Nevertheless part of the work dealt with the *general* theme of the program. Thus R. J. Buehler's investigations included an examination of an attempted generalization of the Pearsonian system of frequency curves to bivariate graduation, due to Van Uven, which was found to be too restricted in scope. New and improved estimation procedures for the parameters of two particular Pearsonian frequency curves were then developed—by H. O. Hartley and H. T. David for maximum likelihood estimation of parameters of the incomplete beta distribution (a special case of the Type I) and by J. A. Greenwood for similar treatment of the gamma distribution (a special case of Type III).

All other work was oriented toward an application to the graduation of "wind distributions." These distributions arise in two main forms: (a) the joint distribution of wind speed components, i.e., "eastings" x and "northings" y; (b) the polar form of (a) resulting in bivariate distributions of "wind speed" $r=\sqrt{x^2+y^2}$ and "wind direction" $\phi=\tan^{-1} y/x$. The latter form of wind rose distribution involves a variate (ϕ) which is periodic. The graduation of such "circular" distributions requires a special methodology, concerning which only limited results have been available. A comprehensive study and development of the theory of circular distributions was therefore undertaken. The results obtained by Greenwood offer numerous powerful possibilities for graduating circular distributions such as the wind direction case.

Statistical literature dealing with the bivariate form (a) of wind speed components is almost exclusively confined to the use of a bivariate normal distribution of x and y involving five parameters, i.e., two means, two standard deviations and a correlation coefficient. Indeed, the earlier literature was satisfied with employing the special case of "circularly symmetrical" normal distributions in which the two standard deviations are equal and the correlation is assumed to be zero. Failures of the bivariate normal distribution to represent wind distributions (a) adequately have often been traced to heterogeneities of the observed distributions in the sense that the latter have been found to be composed of two or more regimes. Hartley therefore offered a two-component mixture of two circularly symmetric normal distributions and a theory of fitting such a distribution by

[1] renamed College of Sciences & Humanities as of July 1, 1959.

either the method of moments or the (somewhat more laborious) method of maximum likelihood. The former was facilitated by a graphical device particularly developed for the purpose.

Buehler followed up the idea of reducing nonnormal distributions to normal ones by variate transformation (i.e., change of scale). For a large class of distributions of x, a function h(x) will have a normal (or other standard) distribution, where h may be any function of x which is linear in parameters to be estimated. Regression analysis leads to asymptotically efficient estimation when one takes into account the estimated covariance structure of the observed class frequencies. The method can be applied to the graduation of bivariate data by transforming the two margins to normality and fitting a bivariate normal distribution to the transformed values.

Finally work by Hartley and Scott Krane dealt with a specific point of bias elimination from wind data obtained by balloon soundings, while David made a particular application of wind distributions to a problem of wind displacements in trajectories.

A lengthy expository report on Phase II is being prepared by Krane on special request from the project sponsors. It can be regarded as an up-to-date textbook on multivariate regression theory with particular emphasis on nonlinear regression laws which are linear in the parameters. The text is illustrated with worked examples mainly derived from problems in meteorological statistics. Some features of the text cover problems not normally dealt with in the statistical literature.

Other work for Phase II has been concerned with the frontier area of regression laws which are nonlinear in the parameters. A search of relevant mathematical and statistical literature was made by Greenwood for contributions to the solving of systems of nonlinear equations. None of the existing methods appeared to be entirely satisfactory for the specific problem of solving nonlinear regression equations arising from the least squares principle. The two methods used most frequently in the past were (a) the method of steepest descent applied to the least squares quadratic form and (b) the Gauss-Newton method which employs a linear approximation to the regression law in the neighborhood of a trial value, solves the linearized problem and seeks the solution of the nonlinear equations by iteration. While the convergence of (a) is usually assured, it has often been found painfully slow in practice. On the other hand, a rapid approach to the near-solution region is made by (b), but it is often found not to converge. A new method was then developed by Hartley which is a modification of (b) in which convergence is assured.

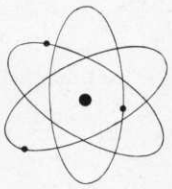
OOR project on fundamental statistical functions

Research was begun in September 1958 on development of a guide for approximations to the incomplete beta function. The project, under H. O. Hartley's direction, is supported by the Office of Ordnance Research at Durham, North Carolina.

Numerous approximations to the incomplete beta function $I_x(a, b)$ have been worked out in the past. While some may give approximations of fairly good accuracy for certain restricted ranges of the three parameters a, b and x, they usually break down in other regions. For the present project it was felt that a determined effort should be made to obtain a single approximation for the entire parameter space, and that approximations suitable for both ad hoc computation to low accuracy and ad hoc computation in an electronic computer would be examined. In particular, three approaches have been studied: approximations to the binomial sum (and hence to $I_x(a, b)$) based on the normal integral, given by M. F. Freeman and John W. Tukey (Annals Math. Stat., Vol. 21, 1950), M. E. Wise's approximation to the "percentage points" of the beta function based on the chi-square integral (Biometrika, Vol. 37, 1950), and a method given by A. W. Kimbal and E. Leach (unpublished manuscript, 1958).

A modification of Wise's procedure was found to be promising. After considerable numerical trials a variate transformation of the incomplete beta variable x to a chi-square variable was developed. This approximation permits evaluating the incomplete beta function, to a precision of about five decimals, by reduction—with the help of a variate transformation which involves two auxiliary quantities A and B—to the chi-square probability integral. Tables of functions A and B are being prepared on an IBM 650 computer as aids to rapid evaluation of the chi-square argument. The present approximation has the desirable property that it is completely exact on the boundary of the triangular region in the a, b plane $1 \leqq b \leqq \infty$; $b \leqq a \leqq \infty$, i.e., for the lines (i) $b = 1$ and any a and x, (ii) $a \to \infty$ and any b and x, and (iii) $a = b$ and any x. The next step will be to compute tables of the chi-square integral which would yield five-decimal interpolation from linear interpolation.

Research supported by NSF grants



A project for estimation of statistical parameters from incomplete data was established in July 1958 with the support of a two-year research grant (NSF-G5415) from the National Science Foundation. Persons working on the project in its first year were H. O. Hartley, as leader in charge, and Edwin J. Hughes. Their work has consisted of two parts.

(1) Estimation procedures for incomplete data from continuous distributions. Previously estimation procedures for incomplete data applicable to discrete distributions were developed (see Hartley, Biometrics, 14:2, 174-194, June 1958). These methods are all directly applicable to continuous frequency distributions by means of the simple device of splitting the range of the continuous variate, x, into group intervals of sufficiently small widths that the effect of grouping is negligible. However, it was soon realized that such a process would be computationally cumbersome, since it would involve a large number of group frequencies. Special procedures have therefore been developed in which the ranges of x corresponding to "censorship" and/or truncation are covered by three to seven equally spaced "representatives" x_i, $i = 1, 2, \ldots, n$, of the range in question with x_1 and x_n chosen as the end points of each range. Any integral over the range in question occurring in the maximum likelihood equations is then replaced by a numerical integration formula involving the evaluation of the respective integrands at the representative values x_i. The numerical integration formulas used were Weddle's

formula and Simpson's rule, in both of which the integral is represented as a weighted sum of the integrands evaluated at the x_i.

The procedures were tried on the following examples of maximum likelihood estimation of parameters of a continuous distribution from incomplete data:

A. The normal distribution
   (i) censored or truncated at one end of the range
   (ii) with two separate intervals of censorship in the middle of the range;
B. The gamma distribution
   (i) censored or truncated at the upper end of the range
   (ii) with one censored interval in the middle of the range.

(2) Establishment of sufficient conditions for the convergence of the iterative procedure. A theorem was provided which supplies the theoretical justification of an estimation procedure previously illustrated with many numerical examples. Further, it was shown that the normal distribution frequency function and the gamma distribution frequency function satisfy the assumptions of the convergence theorem.

A new project in the area of experimental design, under the direction of O. Kempthorne, was initiated with the support of a three-year grant (NSF-G5249) as an offshoot of work of recent years on randomization. The general notion is that there are three basic structural relationships of classificatory factors in balanced data, namely, crossing, nesting and random confounding. The aim of the present research is to study the possible types of structures which can result from combinations of these basic relationships and to develop simple rules by which analyses of variance and expectations of mean squares can be written down. Some progress has been made in the 1958-59 year by T. N. Throckmorton on preliminary stages of the work.

A third NSF grant (NSF-G5248), providing support for three years, enabled establishment of a project for research on distribution and estimation theory, under John Gurland's direction. In fitting contagious distributions, one of the main difficulties is the computation of probabilities, due to the lengthy recurrence formulae involved. If an error is made in obtaining the early probabilities it will affect all succeeding probabilities. Research was begun by Robert Shumway in September 1958 on how to simplify the computation. It was shown that considerable simplification can be achieved through use of appropriately chosen moments of the distributions involved. Further research was formulated and planned to apply the above ideas to a number of contagious distributions.

WADC project in experimental design

A research project for investigation of highly fractionated factorial designs was established on July 1, 1958 with the support of an initial one-year contract with the U.S. Air Forces, the Wright Air Development Center being designated as monitor. Project personnel working under O. Kempthorne's direction have been Sidney Addelman and, for the first two months only, George Zyskind.

Zyskind completed some investigations on the relevance of structural formulations in experimental designs and prepared a written report on his work for the WADC. The prominent role of Σ's (cap sigmas) in simplifying forms of expectations of squares of interest was exhibited. The formulation developed was then applied to the consideration of experiments in which intended treatment amounts may not be reproducible or otherwise put subject to error. A number of representative alternative schemes were considered, and simple Σ expansions of the expected values of mean squares were obtained.

Consideration of the examples investigated allows one to abstract the following general conclusions. If treatment errors are operative, then repeated independent attempts at realizing the preassigned amounts of treatments are to be desired, since without them partial or total confounding of treatment amounts and treatment errors will result. The presence of treatment errors tends to decrease the sensitivity of tests of significance for treatment effects. As is also the case with interactions involving experimental units, the presence of interactions involving treatment errors tends not only to further decrease the sensitivity of tests but also to introduce negative bias both into tests of significance for treatments and into the estimation of the treatment component of variation; but the presence of these interactions tends to overestimate the average variance of estimates of treatment differences. Since the magnitudes of nonadditivities are scale-dependent, the results of the present report lend further support to the importance of searching for a scale which as nearly as possible achieves additivity.

Two distinct types of fractionated designs were considered by Addelman. The first type, which was orthogonal, permitted the estimation of all main effects assuming all interactions to be absent. Such designs are known as main-effect designs. The second type consists of irregular fractions of factorial experiments which permit nonorthogonal estimation of all main effects and two-factor interactions.

In the preliminary stages this research was confined primarily to a review of the literature dealing with confounding and fractional replication in factorial experiments. Topics which are related are weighing designs, multifactorial designs and a system of confounding for factorial experiments developed by R. A. Fisher. Methods of constructing main-effect plans for asymmetrical (mixed) factorial experiments were considered by Addelman, and a start was made on developing a catalog of such plans. Some progress was also made on the development of a general theory dealing with irregular fractions of factorial experiments.

Iowa Agricultural & Home Economics Experiment Station

Design of experiments and analysis of data

Project 890 research, under the direction of O. Kempthorne, has been directed to a variety of topics in the past year. In some cases it has led to publications, while in other cases sufficient work for completion of manuscripts has not been possible. The following topics were dealt with:

(1) Practical implications of the randomization theory results on the conduct of experiments.

(2) The comparative merits of causal inferences from designed experiments and from observations obtained with a sample survey.

(3) The design of experiments on weather modification.

(4) The efficiency of blocking in incomplete block designs. A manuscript by L. J. Folks and O. Kempthorne has been accepted by Biometrika.

(5) The analysis of quadruple lattice designs. A paper by L. J. Folks was published in Biometrics and is summarized on p. 23.

(6) The development of restricted selection indices. A paper by O. Kempthorne and A. W. Nordskog of the Poultry Husbandry Dept. was published in Biometrics; a summary is given on p. 27.

(7) The separation of environmental and genetic trends with incompletely repeated records. A paper on which Kempthorne collaborated with M. Von Krosigk of Iowa State and with C. R. Henderson and S. R. Searle of Cornell U. has been published in Biometrics and is summarized on page 27. Some further work on biases in estimation of repeatability by interclass methods is being done.

(8) The present status of the theory of quantitative inheritance. A paper on the relevance of the theoretical results on correlations between relatives in mathematically formulated genetic populations will be published in the proceedings of the International Symposium on Biometrical Genetics held at Ottawa in August. Kempthorne is editing the forthcoming volume of symposium papers. Neeti Bohidar has been preparing the indices for the book and assisting on other editorial details.

Methodology for analysis of groups of experiments

A three-year program of research supported contractually, through Project 1341, by the USDA Agricultural Engineering Research Division was concluded as of September 1, 1958 by the completion of a final report, "The analysis of tillage experiments," by Basilio A. Rojas, principal investigator. The project has been aimed at both the development of statistical methodology and the analysis of a series of experiments performed over the years 1944 to 1950 to compare various tillage treatments, primarily plowing, hard listing and subsurface tillage, with other treatments represented sporadically through the years. The substantive results of the analysis of this particular series of experiments are to be published by staff members of the Iowa Agricultural & Home Economics Experiment Station. The 123-page, multilithed final report describes at a working level the statistical procedures that were used for the general study. Illustrations of procedures use actual data of the tillage series of experiments. The report bears a close relationship to and complements the doctoral thesis of Rojas (summarized in the 1957-58 Annual Report of the Statistical Laboratory) on the general problems of analysis of a series of similar experiments. O. Kempthorne, W. G. Lovely of the AERD, and Agronomy Dept. members Frank Schaller and W. E. Larson have served as project advisors, while general supervision was provided by E. L. LeClerg, director of the Biometrical Services Unit, Agricultural Research Service, USDA, at Beltsville, Maryland.

The general problems in the analysis of a series of experiments are: (a) to classify the experiments into useful groups which can be treated as samples from distinct populations, (b) to take account of unequal representation of the treatments in the classification of experiments by years and in the present case broad soil types, and (c) to take account of unequal precision of individual experiments. The aims of the analysis will generally be to obtain good estimates of treatment differences, tests of significance of estimates of treatment differences and of interactions with various classifications of the experiments, such as by years.

In this report tests of significance and estimation procedures are discussed and numerically illustrated for the following cases:

(1) Experiments on one agricultural area with the same treatments, homogeneity of error variances and equal number of replicates in each individual trial.

(2) Experiments on one agricultural area with the same treatments, homogeneity of error variances and unequal number of replicates.

(3) Experiments on one agricultural area with the same treatments and heterogeneity of error variances.

(4) Experiments on one agricultural area with unequal representation of treatments.

(5) Experiments on several agricultural areas.

(6) Optimum allocation of experiments in space and time.

(7) Analysis of bi-annual experiments.

Research in statistical genetics

Project 1285 provides for consultation (see pp. 15 and 16) and research in statistical genetics by O. Kempthorne and Neeti Bohidar. A study of the role of sex-linked genes in quantitative inheritance was continued by Bohidar. With the assumption of gene effects being dependent on sex, the genotypic variances of male and female were partitioned into their respective constituents, and a general structure of the covariances of (i) male and male, (ii) female and male and (iii) female and female was constructed for both single-locus and multiple-loci cases with an arbitrary number of alleles and independent segregation.

The theory of the diallel cross was considered under the supposition of both sex-linked and autosomal transmission. An experiment was constructed to evaluate the variances due to sex linkage and the consequent bias. Random sires and dams were crossed in a diallel fashion, and the components of variance—e.g., Sire (S), Dam (D), Sire $\times$ Dam (SD) and Residual (R)—were expressed in terms of their contribution to the genetic variances. With the assumption of females' being heterogametic, $2(S-D)/T$ and $4(D-S)/T$ (where $T=S+D+SD+R$) estimated the proportion of variance due to sex linkage in the analyses of female progenies and male progenies, respectively. If the characteristics were expressed in both sexes, a particular linear function of the variance components of both analyses, I/T, could be shown to be highly sensitive to additive and dominance and epistatic male sex-linked variances. Estimation of heritabilities based on $4S/T$ or $4D/T$ has an upward bias due to sex linkage.

Other research has been mentioned under Project 890 (see p. 11).

Design of surveys and analysis of the data

A contractual project in statistics was established early in 1959 in the experiment station by an arrangement with the U.S. Bureau of the Census for participation in the planning of the 1959 Census of Agriculture Evaluation Program. The project workers have been N. V. Strand and Harold Baker of the Survey Group. Strand spent six weeks in Washington, D.C., working on the design for the Evaluation Program and preparation of manuals for the field forms, or other aspects of the planning phase. For this purpose trips were made to the Census Bureau in late January, mid-March, mid-April and the first of June.

Research in sample census methods in agriculture

The Laboratory's Corn Production Study was continued from 1957-58 by agreement with the Agricultural Estimates Division, Agricultural Marketing Service, USDA. This work is performed under Project 1207, a joint project of the Statistical Laboratory and the Agricultural & Home Economics Experiment Station which is supported mainly by funds from the AMS division. Principal personnel were N. V. Strand, José Nieto de Pascual and (fall quarter only) Pedro Altemir.

Data on growth characteristics of individual ears of the 1958 corn crop were collected through repeated objective field sampling from late July until harvest time in the same three crop reporting districts used in the preceding studies. The growth study results were then compared with those obtained in the 1955-57 crop years, with regard to their use in obtaining both forecasts and objective estimates of corn production for grain. Some refinements in the analysis of kernel counts had been obtained through use of double sampling and a ratio-of-means estimator. The kernel count estimate was further refined with the introduction of a new regression-type estimator developed by Nieto.

As a service to AMS, project workers again made use of objective estimation procedures to process ears of corn from a regional research study. The resulting measurements were forwarded to Walter A. Hendricks, Chief of the Research & Development staff of the Agricultural Estimates Division.

Special survey projects involving applied research

A three-year project (AAC 1409) was established in the Agricultural Adjustment Center as of July 1, 1958 as a continuation and expansion in scope of studies on consumer preferences for pork formerly carried on under AES project 1263. The new project deals with all kinds of meat products, eggs, cheese and fish and with estimating effects of changes in product development, merchandising and promotion on the demand for livestock; it is a collaborative effort by staff from the Depts. of Dairy & Food Industries, Animal Husbandry, Statistics and Economics & Sociology.

In the first year, for a pilot study, a sample of households in Marshalltown, Iowa, was designed and selected, then interviewed to obtain information on household composition, income level, kinds and amounts of meat eaten in a given week, and related information. For sampling purposes, Marshalltown was cruised to get eye-estimate counts of occupied dwelling units by blocks. The sample is to be used further as the basis for selection of a food panel for the second year of the project.

The tabulation phase of the Statistical Laboratory's work for the Soil Conservation Service, USDA, was continued during the 1958-59 year under the direction of N. V. Strand. Data collected on nearly 900 counties by SCS staff were processed for the National Inventory of Soil and Water Conservation Needs. This phase included coding and punching data on soil measurement units as designated by the field personnel, such units having been classified by state, county, land resource area, soil conservation district and ownership. Estimates were made of total acreages in specified land uses by land capability units.

The Laboratory's previous area sampling work for the national inventory led to drawing supplementary samples in a number of counties for watersheds, irrigated areas, land resource areas and other areas where more accurate estimates were desired than could be obtained from the standard sampling scheme used on a nation-wide basis. (A 1/48 rate had been used for the national inventory.)

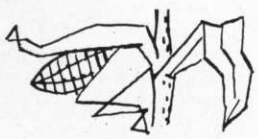
Research work on various estimation problems arising in soil mapping surveys resulted in Howard Taylor's Ph.D. thesis (summarized on p. 33), which was later modified and prepared in mimeographed form as a report for the Soil Conservation Service. The use of land resource areas as post-strata, the pooling of sample information from similar post-strata, and the utilization of existing information for increasing accuracy of estimates were considered at length.

Participation in Operations Analysis Standby Unit

Emil H. Jebe served as the statistics member of the U.S. Air Forces—Iowa State College Operations Analysis (standby) Unit during the year. In that connection he visited the Operations Analysis, USAF, headquarters in Washington, D.C., and defense installations in Maryland.

USDA Agricultural Marketing Service

A field office of the Agricultural Estimates Division of the Agricultural Marketing Service, United States Dept. of Agriculture, is located within the Statistical Laboratory and staffed on a part-time basis by N. V. Strand and M. Kirwin. Its work during the year was mainly connected with the Corn Production Study already described on p. 12.



Through consulting activities, the staff come into contact with much of the research work being carried on in agriculture, science, engineering and home economics at Iowa State College.

General Statistical Laboratory Consulting

The Statistical Laboratory Budget, provided by the President's Office, supports consultation in mathematical statistics and computational methodology, as well as general statistical consultation in areas where no other specific funds have been provided for advisory work. Recent problems are exemplified in the material which follows.

Consulting by D. V. Huntsberger on statistical problems in chemical engineering dealt with (a) design and analysis of an experiment to study the effect of supersonics on heat transfer in liquids and (b) sampling problems for getting data in an experiment concerning pulse column extractors. The latter involved obtaining samples of bubbles through photographic techniques.

In an agricultural engineering investigation, Herbert T. David consulted with the research staff on a study of the distribution of passage times for particles flowing through a filtration tank. In another study he proposed analyses for a long-term split-split plot experiment for measuring the effect of drainage and other factors on crop yield over a period of several years. Of special interest here was the fact that partial replication permitted estimation of several error components by both replication mean squares and high-order interaction mean squares, thus providing a check of the model underlying the analysis.

For a master's thesis project in foods and nutrition, David advised on the use of experimental data for various diets to study the correlation matrix for seven measures of metabolic activity of rats. Consultations on design and analysis of an experiment for a preliminary study of the effects of various factors on flakiness of pastry led to Huntsberger's setting up a randomized block design incorporating sampling.

For projects in industrial engineering, David consulted on applying regression techniques to a time study problem in the egg packaging industry and to a study of accident-proneness as a function of age of worker and length of employment, while Scott Krane and H. O. Hartley advised on procedures for analysis of data on retirement of industrial properties. Engineering and climatology members of the USAF-ISC Operations Analysis Unit, because of a particular interest in the variability of wind at different altitudes, conferred with Hartley on the results of statistical analyses of wind distributions made by the Statistical Laboratory.

Hartley advised on such thesis problems in economics as (a) solution of nonlinear equations arising in a problem of estimating optimum fertilizer levels required to maximize profit from an estimated yield response law, (b) both linear and nonlinear programming problems in conjunction with finding optimum production patterns for farms and (c) analysis of variance and regression analysis for a study covering a series of years and the incomes of cooperative elevator operators belonging to the Farmers' Grain Dealers Association of Iowa.

For thesis problems in veterinary science, Hartley aided in analyses of variance of (a) survey data on serological determinations of leptospirosis in cattle and (b) experimental data confirming the survey findings. The survey involved a number of federal laboratories using assorted techniques and test procedures and was to examine the degree of reproducibility with a view toward the making of recommendations for standardizations. For research in genetics he advised on the use of the Gompertz curve to represent the response-time relationship in radiation studies. Other conferences were held with a bacteriology staff member on construction of a universal code covering all species of bacteria for the purpose of research coordination and automatization.

D. V. Huntsberger worked with two foresters on analysis and interpretation of data concerning differences between certain characteristics of stem- and crown-formed wood from a lumbering standpoint. He advised another forester on analysis of experimental results concerned with the effects of several factors on the rooting of hybrid aspens. The incomplete factorial experiment had been designed by Paul Homeyer. H. T. David consulted on problems of experimental design and regression analysis arising in the work of the Ames Branch of the Central States Forest Experiment Station. Then he continued Homeyer's work on the analysis phase of a tree sampling study which involved extensive sampling data; assistance was provided on (a) investigation of spatial correlation of certain wood cell properties within given tree growth rings and (b) investigation of the effects of 15 factors on the formation of anomalous wood cells. Results were to be used in a Ph.D. thesis in forestry.

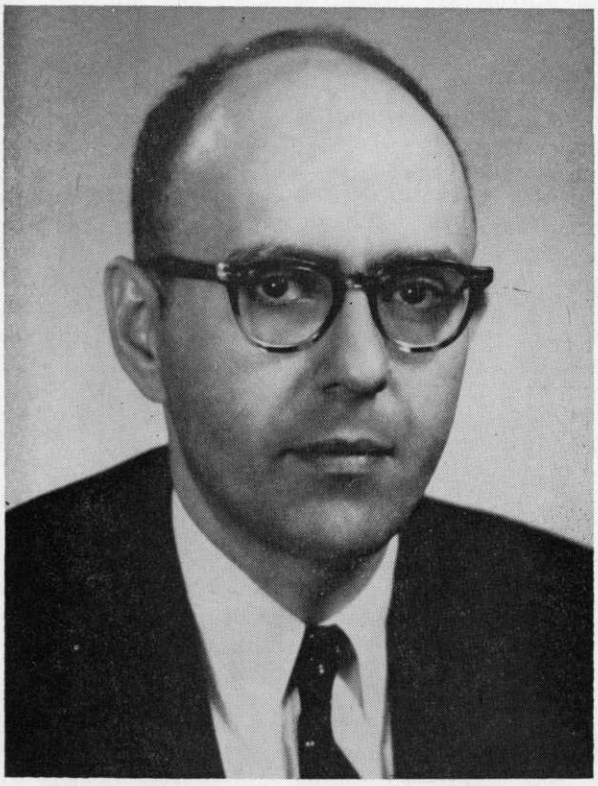
John Gurland advised on fitting various discrete distributions to frequency counts of damaged cells for several species of lilies which had been irradiated at different intensities. For a research program in swine nutrition, involving calcium and phosphorus studies with baby pigs, he advised on regression and other estimation problems arising in estimation of bone density from optical density values. X-ray pictures had been used to estimate optical density values for bone and soft tissue combined and for soft tissue alone, an aluminum step-wedge of known degrees of thickness and density serving as a standard for comparison in each case.

N. V. Strand and E. H. Jebe met with representatives of the Engineering Extension Service, State Dept. of Education and other state-supported schools to advise on proposed plans for a survey of the need and demand for vocational and technical training institutes in the state.

Leroy Wolins met with a wide variety of computational and statistical problems in the course of consulting with graduate students and staff in the behavioral sciences. As the examples which follow suggest, advice was most often requested on the use and interpretation of statistical methods in analysis.

For a master's thesis project in child development, each of four tests of infant intelligence was administered four times—at ages 3, 6, 9 and 12 months—to each of 100 infants. A three-way analysis of variance was used to analyze the data. Doctoral research in home economics education was conducted to explore three criteria of teacher effectiveness: average increase in achievement test scores by students, ratings by observer and ratings by students. Each teacher under study taught several classes which varied in size and grade level. Even though the error term used in the analysis of variance was probably too small—it was based on within size, within level, within school variance—the data provided no evidence for rejecting the hypothesis that the teachers did not differ on these criteria.

A master's thesis study in sociology presented a computational problem. The "personality adjustment" of about 1,600 school children had been assessed by 50 questions in an attempt to determine if children's personalities were adversely affected by mothers' having worked during the children's preschool years. It was intended that factor analysis would be carried out if the items did discriminate between children whose mothers had worked and those whose mothers had not. Thus the first stage was to intercorrelate responses to all 50 questions and other measures together with the dichotomous measure of mother's working status. It turned out to be much cheaper to use the IBM 402 rather than the IBM 650 to process the data. Results showed that the items did not discriminate between children of working and of nonworking mothers.



Leroy Wolins, assistant professor, has been at Iowa State since September 1957 on a joint appointment in psychology and statistics. For the Dept. of Psychology he teaches advanced undergraduate and graduate courses in tests and educational measurements, attitude scale construction and psychological statistics (Stat. 505), besides engaging in research. He also reviews all thesis projects in psychology for their statistical requirements. On the other half of his appointment, in the Statistical Laboratory and the Dept. of Statistics, he has been consulting on statistical problems with staff and graduate students in the behavioral sciences, as well as teaching a statistical methods sequence for research workers in those fields.

Dr. Wolins earned all academic degrees at Ohio State U. in psychology with emphasis on statistics. After serving as a research and teaching assistant there, be became assistant director of the Test Research Dept., Science Research Associates, in Chicago, Illinois, for two years. His present research interests lie in two areas: factor analysis and psychological measurement.

A master's thesis project in psychology was directed toward determining whether judges sorted (or scaled) subjective stimuli differently when using different numbers of categories in making the sorts and when using different sorting procedures. Each of three different procedures was used with 5, 9 and 11 categories by each of 30 judges. Even though the lowest correlation between scale values determined by different combinations of procedures and categories was .96, the item-procedure interaction was highly significant. The results indicated that a particular type of subjective stimuli tended to be judged consistently lower by one procedure than by the others, so procedure was also significant. Number of categories did not result in different scale values when the proper linear transformation was used.

For the college Driver Training Research Laboratory and the state Dept. of Public Safety, Scott Krane derived a mathematical model for number of traffic fatalities and used it to assess the results of a safety campaign. For a doctoral study in vocational education, he consulted on analysis of a survey of Iowa county school superintendents to determine goals of public schools; the main problem was statistical assessment of the extent of agreement among superintendents in their judgments or opinions.

The Scientific Computing Group

Consulting on scientific computing, numerical analysis and systems of programming was carried on by all members of the Statistical Laboratory's Scientific Computing Group. This service was provided mainly to people who made use of the Laboratory's operational computing services, mentioned in a section which follows, but applied research items of specific interest are listed below.

The solution of an integral equation was required in a mathematics-Engineering Experiment Station project in fundamental theoretical mechanics. The problem was reduced by H. O. Hartley to a special method of solving a system of simultaneous linear equations; this involved integrals of Bessel functions. Advice was given on the fitting of mixtures of exponential distributions arising in problems of molecular structure in chemical physics and, for a chemical engineering project, a procedure for fitting second-order regression laws to data on subterranean disturbances.

Howard Jespersen consulted on various computational problems and their programming for solution on an IBM 650 computer. One such problem arose in a physics study of heat flow in metallic materials and led to the rewriting and simplification of a relatively time-consuming 650 program in order to achieve optimum speed. The computations of interest were required in an in-

vestigation of how the diffusivity constant, K, varies as a function of absolute temperature T in the classical heat equation where the boundary conditions are determined experimentally. The final program provided very satisfactory estimates of K yet took only 1/20 of the time that the earlier program required.

Hartley, Jespersen and Russell Altenberger consulted on simulation of a neutron-scattering and attenuation process through a reactor shield consisting of alternate slabs of iron and water. A Monte Carlo approach developed by the nuclear engineer posing the problem was improved by the use of statistical techniques reducing the sample sizes required. Special decks of random variates from the exponential distribution were prepared on the IBM 650 with the aid of the RAND card tables of random normal deviates.

Jespersen consulted with dairy husbandry staff on analysis of progeny testing records for herd indexing. As a preparatory step toward cow indexing by means of the 650, he prepared a modification of an existing program. He also consulted on a distribution problem in animal husbandry; this involved obtaining the distribution of genetical correlation coefficients with the help of Monte Carlo calculations for which he used a variance and covariance analysis program specially written by him in fixed-point, double-precision arithmetic.

Dale Grosvenor consulted on the setting up of linear programs with numerous people in agricultural economics, notably those involved in the Agricultural Adjustment Center. Many of their problems led to very large tableaus and often required special techniques such as variable price and/or resource programming for solution.

Aaron Booker conferred with an agricultural economist on the evaluation of optimum value for a nonlinear production model involving three variables which had to satisfy a nonlinear side condition. A program incorporating a trial-and-error solution was written by Booker. Altenberger consulted on a thesis problem in industrial engineering which resulted in his writing a program to calculate tables on industrial plant and equipment retirements. He worked with Herbert T. David and an industrial administration staff member on the objective formulation of business decision-making in a manner suitable for programming on a high-speed computer.

Iowa Agricultural & Home Economics Experiment Station

This experiment station provides financial support to permit certain members of the Statistical Laboratory to engage in relatively extensive consulting on statistical problems in the biological and agricultural sciences.

Statistical services primarily in the animal sciences

In September Paul Homeyer brought to a close his long period of collaboration in the animal nutrition research program of the station. As an active partner in that work, he was in a position to help in planning the methodological aspects, and review the progress, of every experiment in swine and pig nutrition currently carried on. He had made extensive methodological studies of available experimental data from the standpoints of designs, techniques and statistical analyses used in past experiments on cattle and calf nutrition, dairy bloat studies, poultry and lamb nutrition. The results are reflected in part in the newer programs of nutrition research and the numerous applied papers which have been published on previous experimental investigations.

Following the departures of Homeyer and Robert F. White at the end of the summer in 1958, the work of statistics Project 101 was carried on primarily by George W. Snedecor (fall quarter), C. R. Weaver (winter quarter), T. A. Bancroft, Mary A. Clem, David Hogben, Ta-chuan Chen and J. N. K. Rao. Some of the areas worked in and problems dealt with are mentioned below or in the next section. Certain of these involved joint research with members of other departments in the station; for the remainder, statistical assistance was provided through consulting and computational services.

Snedecor advised on statistical analysis procedures for special studies of pig nutrition data from a randomized-block experiment. For the forestry dept., help was given by Hogben and Snedecor on the analysis of an incomplete block experiment with extra replications and on the analysis of data on the density of wood in different portions of a tree. Bancroft worked with men in fisheries management on estimation procedures for fish-tagging studies and the design of experiments. Weaver, during his quarter as visiting associate professor, did consulting mostly on entomological research problems.

As part of the work of Project 890 (see p. 10), O. Kempthorne, aided by David Hogben under a Research & Development assistantship, consulted on interpretation of data on storage of eggs with different treatments, food technology investigations of cooking chickens by electronic ovens and a study of the relationship of cooking losses to backfat thickness in hogs. Neeti Bohidar conducted the analysis and interpretation of results of a genetic experiment designed to study the effects of radiation on activities of inbred strains of mice. The following information was obtained from the analysis: the mean activity levels of nonradiated mice were similar in both strains; there was a decrease in initial activities of both strains following radiation; this effect appeared to be temporary as was determined by observations for a period of 24 days; the magnitude and duration of the effect varied, on the average, in different strains. Assistance was given by Bohidar in some aspects of the analysis of an experiment to study the genotype $\times$ environment interaction in poultry.

Statistical services in entomology and the plant sciences

Under Project 101, consultation was begun by Paul G. Homeyer, then continued by T. A. Bancroft and Ta-chuan Chen on problems arising in botany studies, e.g.,

(1) The use of statistical analysis in some experiments studying the variability of three methods—Hand, Standard and Climax—and, for each of the last two methods, three kinds of mechanical blowers, as used in purity analysis of Kentucky blue grass seeds. The aim of the study was to find a time-saving method with greater consistency. Also germination percentages and pure-live-seed percentages were investigated statistically. A method for the estimation of a tolerance interval for purity and germination percentages for comparison of the seed test results was developed by Chen.

(2) Design and analysis of a uniformity trial on germination of Kentucky blue grass seeds. An arcsine transformation of the germination percentage data was used in the analysis. Variations, due to different locations and heights of the racks which germination dishes were placed in, and other sources of variation in the germination room were analyzed for methodological purposes.

J. N K. Rao and T. A. Bancroft consulted on the efficiency of two machines, Gamut and Boehmer, in dividing a mixture of seeds—composed of blue grass, rye grass, fescue, bent grass and inert matter—in the expected proportion of $5:2\frac{1}{2}:1:\frac{1}{2}:1$. This was tested with the help of a chi-square statistic. Chi-square values for the samples from both machines were found to be significant and suggested poor machine performance. But Boehmer had performed better than Gamut, since the chi squares for Gamut were very high compared to those for the other machine. Advice was given on further study involving a seed mixture experiment. In addition, the two men outlined analysis procedures for a long-term experiment in which several kinds of seed were to be stored under different conditions. Conferences were held with a staff member in biochemistry regarding the statistical analysis of experimental data from forage sampling at time of ensiling and data from silage sampling after fermentation of the forage. This was a continuation of Homeyer's work under Project 101.

After reviewing some results obtained at Purdue, Bancroft and Chen advised on statistical aspects of a proposal to change the rules and regulations for setting tolerances for purity analyses of seed as used by various federal, international, state and other agencies. Under Project 169, Bancroft acted as statistical consultant to the Iowa Corn Yield Test Committee on behalf of the college. Besides reviewing a report summarizing results of the 1958 Iowa hybrid corn yield trials, he worked with Chen on a combined statistical analysis of data from trials conducted by the Iowa Corn & Small Grain Growers Association over the years 1955-58. The data represented both experiments with fixed locations and ones with varying locations.

Neeti Bohidar conducted the analysis of a genetic experiment on potatoes to study the general combining abilities of six varieties tested on 45 randomly chosen strains. Tester $\times$ strain interactions were evaluated from the analysis, and the experiment gave some indication of the specific combining abilities. This experiment is the first of its kind on potatoes, and the analysis will help in obtaining information on refinement of genetic material and techniques for future experimentation. Further assistance was given by Bohidar on analyzing and interpreting the results of an experiment on Easter lilies to study the interdependence of seven variables.

As in previous years statistical aid was provided through the experiment station to the cooperative entomological research at the USDA European Corn Borer Laboratory at Ankeny, Iowa. In the 1958-59 period the statistical work for the corn borer research program was carried on by Donald V. Sisson under the supervision of T. A. Bancroft and John Gurland.

The NC-20 regional project, an ecological project concerned with factors affecting corn borer populations, required the most statistical assistance. Its largest phase is a recurring experiment carried on identically in each of three states, Iowa, Minnesota and Ohio. A change in experimental design, from a split-split plot to a split-plot scheme beginning in 1958, prompted a question as to whether the $\sqrt{X+.5}$ transformation used on borer and cavity counts was actually the proper one. Therefore data from previous years were subjected to chi-square goodness-of-fit tests; these, together with graphs plotting the means against their variances, indicated that the distribution of the data was closely approximated by a Poisson distribution and that the existing transformation was proper.

Another phase of the NC-20 project is the annual corn borer survey carried on during the spring, at midsummer and in the fall in six North Central states. Two reports were prepared from data obtained in the survey during the past four years. The objectives of the second report, which presented the more detailed analysis of the data from each state, were to point out the apparent weaknesses in the present sampling scheme and to offer a proposed change.

Regression analyses were employed in an investigation to evaluate the relationship between leaf lesions produced by the European corn borer and corn yield on an individual plant basis; the results are being used to assess the potentialities of a leaf lesion criterion for evaluation of borer populations and prediction of yield loss. Computations were continued on the Boone County ecological project to relate a number of variables to borer population levels.

Throughout the year, consultation was given on the design and analysis of experiments involving insecticidal control of the European corn borer. The predominant design used was a randomized complete block design. In most of the timing experiments, however, a split-plot design was utilized. Duncan's multiple-range test was employed in those experiments where it was desirable to make all possible comparisons among the means. Statistical aid was also given in a number of physiological experiments involving corn borer nutrition and experiments involving phases of entomology other than the European corn borer—notably mites and aphids.

Under entomology Project 1351, a contractual research project supported by the U.S. Public Health Service, John Gurland and Ilbok Lee continued work on analysis of data obtained from alfalfa samples sprayed with the insecticide Guthion. A technique involving a generalization of Berkson's minimum logit chi-square technique was employed to analyze quantal data from a housefly bioassay with a trichotomous response (alive, moribund, dead). This achieved a more efficient utilization of the results than the common procedure of pooling the numbers of dead and moribund flies would.

Statistical assistance was also given on a study to determine insecticidal residues on green beans which had been sprayed in the field. An experimental plot near Ankeny, Iowa, had been sprayed with Guthion in July 1958, and samples were collected $1\frac{1}{2}$ days later. The plot, $100' \times 270'$ in size, contained 30 rows, each $270'$ in length and marked into $45'$ segments. A system of random rectangular coordinates was employed to collect composite samples each comprised of the beans from ten segments. The same procedures were followed in sampling a similarly divided plot after application of DDT. Bioassay experiments involving housefly mortality as the response were carried out to determine the insecticidal residues in the beans after processing by different canning and freezing procedures. The data were analyzed by the minimum logit chi-square technique.

Research and development program

A statistics Research & Development program in the experiment station is used to train graduate students as statistical consultants in agricultural and biological fields. This program is supplemental to graduate appointments in statistics which are regularly assigned to specific projects of the statistics dept. or other departments of the station. In 1958-59 Ta-chuan Chen, David Hogben, J. N. K. Rao and Donald V. Sisson held assistantships under the R&D program. Their activities with station research workers are illustrated in earlier sections of this report.

Statistical services primarily for sampling investigations

The Iowa Crop Improvement Association was planning a mail questionnaire survey, with personal interview follow-up, to be based on a sample drawn from lists of operators of ASC farms. These lists contained, under varying circumstances, the name of an individual operator once or more than once for any given farm, but the frequency of mention could not be readily determined by scanning. Consequently an unweighted sample would lead to biased estimates of farm totals and related characteristics. Norman V. Strand formulated a short set of questions for inclusion in the questionnaire which were designed to reveal the number of chances each operator had had of coming into the sample and to obtain weights for use in substantially reducing the effect of the sample bias upon estimates.

He consulted with staff and graduate students in home economics, the social sciences and agriculture on various other survey problems, especially ones of sample design, questionnaire construction and data processing. For example, he conferred with soil scientists on the use of sample data to estimate for tracts of land in certain arbitrary size classes the proportions which would be suitable for the operation of large-scale farm equipment. The data, including information on slope and other geographical characteristics, had been collected on 160-acre areas for the Iowa portion of an inventory of soil and water conservation needs. For a master's thesis study in home management, Strand advised on analysis and estimation procedures for use in relating household meat consumption to occupational and income classes, family size and composition, on the basis of survey data.

Project S113, under E. H. Jebe, continued to provide statistical services in the areas of agricultural economics, agricultural engineering, agronomy, home economics, rural sociology and related areas. A brief account of activities for some of the station projects worked on during the year is given below.

Study progressed on the prediction of maximum individual farm electrical demands. A purposive sampling plan for obtaining records on about 100 farms in northwest Iowa was evolved. Data collected on appliance inventory and monthly use of electricity (kwh) are being analyzed to develop a prediction equation. In part this work has been done by Jebe as a consulting statistician for the Farm Electrification Laboratory, Agricultural Engineering Research Division, ARS, USDA, on its electrical load research studies.

Based on the master's thesis of Neil Throckmorton (summarized on p. 33) and other data collected for a study of relative maintenance costs and satisfactions to users of carpeted and smooth-surfaced floors, a report to the Carpet Institute—co-sponsor with the Iowa station of the project—was prepared by Throckmorton, Jebe and the project leader, Elizabeth Beveridge of the Household Equipment Dept. The experiment employed has been described in previous annual reports of the Statistical Laboratory.

Under a separate home economics research project, cooperative with regional project NC-9, studies are underway on the development of guides for choice, use and care of structural floor coverings. Surveys are being considered for several universes of interest: (1) firms selling and installing such floor coverings (floor tile and wall-to-wall carpets), (2) household consumers of structural floor coverings in general and possibly (3) restricted groups of consumers who have recently purchased or who are planning purchase of those floor coverings.

An agronomic project has been concerned with measurement, by plant response and soil tests in six horizons, of the availability of potash to plants in the profiles of midwestern soils. Extensive regression calculations were made under Jebe's supervision to relate availability measures to the soil tests. Assistance was also given in regression studies in agronomy to investigate the possibility of the generalization of crop response to fertilizer over different soils.

Consulting work and preparation of special analyses has continued for Project 1021, a nutritional investigation. The analyses were aimed at the study of gains in weight of teen-age girls who took part in a diet supplementation experiment in four Story County (Iowa) schools. The design for the experiment had been developed by O. Kempthorne and E. H. Jebe. Another home economics project is concerned with fundamental investigations on factors influencing the energy expenditure and calorie needs of individuals. Suggestions were given—for a program of observations on a group of human subjects covering a period of several months—that would tend to reduce possible biases in the series of observations.

The relative merits of uncooked, roasted and stewed turkey in a certain recipe for turkey timbals were investigated in a thesis project in institution management. A special arrangement of an incomplete block design was devised for the experiment. The three forms of preparation of turkey have been used in incomplete blocks of size two which were formed from the two halves of the same turkey. The use of three complete replicates made possible an arrangement for assessing the judge error component in the experiment. Six judges were used, and the triangle method of presentation, e.g. T_1 T_2 T_1 or T_2 T_3 T_2, allowed a check on judge repeatability as well. H. T. David assisted in analysis of the design set up by Jebe.

The latter continued to serve as statistician for a study of relative wearing qualities, ease of care and attitudes toward care and maintenance of men's work clothing.

During the years 1957 and 1958 45 experiments, each using a randomized complete block design with two replicates and ten treatments per block, had been conducted on corn at 45 locations in the Marshall and Monona soil areas of western Iowa. Many factors at each location were observed in order to assess the effect of surface soil thickness on corn yield in those soil areas. Statistical assistance was given with computational aspects of the analysis, which included large multiple regression studies to measure the effect of the variable of

interest. It appears that the data may be studied also for other purposes.

Animal husbandry, animal nutrition and agricultural engineering staff are cooperating in the conduct of experiments to investigate the response of swine, in terms of growth, gains and feed efficiency, to differing environmental conditions. Interest attaches, in particular, to the cycling of temperature conditions, since it is much more difficult economically to establish constant controlled environments for swine in feeding trials. For the current series of experiments, a design was set up by Jebe by means of which it will be possible to undertake nutritional and environmental investigations simultaneously within the limited facilities of the station.

Throughout the year, Gerhard Tintner engaged in general consulting with graduate students and staff in economics on numerous statistical and econometric problems. Among these were graduate research problems concerning stochastic linear programming and econometric models for several European economies, the United States and Canada.

Off-campus Advisory Assignments

Nearly all staff members engaged in intermittent consulting with off-campus visitors and correspondents. However, a few specific assignments represented continuing or relatively extensive responsibilities. These were as follows:

E. H. Jebe, serving as statistical consultant, worked with other Iowa State faculty members on preparation of a report for the Iowa College-Community Research Center. The report itself, "An evaluation of Iowa county government" by Donald E. Boles and Herbert C. Cook of Iowa State College, was released as a January 1959 multilithed publication (93 pp. + xi) and used by the Center's research committee in deciding on certain policy recommendations for legislative changes to improve county government in the state. Jebe had helped in the quantitative analysis of county government costs. Both total and per-capita costs were considered for each of the 99 counties in various statistical regression analyses. Exploratory analyses were made to quantify some of the effects of area, population, and rural-urban residence on costs of city and county government. In addition, Jebe prepared "Appendix B: Methodology in the study of county government costs," pp. 70-76 of the report, to supplement the Boles-Cook study.

During the year, two staff members carried out advisory responsibilities with federal agencies: T. A. Bancroft, as member of and statistical consultant to the Advisory Committee on Epidemiology & Biometry, National Institutes of Health, USPHS; H. O. Hartley, as member of the U.S. Bureau of the Census' Advisory Committee on Mathematical Statistics and as consultant to the Office of Ordnance Research, Durham, North Carolina, on inventory control and other problems.

Hartley also continued as consultant on a Princeton U.-National Science Foundation project, for preparation of an index of tables for statisticians, and as a member of the Advisory Board on Quartermaster Research & Development (statistics subcommittee), National Academy of Science-National Research Council. Jebe had consulted with members of the Agricultural Economics Branch, Tennessee Valley Authority, on certain problems in analysis of production functions.

Operational Work

Survey Group

Professional staff members of the Survey Group for 1958-59 were H. O. Hartley, N. V. Strand, Harold Baker, Jack Graham, José Nieto de Pascual and Betty Stewart; also for the summer of 1958, William H. Williams, Leroy Wolins, Marion Bryson and Howard Taylor. This group, with its associated workers and interviewers, provides direct operational services to the rest of the campus on all aspects of sampling, surveys and census-type studies. Research in survey methodology and consulting services are combined with the operational work through the financing of the Statistical Laboratory, the Agricultural & Home Economics Experiment Station and the Industrial Science Research Institute (Statistics Project 887 in sampling research). Allan D. Orman, assistant professor of sociology, was affiliated with the group to serve as project leader on a continuing study to assess the role of the farm-and-home-development approach in extension work.

Within the year four ICA and FAO fellows were observer-participants in connection with training programs in agricultural statistics. José Nieto de Pascual served as staff member in charge of a noncredit seminar on sampling surveys which the two ICA fellows from Jugoslavia attended during their stay at Iowa State. The series of talks given, which emphasized agricultural surveys, is described in the Seminar section (p. 35).

Sampling data for the Cedar Rapids, Iowa, area and advice on design were made available by the Survey Group for a graduate research project in sociology at the State U. of Iowa.

One of the main tasks of the Survey Group within the year was summarization of the data from a recent survey of persons 60 and over in Linn County, Iowa, who were not institutionalized or senile. The Statistical Laboratory had been cooperating in this study with sociology staff, through the Agricultural & Home Economics Experiment Station, and the Linn County Council on Social Planning. From an analysis standpoint, the Linn County study differed in one major respect from most of the recent surveys made by the Survey Group. Usually stratification has been employed in the sample design to reduce sample variation, rather than because the strata represent population segments of interest in themselves. In this case, the survey sponsors were interested in getting separate estimates of proportions and/or totals within primary strata, in addition to the over-all population estimates for all strata combined. The primary stratification was into zones: urban, rural place and open country. In terms of size of questionnaire and amount of extractable information, this was one of the most extensive surveys undertaken here. Under her assistantship, Betty Stewart made a descriptive analysis

of the survey results on health items and supervised the tabulation of data for a final report. Her master's thesis delves into features of the design and other statistical problems. A factor analysis of responses of three samples of people 60 and over in Linn County was done by Leroy Wolins.

The Statistical Laboratory began collaboration on a national audit program with Taylor, Harkins & Lea, Inc., of Philadelphia, Pennsylvania, specialists in medical market research, and the Survey Operations Unit of the U. of North Carolina Institute of Statistics. Bimonthly observations on sales and inventories of animal and poultry medicinal and health products were to be gathered, starting in August 1958, through personal interviewing of national samples of agencies distributing such products to the public. The Laboratory worked with the Institute of Statistics on the national sample design and on methods of making regional and national estimations. Otherwise, its area of concern involved the sample selection, data collection and data processing for roughly half the U.S. Taylor, Harkins & Lea assumed responsibility for subject-matter aspects, including the devising of forms and training materials. A random-stratified probability sampling scheme was adopted which involved differential sampling rates for three volumes of sales for the population of retail outlets. The scheme also was such as to allow for obtaining both regional and national totals for specific products on hand or sold.

The following samples were designed and/or selected during the year:

Two area probability samples expected to contain about 250 farms which met certain eligibility requirements, chosen in a southern area and a northern region in Iowa for an agricultural adjustment and conservation survey made by staff members in economics in the college Agricultural Adjustment Center.

Samples in urban and rural places in Jackson County and parts of Clinton and Jones Counties, for the Dept. of Economics & Sociology, for use in a study concerning the effect of industrial opportunities for employment. Within each zone there was specified a multi-stage sample of area units expected to contain the dwelling units of about three Clinton Engine Co. employees on the average—representing one of the populations of interest for interviewing. The area samples also were to be used to identify an approximately equal-sized sample of "other" households. Two towns per stratum were chosen in each of the three rural place strata with probabilities proportionate to the numbers of Clinton Engine Co. employees. Maquoketa, which comprised the urban zone or stratum, and the selected towns were cruised to get block count estimates of occupied dwelling units for sampling purposes. Assistance was then given in training interviewers.

For an experiment station study being made by the rural sociology staff, a stratified sample of sets of three townships each, selected throughout Iowa. Stratification was by type of farming area, with proportionate allocation of the sample sets among the five areas. Each set was to be screened for new farm housing as a basis for finding out about farmers' use of information in building such housing.

For a survey on occupational plans sponsored by the Agricultural Adjustment Center and the Dept. of Economics & Sociology, a stratified sample of about one seventh of the high-school senior farm boys in Iowa with certain large cities excluded from the universe. The Survey Group also administered the interviewing in the schools, helped set up a code, edited and coded the completed questionnaires, supervised data processing, prepared summary tables and made various statistical analyses.

A random sample of open country farms in Franklin and Floyd Counties for a seeder box survey sponsored by the Iowa Crop Improvement Association. One requirement of the study was that certain information was to be obtained by sampling oat seed from farmers' wagon boxes. High-school students in vocational agriculture classes in the two counties were used as observers, each of which was assigned to a cluster of three sample farms in his neighborhood. During the short season for seeding oats, observers were to note the occasions of seeding and, at those times, get answers to a short questionnaire and make samples of oats for subsequent testing in Ames for germination and weed seed percentages.

Two related samples, incorporating an experimental design with treatment and control, for a study of the effects of fertilizer education on the way farmers use fertilizer and the amounts they use. This study was a cooperative project of the Agricultural & Home Economics Extension Service and the Tennessee Valley Authority and was intended for evaluation of an Extension Service-planned educational program. First an Iowa sample of areas each composed of a cluster of four townships was selected from a universe stratified by type of farming area and by population level within type. This sample was to be used to identify for interview a sample of paired agricultural chemicals dealers and a sample of farmers served by each of those dealers.

Samples of about 50 dwelling units each in the open country portion of Boone County, Iowa, and the city of Ames, requested by E. H. Jebe for Project S113 in connection with his consulting activities with home economics research workers.

For a migration study of Greene County residents being conducted by rural sociology staff, a supplemental sample of dwelling units, chosen from the towns of Grand Junction and Scranton, Iowa, to identify sample households conforming to special eligibility rules. Interview data from the original county-wide sample and the added s.u.'s were coded for eventual summarization.

In addition, the Survey Group's sampling materials were utilized in specifying the population distribution and estimated number of occupied dwelling units in the Boone Biblical College's radio listening area, within a 52-mile radius of the transmitter in Boone, Iowa. Of particular interest were the relative proportions of the population and occupied dwelling units, as of 1950, in the urban, rural place and open country zones within each of five circular bands into which the listening area universe was divided. As an aid to estimation, cruise counts of occupied dwelling units were obtained for the first circular band in Boone (the area within a 988-foot radius of the transmitter).

For a project in sociology, questionnaire responses were coded from a survey of 1,826 seventh and eleventh graders in Cedar Rapids schools made to obtain information on students' feelings about themselves and some of their ideas about their families.

Jack Graham prepared a draft of a report on the design, methodology and estimating procedures used in a recent two-year series of quarterly livestock marketing surveys. This material, with estimates of sampling errors computed for selected items in the study, comprised the statistical portion of a survey report prepared by economics and statistics staff for the agricultural experiment station. The interview data summarized in the report had been gathered under Project 1229, which was supported by a grant of funds from the Chicago Union Stock Yard & Transit Co.

Work continued on the Iowa portion of the North Central Livestock Marketing Research Project, a regional study of livestock marketing institutions. Sampling and field work for the first part of this project, on auction markets, had been completed earlier. A partial listing of marketing agencies provided by the agricultural economics dept. of the experiment station was augmented by field visitations and used to obtain samples of livestock cooperatives, order buyers and dealers in Iowa. Interviewing was supervised by the Survey Group. Later a sample of packer buyers and packing plants was chosen from the same augmented frame mentioned above.

Computing

The Statistical Laboratory's Operational Computing Service, under the supervision of Mary A. Clem, provides computational services on request to any department. In addition, it devotes considerable time to advising research workers on the best ways to transcribe experimental and survey data to be suitable for punching and on the best ways to set up tables after their data are on punched cards.

On the average, about 59 different projects were worked on each month during the 1958-59 fiscal period. Over one half of these involved use of the IBM 650, although use varied from quite incidental operations as part of multivariate regression analyses or analyses of variance to extensive calculations to solve complex mathematical or physical functions.

The consultation in scientific computing and numerical analysis by members of the Scientific Computing Group has already been mentioned in the General Statistical Laboratory Consulting section. The group was composed of the following individuals during the 1958-59 period: H. O. Hartley as head, Mrs. Clem, C. C. Mosier, Howard Jespersen, Russell Altenberger, and programming assistants Dale Grosvenor, Aaron Booker and Herbert Eisenberg—the latter holding an appointment supported by the Engineering Experiment Station and designed to provide programming assistance to its station workers. Within the year, the Scientific Computing Group prepared and used numerous IBM 650 programs, a few of which have been mentioned on pp. 7-8. The members also advised all interested campus users of the 650 on the preparation and testing of programs. The group was not yet much concerned with operation of the Cyclone digital computer, although arrangements had been made for obtaining copies of program tapes and the basic machine was nearly completed.

Qualified staff and graduate students throughout the college are given access to the 650 through a booking arrangement supervised by Mrs. Clem. For their convenience, the Computing Service acts as an informal clearing house for IBM 650 programs from off-campus sources. A number of such research workers, notably those in chemistry and physics, have been developing other programs to meet their computational needs.

In the summer of 1959 a series of informal classes on the IBM 650 and how to program for it in the basic system was held by Jespersen for interested participants in a National Science Foundation-sponsored institute for high school mathematics teachers. Earlier in the 1958-59 year, talks followed by demonstrations had been given by Jespersen, Altenberger and Hartley to an architectural engineering class, undergraduate chemistry and chemical engineering students, and three groups of seniors in industrial engineering. The first two of several management decision-making laboratories utilizing the 650 were held in March and May.

The facilities in operation in the Computing Service included a variety of desk calculating machines and the following IBM equipment: five No. 024 card punches and four No. 056 verifiers all alphabetical; one No. 082 electronic sorter with a No. 978 card counting attachment; two No. 083 sorters, one of which had a No. 978 attachment; one No. 077 collator; one No. 402 alphabet accounting machine; one No. 514 reproducing gang summary punch; one No. 548 interpreter; one IBM 650 electronic data processing machine (No. 533 read punch unit, No. 650 magnetic drum calculator and No. 655 power unit) with alphabetic device; and one each of the older No. 001 and No. 016 card punches, No. 051 and No. 052 verifiers and No. 080 sorters. In special cases, work of the Computing Service is handled under C. C. Mosier's supervision in the college Business Office IBM Service Unit; this unit is equipped with a 604 electronic calculating punch (multiplier) besides the more usual machines and on occasion has access to a second 650 computer.

The principal users of the services provided by the Computing Service were the following: the Survey Group of the Statistical Laboratory; the college Institute for Atomic Research and the AEC's Ames Laboratory, represented by a steadily growing number of research groups making use of the IBM 650; within the Agricultural & Home Economics Experiment Station, the depts. of agronomy (agricultural climatology, farm crops and soils), agricultural economics, genetics, rural sociology; the Industrial Science Research Institute, mainly for projects in chemistry and studies cosponsored by the Statistical Laboratory; the Agricultural Adjustment Center; the Agricultural & Home Economics Extension Service and the animal husbandry dept. of the experiment station.

Computational services were also provided for studies —largely within the Engineering Experiment Station— in theoretical and applied mechanics, chemical and nuclear engineering, mechanical engineering, industrial engineering, aeronautical engineering and civil engineering; projects in agricultural engineering; projects of the depts. of poultry husbandry, entomology and wildlife management, home economics research, forestry, horticulture, plant pathology, vocational education and technical journalism, all under the Agricultural & Home Economics Experiment Station; a survey project of the student governing board, Cardinal Guild; as well as other research studies in psychology, physics, statistics, mathematics, political science, economics and sociology, botany, zoology and veterinary medicine. Small tasks

were done for several college administration offices.

Part of the year's work was required for North Central regional studies in which Iowa State College was participating. In addition, computational, consultative and/or programming services were made available to certain off-campus research groups: the USDA Agricultural Research Service, Ames In-Cross, Doane Agricultural Service, U. of Nebraska, Drake U., State U. of Iowa, North Dakota Agricultural College, South Dakota State College, Kansas State College, Hy-Line Poultry Farms, Heisdorf & Nelson Farms, Inc., and American Maize Products Co.

Some of the most extensive jobs performed by members of the Computing Service during the year are described below. (These do not, of course, include certain extensive 650 computations carried out by members of other departments.)

(1) For the Survey Group's project with the U.S. Soil Conservation Service, punching of coded data on soil measurement units and preparation of county-by-county tabulations giving estimated totals for such classifications as soil type, slope and erosion, land use and land capability unit.

(2) Also for the Survey Group, data processing of bimonthly audits of animal and poultry medicinal products obtained from national samples of retail outlets and veterinarians.

(3) With agricultural climatology staff, additional computation, making extensive use of the 650, for statistical analyses of rainfall data collected in a regional study, NC-26. For an experiment station publication based on Weather Bureau data, C. C. Mosier carried out on his unit's IBM equipment the printing of tables bearing on the percentage chance of receiving certain amounts of precipitation in a certain period of time beginning in a given week for a large number of stations in the North Central region. Mosier finished some calculations on the IBM 604 using the 650 output cards—then ran duplimats on the IBM 407 in order to obtain tables ready for printing. These tables were published in July 1959.

(4) Punching, tabulation, listing and computation for studies made by the Genetics Dept.

(5) Data processing of monthly dairy herd test records, carried out under C. C. Mosier's supervision, for Dairy Extension as a service to members of the Dairy Herd Improvement Association. In performing this work, Iowa State College is one of five institutions acting as data processing centers for a national program in cooperation with the Agricultural Research Service, USDA. A special rental arrangement was made with the Iowa State Highway Commission to use its IBM 650 rather than burden the very busy one in the Statistical Laboratory.

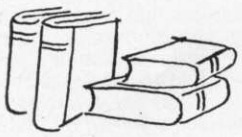
(6) Linear programming computations for projects of the agricultural economics dept. of the experiment station and the Agricultural Adjustment Center.

(7) Scientific computing, mainly on the 650, to solve research problems for staff of the Brace Laboratory of Physics, U. of Nebraska.

(8) Punching, tabulation and statistical analysis of data from numerous field experiments on corn and small grain for the farm crops section of the Agronomy Dept. and/or for the ARS, USDA.

Publications

Several staff members served on publications in major editorial capacities. O. Kempthorne became an associate editor of the Annals of Mathematical Statistics starting with the March 1959 issue. He continued as a member of the editorial board of Biometrics. Gerhard Tintner continued as associate editor and book review editor for Econometrica, member of the editorial board of Metroeconomica, and associate editor of Unternehmensforschung—Operations Research. He and H. O. Hartley were abstracters for Mathematical Reviews. George W. Snedecor resigned as editor of the Queries section of Biometrics after heading that department for over 13 years; however, he remained on the Biometrics editorial board.



Papers[1] and Textbooks with Summaries

*T. A. BANCROFT and T. A. Brindley: "Methods for estimation of size of corn borer populations"—paper presented at the 10th International Congress of Entomology, held in Montreal, P. Q., Canada on August 17-25, 1956. Proc. Tenth Internat. Congress Entom. —Vol. 2, 1956 (1958). Pp. 1003-1014. (Jour. paper J-3075, Iowa Agr. Exp. Sta. Projects 169, 1193.) Reprint Series No. 56, Statistical Laboratory, Iowa State College.

Methods are given illustrating the use of nested sampling designs for the efficient estimation of the mean and variance of corn borer populations. Such methods, involving optimum allocation, are extended to include the case of multiple available estimates of variance components. A proposal to consider optimum size of sampling unit as part of the optimum allocation problem, for nested sampling designs in corn borer surveys, is presented. Some observations on the national corn borer survey and stratified sampling with nested sampling are included.

Judson U. McGuire, Tom A. Brindley and T. A. BANCROFT: "Note: Errata and extensions for 'The distribution of the European corn borer larvae *Pyrausta nubilalis* (HBN.) in field corn.'" Biometrics. 14:3, 432-434. September 1958. (Jour. paper J-3454, Iowa Agr. Exp. Sta. Project 1193.)

Corrections are given for certain misprints, numerical inaccuracies and oversights in a paper originally published in Biometrics (Vol. 13, No. 1, March 1957). Re-

[1] * indicates reprints available; ** indicates reprints available but in limited supply. Where parenthetical material follows an author's name, it mentions first the institution he was with at time of publication and then the previous institution when it had supported part or all of the work on which the paper was based; in such cases, institution names are linked by an & when the work is attributed to both places.

sults obtained by D. A. Sprott (1958), after publication of the paper mentioned above, are used to compare the ordinary chi-square goodness-of-fit values for certain numerical distributions when the negative binomial and the Poisson binomial are both fitted by the method of maximum likelihood.

*Herbert T. David: "A three-sample Kolmogorov-Smirnov test"—paper presented at the 117th annual meeting of the American Statistical Association held in Atlantic City, New Jersey, on September 10-13, 1957. Annals Math. Stat. 29:3, 842-851. September 1958. Reprint Series No. 54, Statistical Laboratory, Iowa State College.

This paper suggests a three-sample Kolmogorov-Smirnov statistic and derives both its small-sample and asymptotic null distributions.

Herbert T. David and William H. Kruskal: "Correction to 'The WAGR sequential t-test reaches a decision with probability one.'" Annals Math. Stat. 29:3, 936. September 1958.

Corrections are indicated for two lines in the paper with the above title which appeared in the Annals of Mathematical Statistics, Vol. 27, No. 3, pp. 797-805, September 1956.

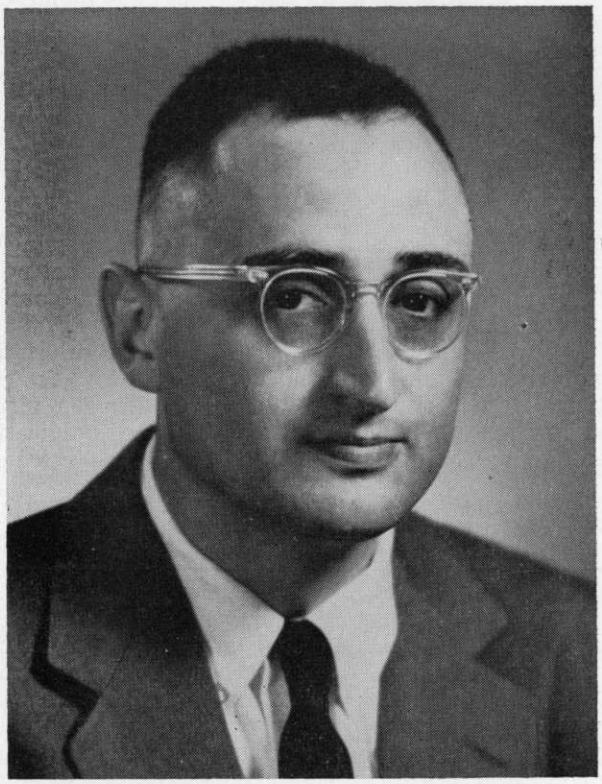
*Herbert T. David (Iowa State College & U. of Chicago), Edward A. Fay and John E. Walsh: "Acceptance inspection by variables when the measurements are subject to error." Annals Inst. Stat. Math. (Japan). 10:2, 107-129. 1959. Reprint Series No. 61, Statistical Laboratory, Iowa State College.

This paper proposes a t-test which will ensure specified error rates of the first and second kind when the observations are subject to measurement error.

*Olive Jean Dunn (U. of California at Los Angeles & Iowa State College): "Estimation of the means of dependent variables"—paper given at a Western Region meeting of the Institute of Mathematical Statistics held in Monterey, California on November 14-15, 1958. Annals Math. Stat. 29:4, 1095-1111. December 1958. Reprint Series No. 55, Statistical Laboratory, Iowa State College.

Various methods are used to construct simultaneous confidence intervals for the means of k variables which follow a multivariate normal distribution when nothing is known about the covariances but the variances are assumed to be equal or of known ratios. (1) The first method involves the use of independent linear combinations of the sample values. The intervals thus constructed have an exact confidence level, but they are unduly long. (2) Next, confidence intervals are made using Hotelling's T^2. These are of bounded confidence level and are rather long when the number of variables is large. (3) Confidence intervals based on Scheffé's simultaneous intervals for the totality of linear contrasts are discussed. These are also of bounded confidence level and are somewhat shorter than those of (1) and (2).

(4) Next, intervals of bounded confidence level are obtained using the Student t-distribution and a Bonferroni inequality. (5) Finally it is conjectured that the same intervals which would be used for the means if the variables were independent may also be used for dependent variables. These intervals involve the use of a multivariate analogue of Student's t-distribution, and are of bounded confidence level. This conjecture has been proved only for two and for three variables. The intervals obtained in (5) are the shortest intervals possible when nothing is known about the correlations between the variables. However, the intervals of (4) using the Student t-distribution are seen to be almost as short as those of (5) provided the confidence level is high and the degrees of freedom are not too small.



Herbert T. David, assistant professor of statistics, joined the staff in 1956 after having completed all doctoral requirements except the thesis at the U. of Chicago. His main interests center on the theory and application of industrial statistics. At present most of his time is devoted to teaching, notably a sequence in industrial statistics and a special section of a statistical methods sequence offered for graduate students in the physical and engineering sciences and mathematics. Prof. David has also taught the set of courses in statistical theory which has been developed for graduate students in other fields minoring in statistics. Some time is reserved for consulting problems and contractual research carried on in the Statistical Laboratory for the Army Ballistic Missile Agency.

Prof. David received a B.A. degree at Harvard U. in mathematics (cum laude). After obtaining an M.A. degree in mathematical statistics from Columbia a year later, he spent three years with the Institute for Cooperative Research at Johns Hopkins U. and then, from 1951 to 1956, was engaged in industrial consulting at the U. of Chicago as a research associate in statistics on a Naval contract project. Summer assignments have involved serving as lecturer in statistics for the U. of Chicago School of Business and as consultant at U.S. Steel's Applied Research Laboratory. He was the first president of the Central Iowa chapter of the American Statistical Association and is now a member of the society's national council.

*Olive Jean Dunn (U. of California at Los Angeles & Iowa State College): "Estimation of the medians for dependent variables"—paper presented at the Cambridge, Massachusetts meeting of the Institute of Mathematical Statistics held on August 25-28, 1958. Annals Math. Stat. 30:1, 192-197. March 1959. Reprint Series No. 65, Statistical Laboratory, Iowa State College.

A nonparametric method is used to estimate the unknown medians, ν_1 and ν_2, of two dependent variables, y_1 and y_2. It is assumed only that the two marginal distributions are continuous.

Confidence intervals of the classic type using order statistics are formed separately for ν_1 and for ν_2. If the variables y_1 and y_2 were independent, these two intervals could be used as simultaneous confidence intervals for ν_1 and ν_2 by simply multiplying the two probabilities to obtain the new confidence level. In this paper it is proved that, when y_1 and y_2 are independent, those same intervals may be used as a set with bounded confidence level. Comparisons are made on the basis of average length between those intervals and other joint intervals for the means of a bivariate normal distribution. It is shown by means of a counter-example that the method for obtaining confidence intervals established in this paper cannot be directly extended to three or more variables.

*John Leroy Folks (Texas Instruments, Inc., Dallas, Texas; Iowa State College): "Analysis of quadruple rectangular lattice designs." Biometrics. 15:1, 74-86. March 1959. (Jour. paper J-3465, Iowa Agr. & Home Econ. Exp. Sta. Project 890.) Reprint Series No. 60, Statistical Laboratory, Iowa State College.

The analysis of a quadruple rectangular lattice design is given. This includes estimates of treatment differences, the analysis of variance, and variances of treatment differences. Some comparisons are also made concerning efficiency of the design relative to other designs, and some numerical examples are given.

R. M. Melampy, John Gurland and J. M. Rakes: "Estrogen excretion by cows after oral administration of diethylstilbestrol"—paper presented at the 49th annual meeting of the American Society of Animal Production held in Chicago, Illinois, on November 29-30, 1957. Jour. Animal Sci. 18:1, 178-186. February 1959. (Jour. paper J-3409, Iowa Agr. & Home Econ. Exp. Sta. Project 1325.)

The study presented here dealt with fecal and urinary excretion of estrogen by ovariectomized cows treated with diethylstilbestrol. Also the estrogenic activity of milk from pregnant and nonpregnant cows—and of bile from nonpregnant cows—before and after diethylstilbestrol treatment was evaluated. The experimental animals were fed a ration consisting of medium quality alfalfa hay with corn, oats, wheat, bran and soybean oil meal. Excreta were collected from certain animals on the basal ration and subsequently while they were on the same ration plus diethylstilbestrol treatment. These animals received 10 mg. daily for eight consecutive days, with excreta collections being made over a three-day period; later, similar procedures were followed, with 100 mg. being given daily. Milk samples were obtained from three cows before treatment and on the eighth day of treatment at the 10 mg. daily rate.

Estrogenic activity was estimated through biological assay using as response the uterine weight of immature mice. Materials to be assayed were added directly to a basal ration consisting of corn meal, dried nonfat milk solids, and corn oil. Treatments were assigned randomly to groups of eight to ten mice. Preliminary assays established linearity between uterine response and log-dose over a certain range. Doses of both standard and test preparations which would give responses in this range were selected for the assays. The hypothesis of parallelism for the standard and test preparations was supported by the data obtained. The results showed that the combined daily fecal and urinary excretion of estrogenic activity ranged from 55% to 84% for ovariectomized cows receiving orally 10 mg. of diethylstilbestrol per day. When the daily diethylstilbestrol intake level was 100 mg., the excretion range was from 42% to 76%. Results from the assays of milk and bile for estrogenic activity are also presented and discussed.

D. A. Lindquist, M. L. Fairchild, P. A. Dahm and J. Gurland: "Thiodan residues on corn plants"—paper presented at the 5th annual meeting of the Entomological Society of America, on December 4, 1957, in Memphis, Tennessee. Jour. Econ. Entom. 52:1, 102-106. February 1959. (Jour. paper J-3461, Iowa Agr. & Home Econ. Exp. Sta. Projects 1256, 1336 and 1351.)

The experiments reported here were designed to (1) compare the dissipation of Thiodan residues on corn plants treated with Thiodan water emulsion and granulated formulations and (2) evaluate three methods of analyzing Thiodan residues. Field corn grown on the Iowa State U. farm near Ankeny, was used. When three to four feet tall it was treated by an emulsion applied at a rate of 1.5 lbs. of Thiodan per acre or a 5% granulated formulation applied at a rate of 20 lbs. per acre. The samples collected at specified times after treatment consisted of 10 plants each, all plants being cut about two inches above the ground. Each 10-plant sample was then cut, with a small feed chopper, into approximately two-inch pieces from which extracts were formed for the purpose of residue analyses.

One of the three analytical procedures used to estimate Thiodan residues was a biological assay method employing a six-point assay with aliquots of each residue extract; each standard and test assay consisted of three dose levels so chosen that the resulting mortalities of the insects were expected to fall between 15% and 85%. Three- to four-day-old female house flies taken from an insecticide-susceptible laboratory strain were used at the rate of 50 flies per dose in both test and standard assays. A measured volume of untreated plant extract had been added to each jar of treated extract. Then, to conserve similarity between the standard and test preparations, the same amounts of total plant extract were used at each dose level for both standard and test assays.

In analysis of the bioassay data a correction for natural mortality was applied according to Abbott's formula. Berkson's minimum logit chi-square method was followed. The statistical analyses included tests of linearity and parallelism. Results indicated that small but detectable residues persisted longer than nine weeks after

application of the insecticide. Approximately one week after application of the two treatment formulations of Thiodan there were no appreciable residue differences resulting from the treatments. The residue data obtained by the three analytical methods were all quite similar.

H. O. HARTLEY: "Changes in the outlook of statistics brought about by modern computers"—paper given at a conference held in Washington, D.C., on October 16-18, 1957. Proc. Third Conf. Design of Experiments in Army Res., Development and Testing. Office of Ordnance Research, U.S. Army, Durham, North Carolina. Pp. 345-363. 1958.

This paper assesses the effect of high-speed computers on statistical research and methodology. The first section deals with the impact of computers on the tabulation of statistical functions, classifying such tabulations by (a) the computational labor and cost of printing when publishing multivariate statistical tables and (b) the degree of difficulty of the underlying mathematical analysis, and pinpointing the use of computational devices in the various tabulation tasks so classified. Situations are illustrated by examples of both solved statistical problems and the approximate solutions of unsolved problems by Monte Carlo calculations.

The impact of computers on statistical data processing tasks is illustrated by the detailed discussion of an analysis of variance program and a program for multiple correlation and regression analysis. For the latter problem, high-speed facilities have been used to compute all possible $2^k - 1$ selections of independent variables out of a total of k independent variables for "predicting" a dependent y variable, and this situation is used to illustrate the danger of misusing computing facilities in a situation in which the theoretical background is of uncertain validity.

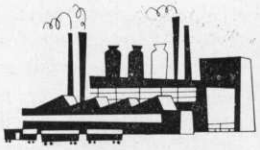
*HERMAN O. HARTLEY and Laurel D. Loftsgard: "Linear programming with variable restraints." Iowa State College Jour. Sci. 33:2, 161-172. November 15, 1958. (Jour. paper J-3494, Iowa Agr. & Home Econ. Exp. Sta. Project 1135.) Reprint Series No. 57, Statistical Laboratory, Iowa State College.

Linear programming methods are becoming increasingly important for analyzing economic situations. In particular, programming methods have been extensively applied to farm management problems, where maximum revenue defines optimum solutions. In these problems, the magnitude of attainable revenue depends on the alternatives of resource use and boundaries of the planning situation as represented by available resource supplies. This paper deals with the latter stipulation concerning resource supplies.

A more comprehensive method of programming is one that allows variation of resource supplies. That is, a method that determines continuous optimum solutions when one resource supply is varied within a relevant range and other resource supplies are held constant. One such method developed by Candler is a modified simplex solution for linear programming with variable capital restrictions. This paper discusses a different modification of the simplex solution with continuous variation of one restraint. It is believed that the method proposed here has considerable advantages for programming on high-speed computers. The procedure is numerically illustrated by use of a sample problem from Candler's article.

H. O. HARTLEY: "Estimation from incomplete data in industrial research"—paper presented at a symposium held at Virginia Polytechnic Institute, Blacksburg, Virginia, on August 5-8, 1958, and cosponsored by the Director of Guided Missiles, Office of the Secretary of Defense, and the Office of Ordnance Research. Proc. Stat. Techniques in Missile Evaluation Symp. Pp. 179-198. December 1958.

This paper constitutes a follow-up to an earlier one by Hartley in Biometrics ("Maximum likelihood estimation from incomplete data," 14:2, June 1958) but places an emphasis on examples of incomplete data arising in industrial research. The method previously described is applied to the following situations:



(1) Simple censored life testing, truncated at the upper end of the time of failure scale.

(2) Estimation of a mean dimension from gauge data—this is a case of censored data since only the *frequencies* of parts below the low gauge limit and above the high gauge limit and between the limits are available.

(3) Weight gauging, which is similar to (2) for the binomial distribution.

(4) Estimation of percentage defectives from curtailed inspection data—this can be seen to lead to a binomial distribution censored at the upper end.

(5) Various situations in which production data from two sources of production have been mixed up.

**DONALD R. HILL (Minnesota Mining & Manufacturing Co., St. Paul, Minnesota; Iowa State College & Bureau of Commercial Fisheries, U.S. Fish & Wildlife Service): "Some uses of statistical analysis in classifying races of American shad (*Alosa sapidissima*)"—paper presented at the AAAS-Biometric Society meetings held in Indianapolis, Indiana, on December 27-28, 1957. Fishery Bul. Fish & Wildlife Service. 59:147, 269-286. 1959. (Reprinted as Fishery Bulletin 147. Washington, U.S. Govt. Print. Off., 1959.)

Each year pound nets fished in the ocean off the coasts of New York and New Jersey catch large quantities of shad. The majority of those fish are believed to be native to the Hudson and Connecticut Rivers. To establish a management plan for the two rivers which would include the ocean fisheries, estimates of the racial composition of the catches must be made. In the past, that could be done only by means of tagging experiments. This paper is based on an M.S. thesis in statistics completed at Iowa State. An analysis of some meristic counts for shad is presented to support the racial theory. Samples were examined, and it was found that the meristic counts used could be considered representative of the populations. Analyses of variance of various characters gave evidence for the existence of races.

A discriminant function is presented which will correctly classify approximately 81 percent of a mixed sample of Hudson River and Connecticut River shad. The function was constructed from meristic data obtained from the Hudson River in 1939 and from the Connecti-

cut River in 1945. The mean value of this function is 74.103 for the Hudson for 1939 and 70.940 for the Connecticut for 1945. When meristic data collected from a sample of Hudson River shad in 1940 were substituted into the discriminant function, 16 out of 105 fish were incorrectly classified; this result is in good agreement with the theoretical 19 percent misclassification expected. The number of misclassifications can be considerably reduced if the individuals falling close to the midpoint between the two populations are not classified. By refusing to classify about one half of the sample, it is possible to reduce the number of wrong classifications to 3.7 percent. Several methods of estimating the population composition of a mixed sample of shad are presented.

R. H. Johnson, L. R. Brown, N. L. Jacobson and P. G. HOMEYER: "Effectiveness and practicability of some oils, penicillin, n-decyl alcohol, and lecithin in the control of alfalfa bloat"—paper presented at the 49th annual meeting of the American Society of Animal Production held on November 29-30, 1957 in Chicago, Illinois. Jour. Animal Sci. 17:3, 893-902. August 1958. (Jour. paper J-3388, Iowa Agr. & Home Econ. Exp. Sta. Project 1267.)

In a series of eight trials during the spring and summer of 1957, 36 steers on alfalfa pasture received various prophylactic agents in dry feed or in water before grazing twice daily. This report gives the results on average bloat incidence and severity and average daily weight gain. A subsequent report will present the interrelationships among forage composition, rumen fluid characteristics, weather, and incidence and severity of bloat.

Because of the large amount of data collected, IBM cards and machines were used to summarize and analyze the data. Analysis of variance and covariance and regression analyses were computed. Soybean oil, lard oil, and lecithin mixed with soybean oil significantly reduced bloat for several hours when fed at the rate of 0.25 lb. or more per animal at each feeding or at a rate of 2 percent in the drinking water; these agents also appreciably increased weight gains.

C. F. Foreman, N. H. Curry, P. G. HOMEYER and A. R. Porter: "A comparison of different types of stalls for dairy cattle"—paper presented at the 70th session of the Iowa Academy of Science held on April 18, 1958 in Des Moines, Iowa. Iowa State College Jour. Sci. 33:1, 43-53. August 15, 1958. (Jour. paper J-3419, Iowa Agr. & Home Econ. Exp. Sta. Project 1292.)

Thirty-three Holstein and nine Brown Swiss cows were divided into fourteen groups of three, each based on breed, weight, age, and stage of lactation. The cows within each group were assigned at random to the three types of stalls—comfort, tie and stanchion. Observations were made on cleanliness of cow and stall, bedding and labor requirement, and health and apparent comfort of cows. Data were analyzed by the analysis of variance.

C. F. Foreman, R. S. Allen, A. R. Porter and P. G. HOMEYER: "Comparison of alfalfa fed as soilage or silage as the only forage for lactating dairy cows." Jour. Dairy Sci. 41:12, 1730-1737. December 1958. (Jour. paper J-3436, Iowa Agr. & Home Econ. Exp. Sta. Project 1292.)

Twenty Holstein and Brown Swiss cows were paired by breed and as closely as possible by milk production and stage of lactation. All cows were treated alike during a two-week preliminary period. For the eight-week experimental period one cow in each pair was randomly assigned to soilage and the other to silage. The experimental period was followed by a two-week post-experimental period. Samples of soilage and silage were taken for chemical analyses. Daily milk weights produced by each cow were recorded, and weekly milk samples were taken for chemical analyses.

The gains in statistical efficiency from pairing cows within breeds were 304, 127, 78 and 203 percent for pounds of milk produced, percent total solids, percent fat and pounds 4 percent fat-corrected milk, respectively. Additional gains in efficiency by using covariance analysis of response during the experimental period on the corresponding response during the preliminary period were 2.5, 76.6, 31.5 and 10.1 percent for pounds milk produced, percent total solids, percent fat, and pounds 4 percent fat-corrected milk, respectively. Cows fed soilage on the average produced 5.7 ± 1.6 pounds more milk and 4.3 ± 1.4 pounds more 4 percent fat-corrected milk than cows fed silage produced.

F. Diaz, V. C. Speer, P. G. HOMEYER, V. W. Hays and D. V. Catron: "Comparative performances of baby pigs fed infant and baby pig diets." Jour. Nutrition. 68:1, 131-140. May 10, 1959. (Jour. paper J-3360, Iowa Agr. & Home Econ. Exp. Sta. Project 959.)

Two experiments were conducted to compare the relative value of commercially available human infant diets with previously tested baby pig diets when fed to baby pigs. Eight diets were tested in each experiment. In the first experiment two pens of four pigs each were fed each diet, and in the second experiment four pens of four pigs each were fed each diet. Analyses of covariance were used to interpret the data on weight gains.

DAVID V. HUNTSBERGER: *Elementary Principles of Statistics—Part* I (Preliminary edition). Dubuque, Iowa: Wm. C. Brown Book Co. 189 + v pp. Offset, spiral-bound. August 1958.

This book is an introduction to some of the basic concepts and techniques of statistical inference that play an important role in solution of problems arising in our increasingly complex society. The techniques and methods presented are those which are generally applicable in many spheres of human activity. An augmented hard-cover edition is scheduled for publication by Allyn & Bacon in 1961.

The book may serve as a text for a general course for students who want to know "what Statistics is all about" or who need to be familiar with at least the language and fundamental concepts of Statistics in order to achieve increased competence in their chosen fields. The material presented will provide necessary background for those planning to take more advanced courses in Statistics or its specialized applications. Examples and problems have been selected from a wide variety of subject-matter areas and in many cases represent unabridged results of actual samples and experiments or were abridged from real sets of data. The only mathe-

matical prerequisites are a knowledge of arithmetic and some exposure to algebra. Summation notation is widely used but is preceded by a fairly detailed exposition.

Since statistical inference is the primary consideration of the book, descriptive aspects of Statistics have been treated more briefly than is usual. However, two chapters have been devoted to empirical frequency distributions, their graphical representation, and descriptive measures with emphasis on those which are later employed in making inferences. These topics are included for two reasons: to familiarize students with topics which are in frequent use in many areas and to provide a springboard into and motivation for subsequent chapters on inductive statistics. Chapter headings of the present edition are as follows: Introduction; Empirical frequency distributions; Descriptive measures; Elementary probability; Populations, samples and theoretical distributions; Statistical inference I: normal populations; Statistical inference II: discrete data; and Regression and correlation. An appendix section contains reference tables.

Charlotte Roderuck, EMIL H. JEBE *et al.*: "Estimated dietary intake, urinary excretion and blood vitamin C in women of different ages." Jour. Nutrition. 66:1, 15-27. September 1958. (Jour. paper J-3304, Iowa Agr. & Home Econ. Exp. Sta. Projects 1028 and 113. Also Jour. series No. 857, Nebr. Agr. Exp. Sta., and Jour. art. No. 1824, Michigan Agr. Exp. Sta.)

The nutritional status of 569 women from five locations in the North Central states has been examined with respect to vitamin C. Whole blood, plasma or serum concentrations of vitamin C were related to the estimated dietary intake for the women taking part in the study. It was found that age was not associated with either the mean intake of vitamin C or its mean concentration in the blood. An ascorbic acid intake of 1.1 mg. or more per kg. of body weight from self-selected diets provides women with apparently satisfactory amounts of this vitamin.

Results from some 400-mg. load dose studies indicated that at low intakes basal urinary excretion of vitamin C exhibited random variation, but when the average daily intake exceeded 1.1 mg. per kg. of body weight the relation of basal excretion to intake was nearly linear. Beyond intakes of 1.25 mg. per kg. of body weight, the slope of the mean line of load dose excretion was less steep than at lower intakes.

Pearl Swanson, Elisabeth Willis, EMIL JEBE, *et al.*: "Food intakes of 2,189 women in five North Central states." Iowa Agr. & Home Econ. Exp. Sta. Iowa State U., Ames, Iowa. Res Bul. 468, Pp. 473-499. May 1959. (North Central Reg. Pub. No. 83.)

Nearly 2,200 women, ranging in age from 30 to more than 90 years and living in five North Central states, provided the 24-hour dietaries from which data summarized in this bulletin were obtained. The women interviewed in Iowa and South Dakota were selected by area-probability sampling methods, so that they represented all women over 29 years of age in each of those two states. Four other samples were drawn: one from Urbana, Illinois; two (one white, one Negro) from Lansing-East Lansing, Michigan; and one from St. Paul, Minnesota.

The data from these surveys were summarized to provide mean nutritive values of the 24-hour dietaries for food energy values in calories; protein values in grams; calcium in grams; iron, ascorbic acid, thiamine, riboflavin and niacin in milligrams; and vitamin A value in International Units. A considerable number of women in each sample reported days' diets of markedly low nutritive value even though mean amounts of most nutrients in the dietaries of white women approximated the allowances recommended by the National Research Council for groups of moderately active women 45 years old. Thus the diets of many women in this age group apparently need improvement, especially in regard to calcium, ascorbic acid and vitamin A. A special study of the Iowa sample indicated that daily food intakes providing more than 60 grams of protein in general furnished amounts of iron, thiamine, riboflavin and niacin that met recommended allowances.

Women in each sample were classified in five age groups (i.e., 30-39 years, 40-49, etc.). Mean intakes of most nutrients decreased slightly from the fourth through the seventh decade. Beyond this age, decreases in intake were more marked. Analyis of the data from the Iowa sample indicated that regressions of food energy, protein and calcium values of dietaries on age were significant, but those of ascorbic acid and vitamin A value were not.

In the two state-wide samples, women in each group living in the open country zone reported dietaries with mean values for energy and nutrients that were generally higher than those of dietaries reported by women of the same age living in the rural place zone and the urban zone. From 14 to 28 percent of the women in the five samples of white women were more than 20 percent above desirable weight. The mean energy values of diets of these over-weight women were from 100 to 200 calories below the coresponding values for diets of all women in each sample. In general, the data collected suggest that 1,600 to 2,000 calories per day may be adequate for the maintenance of normal body weight in women more than 30 years old following patterns of activity characteristic of modern life—the requirement decreasing with age.

**RAYMOND J. JESSEN (General Analysis Corp., Los Angeles, California; Iowa State U. & FAO) and Donovan J. Thompson: "Encuesta por muestreo de las fincas en la provincia de Buenos Aires, Argentina." Estadistica. 16:61, 464-504. December 1958.

This article, written in Spanish with a brief English summary section, deals with a design, description, and remarks on properties of a survey based on a sample which could be used under actual Latin American conditions for obtaining agricultural information quickly and efficiently, yet with high precision. The survey was a part of the plan for the Latin American Demonstration Center on Agricultural Sampling Techniques, which was held in Buenos Aires in 1955 with the authors serving there as experts for the United Nations' FAO.

Certain physical limitations essentially dictate the scope and extent of a survey of this sort. For example, the number of participants and the maximum time which can be reasonably devoted to field work—and therefore away from other training activities of the Center—keep the survey somewhat smaller than if these limitations were not imposed. Moreover, since the

survey was to be used as a teaching device, its logical structure should be kept simpler than would otherwise be advisable. Despite these restrictions, the survey needed to be reasonably efficient so as to demonstrate successfully the power and utility of sampling as a technique. Obviously the objectives of simplicity, small input of human and time resources, precision and efficiency were mutually somewhat conflicting. However, in the plan devised a reasonable compromise was attempted. The article is comprised of five main parts: (1) The sampling plan, (2) the field plan, (3) acceptance of the field work, (4) processing and (5) estimation.

The sampling design used was a standard stratified random scheme using area sampling units. However, a different scheme was used in "associating" farms with the sample areas. The usual method is to regard those farms whose "headquarters" are in the sample areas as sample farms and to ignore all other farms. In this survey all farms having any part lying within the boundaries of the sample area were regarded as sample farms and were therefore enumerated. In order to keep the estimating procedure unbiased, a weight was given to each farm, where the weight was simply the fraction of the farm lying within the sample area. Suitable data for such a weight are usually very easy to obtain. In this case, when compared to the standard technique, the new "inclusion" technique which was used only on "large" farms was found to reduce relative variance about 30 percent on the average and to greatly reduce biases due to erroneous decisions on the inclusion of "headquarters" farms.

*Oscar Kempthorne and Arne W. Nordskog: "Restricted selection indices." Biometrics. 15:1, 10-19. March 1959. (Jour. paper J-3462, Iowa Agr. & Home Econ. Exp. Sta. Projects 890 and 1039.) Reprint Series No. 59, Statistical Laboratory, Iowa State College.

The selection index procedure, which stems originally from the discriminant function idea of R. A. Fisher, was developed by Fairfield Smith in the case of varietal selection and by L. N. Hazel in the case of selection under genetic segregation. The general framework is that observations, x_i, $i = 1,2,\ldots p$, are visualized as having the structure

$$x_i = G_i + e_i$$

where G_i and e_i are uncorrelated random variables, and one wishes to construct a linear function of the x's, say $\Sigma\, b_i x_i$ $(= b' x)$, which best correlates with a linear function $\Sigma\, a_i G_i$ $(= a'G)$ in which the a_i are known and frequently referred to as economic genetic weights. A problem exists only because the G_i, the true values, cannot be determined, although one can perform studies which lead to the variance-covariance matrices of the x's and of the G's, say P and G respectively. Then b is given by the equation

$$b = p^{-1}\, Ga.$$

The case considered in the present paper is that in which one wants to select—on the basis of an index $\Sigma\, b_i x_i$—individuals for whom $\Sigma\, a_i G_i$ is as large as possible subject to restrictions. The restrictions are of the form that one or more of the G's or linear functions of the G's are to be kept constant. The best index was obtained, and an example illustrating the use of the index is presented. This is a more general case than the original one considered by Smith and Hazel in that theirs occurs as a special case when there are no restrictions.

*Oscar Kempthorne: "Random balance: an evaluation." Technometrics. 1:2, 159-166. May 1959. Reprint Series No. 64, Statistical Laboratory, Iowa State College.

The principle of random balance, which has been advocated by F. E. Satterthwaite, is that, when one wishes to examine the effects of a number of factors (usually large) on some output, one should choose the level of each factor in each treatment combination at random, possibly subject to a restriction on equal representation of levels. This principle was stated in a paper for which the present one is a discussion paper. It is concluded that the possible benefits from use of the principle are slight and that the case presented by its proponents is inadequate. These conclusions are based in part on research supported by the U.S. Air Forces under a contract monitored by the Aeronautical Research Laboratory, Wright Air Development Center.

*C. R. Henderson, Oscar Kempthorne, S. R. Searle and C. M. Von Krosigk: "The estimation of environmental and genetic trends from records subject to culling"—based in part on a paper presented at the 10th annual meeting of the Biometric Society (ENAR), in a joint session with the American Statistical Association on September 11, 1957, in Atlantic City, New Jersey. Biometrics. 15:2, 192-218. June 1959. (Jour. paper J-3458, Iowa Agr. & Home Econ. Exp. Sta. Project 890.) Reprint Series No. 62. Statistical Laboratory, Iowa State College.

A situation of rather wide scientific occurrence is the following. It is hypothesized that individuals have a true ability on which successive measures subject to error exist, but the occurrence of the successive measures depends on the values of prior measures. An agricultural example arises in a dairy herd, for which one may wish to hypothesize a true producing ability for each cow but where those cows which performed badly in their first record are removed from the herd. Similarly, individuals who perform only moderately on their first record and only moderately on their second record are removed from the herd after making the second record. A problem in the case of the dairy herd is to estimate environmental and genetic trends. The differential culling of cows prevents use of ordinary methods for multiclassified data.

Two methods are presented: The first, by Henderson, assumes that repeatability within defined groups is known, and the second, by Kempthorne and von Krosigk, assumes that repeatability is unknown. The relevance of the latter method to the estimation of repeatability is apparent, because it seems clear that commonly used methods for estimation of repeatability which do not take account of the culling that has occurred in the data will lead to estimates whose properties are unknown. The two methods presented here are exemplified at least partially by application to actual data.

Paul Peperzak, W. D. Shrader and Oscar Kempthorne: "Correlation of selected soil indices with plant growth on highway backslopes in Iowa"—paper

presented at the 38th annual meeting of the Highway Research Board, Division of Engineering and Industrial Research, National Academy of Sciences—National Research Council, held in Washington, D.C., on January 5-9, 1959. Highway Res. Bd.: Proc., Thirty-eighth Annual Meeting. 38, 622-637. 1959. (NAS-NRC Pub. 674.) (Jour. paper J-3303, Iowa Agr. & Home Econ. Exp. Sta.)

In an attempt to evaluate and analyze the problem of highway backslope revegetation in Iowa, a survey was made of backslope exposures along 3,500 miles of highways in that state. Some 55 roadcuts exhibiting differences in vegetation among the various zones within the same slopes were studied in greater detail. Plant growth was measured on 241 sampling sites within these cuts, and soil samples from the same sites have been described and analyzed on 20 preselected soil properties.

A description of backslope materials of major occurrence is made on the basis of analytical data. Correlations between plant yields and soil properties were statistically examined and analyzed by the chi-square method of association and, subsequently, by multiple regression. Regression statistics indicate that of all factors nitrifiable nitrogen and available phosphorus exert the largest positive influence on plant growth in backslope materials of low clay content (till, loess, buried A_2 horizons). In the same group of materials exchangeable hydrogen and sand content are the main negative factors. Plant growth on clay-rich materials (gumbotil, ferretto, and B horizons) appears to be increased by available and nitrifiable nitrogen, and decreased by high capillary porosity and sand content.

W. F. Kwolek (Lederle Laboratories, Pearl River, New York; Iowa State College) and T. A. Brindley: "The effects of the European corn borer, *Pyrausta nubilalis* (Hbn.), on corn yield." Iowa State College Jour. Sci. 33:3, 293-323. February 15, 1959. (Jour. paper J-3516, Iowa Agr. & Home Econ. Exp. Sta. Project 1193.)

Data from split-split plot experiments conducted at Ankeny, Iowa, Waseca, Minnesota, and Wooster, Ohio from 1953 to 1956 for Regional Project NC-20 were considered for study, by use of regression methods, of the loss in yield of corn relative to the number of borers or cavities. The experiments involved two corn hybrids—a susceptible single cross and a resistant one, two planting dates and eight combinations of first and second brood infestations. The same experimental design and methods were used in all three states. Midsummer dissections were made to obtain an estimate of the first brood infestation, and fall dissections were used in estimating the number of borers and cavities resulting from both broods.

The most important point established by the data was the inconsistency from state to state in the relative importance of the two broods to corn yield. The statistical analyses also indicated that time of dissection was important: here again there were differences among states. In terms of the number of meaningful estimating equations obtained or the relative variation of the yield loss-regression coefficients, no differences were observable in the effectiveness of borers or cavities for estimating yield losses. Cavities were suggested as being a more stable criterion in the presence of interactions between first and second broods. The relation between populations of the two broods was found to be important when studying yield losses and suggests the use of all possible infestation level-brood combinations. When the computation of loss equations pooled over years was considered, the resistance of the hybrid was a factor in the success of obtaining a significant regression equation, particularly with first brood populations.

Ray Mickey (General Analysis Corp., Los Angeles, California; Iowa State College): "Some bounds on the distribution functions of the largest and smallest roots of normal determinantal equations." Annals Math. Stat. 30:1, 242-243. March 1959.

A lower bound on the distribution function of the smallest root and an upper bound on the distribution function of the largest root are presented for normal determinantal equations. These theoretical results were obtained in connection with work carried out at the Statistical Laboratory under an AEC contract for the application of statistical ideas and methods to the problem of uranium ore exploration.

Augusto J. de Oliveira (Estacao Agronómica Nacional, Lisbon, Portugal; Iowa State College): "Analysis of a group of experiments on oats. II—Incomplete data." Agronomia Lusitana. 20:2, 155-176. 1958. (Jour. paper J-3356, Iowa Agr. & Home Econ. Exp. Sta. Project 1176.)

This is the second of two papers based on an M.S. thesis in statistics completed at Iowa State College and summarized in the 1957-58 Annual Report of the Statistical Laboratory (p. 32). The earlier paper concerned the analysis of complete data derived from groups of related trials on oats. It had emphasized that the combined analysis of groups of experiments meets special problems not encountered in single experiments. For the case of groups of oats variety trials with the same varieties but different design and unequal numbers of replications, an unweighted analysis was then exemplified.

In the present paper, the lack of a general and quick method for handling incomplete data for groups of experiments of types (i), experiments with varying numbers of treatments for a set of locations or years, and (ii), experiments with varying numbers of treatments over a set of locations and years, is pointed out. For case (i), with incomplete data, an iterative approach to the method of fitting constants, which allows the adjustment of the treatment means and the computation of the standard error for any comparison, is described. A method for the combined analysis of nonorthogonal experiments of case (ii) is also considered. Data concerning the series of "Elite" oat trials conducted at several places in Iowa during the period 1950-1954 are used to illustrate the computations of average responses and respective errors for the two types of groups of experiments. Some conclusions of practical value about these tests on oats are given.

J. N. K. Rao: "Acknowledgement of priority." Annals Math. Stat. 30:2, 610. June 1959.

Credit is given to earlier work by R. G. Laha which is relevant to a note published by J. N. K. Rao on "A characterization of the normal distribution" in the Annals of Mathematical Statistics, 29:3, 914-919, September 1958.

GEORGE W. SNEDECOR: "Chi-squares of Bartlett, Mood, and Lancaster in a 2^3 contingency table"—Query and Answer. Biometrics. 14:4, 560-562. December 1958.

G. TINTNER: "Eine neue Methode für die Schätzung der logistischen Funktion"—based on a paper presented for the Biometric Congress held in Linz, Austria, on September 30-October 3, 1956. Metrika. 1:2, 154-157. 1958.

A linear differential equation of the first order is developed for the reciprocal of the logistic function. This permits a rapid estimation of the constants. The method is applied to decennial Swedish population data for 1850-1950.

G. TINTNER: "The use of mathematics in econometrics and economic statistics" (in Arabic), translated by Ibrahim Hilmy Abd-al-Rahman. Readings in the Social Sciences. No. 1, pp. 105-124. Winter 1958-59. (Published by the Social Sciences Section, UNESCO Middle East Science Cooperation Office, Cairo, Egypt, with the cooperation of the Dar Al-Ma'aref Printing House.)

This is an Arabic translation of a paper, with the same title, by Gerhard Tintner which first appeared in the International Social Sciences Bulletin (6:4, 640-651, 1954).

GERHARD TINTNER (Iowa State College; U. of Vienna): "Einkommenselastizitäten im österreichischen Konsum—Ökonometrische Untersuchungen zur österreichischen Konsumerhebung 1954/55." Monatsberichte des Österreichischen Institutes für Wirtschaftsforschung. 32: Supplement No. 57, 1-18. February 1959.

This investigation is based upon a random sample of 7,000 urban households. Income elasticities are computed for 22 groups of commodities for the urban population in Austria for 1954-55 and are also computed for 62 types of food consumption. Income elasticities are given separately for entrepreneurs, white collar workers, manual workers and retired people. The differences in income elasticities between social groups are investigated statistically. The problem of homogeneity with respect to the number of people in the household is examined—as are quality elasticities, which are given for 21 commodities. The results are compared to other investigations in Germany, Sweden, France and England.

*ROBERT F. WHITE (U. of Wyoming; Iowa State College) and Joseph G. Graca: "Multinomially grouped response times for the quantal response bioassay"—paper presented during the meetings of the Biometric Society and the American Association for the Advancement of Science held in Indianapolis, Indiana, on December 27-28, 1957. Biometrics. 14:4, 462-488. December 1958. (Jour. paper J-3510, Iowa Agr. & Home Econ. Exp. Sta. Project 890.) Reprint Series No. 58, Statistical Laboratory, Iowa State College.

The paper is concerned with a method for analyzing quantal response data in which the response times have been "multinomially" grouped into intervals by the fact that each individual has been observed only at several prespecified times, rather than continuously. Particular attention is given to the model which may be represented by

$$y = a + bx + ct + dxt$$

where x and t are the values of the dose and time metameters and y is, say, the logit of the response at that dose and time and where in some cases d may be assumed to be zero. Since the response numbers are accumulated for the successive times within a dose, the observed y values are not independent within doses. This introduces some complexity into the analysis which is at least partly resolved by the use of an outlined minimum modified chi-square method for estimating a, b, c, d. Methods of choosing metameters are discussed, and an example is given in which the dose metameter is log dose and the time metameter is the reciprocal of the square root of time.

Abstracts of Unpublished Papers Presented at Professional Meetings

OLIVE JEAN DUNN (U. of California at Los Angeles & Iowa State College): "Estimation of the medians for dependent variables"—paper presented at the Cambridge. Massachusetts meeting of the Institute of Mathematical Statistics held on August 25-28, 1958. Annals Math. Stat. 29:4, 1279. December 1958.

HERBERT B. EISENBERG: "Bayesian lot-by-lot sampling inspection"—paper given by title at the 1959 Eastern Regional meeting of the Institute of Mathematical Statistics, held on March 19-21, 1959, in Pittsburgh, Pennsylvania. Annals Math. Stat. 30:2, 624. June 1959.

JOHN LEROY FOLKS: (Texas Instruments, Inc., Dallas, Texas, & Iowa State College): "Comparison of designs for exploration of response relationships"—paper presented at the 118th annual meeting of the American Statistical Association, held in Chicago, Illinois, on December 27-30, 1958. Jour. Amer. Stat. Assn. 54:286, 494. June 1959.

J. ARTHUR GREENWOOD (Iowa State College & Harvard U.) and David Durand: "Aids for fitting the Pearson type III curve by maximum likelihood. (Preliminary report)"—paper presented at the Cambridge, Massachusetts meeting of the Institute of Mathematical Statistics. Annals Math. Stat. 29:4, 1280. December 1958.

JOHN GURLAND, with Roger S. McCullough (see McCullough).

H. O. HARTLEY: "Some problems in linear and nonlinear programming"—paper presented at the 118th annual meeting of the American Statistical Association and the annual meeting of the Biometric Society (ENAR), held in Chicago, Illinois, on December 27-30, 1958. Biometrics. 15:2, 336-337. June 1959.

V. W. Hays, D. L. Frape, P. G. HOMEYER, V. C. Speer and D. V. Catron: "Factors contributing to within treatment variability in baby pig nutrition experiments"—paper presented at the 50th annual meeting of the American Society of Animal Production held in Chicago on November 28-29, 1958. Jour. Animal Sci. 17:4, 1160-1161. November 1958.

L. R. Brown, R. S. Allen, R. H. Johnson, N. L. Jacobson and P. G. HOMEYER: "Levels of various blood components in cattle grazing alfalfa pasture and their possible relationship to bloat"—paper presented at the 50th annual meeting of the American Society of Animal Production. Jour. Animal Sci. 17:4, 1188. November 1958.

R. H. Johnson, L. R. Brown, R. S. Allen, N. L. Jacobson and P. G. HOMEYER: "Further observations on bloat etiology, prophylaxis and therapy"—paper given at the 50th annual meeting of the American Society of Animal Production. Jour. Animal Sci. 17:4, 1219-1220. November 1958.

Ned Raun, Edmund Cheng, Arthur Raun, Stanley Balloun and PAUL HOMEYER: "Radioactive tracer technique for assaying goitrogenic residues in beef tissues"—paper presented at the 50th annual meeting of the American Society of Animal Production. Jour. Animal Sci. 17:4, 1227. November 1958.

P. G. HOMEYER, R. L. Preston and W. Burroughs: "The design and interpretation of a bioassay for detecting small quantities in the presence of interfering substances"—paper presented by title at the 4th International Biometric Conference held in Ottawa, Canada, from August 28 to September 2, 1958. Biometrics. 15:1, 152-153. March 1959.

O. KEMPTHORNE: "Biometrical relations among relatives with reference to selection theory"—paper presented at the 4th International Biometric Conference. Biometrics. 15:1, 140. March 1959.

A. W. Nordskog and O. KEMPTHORNE: "Importance of genotype-environmental interactions in random sample poultry tests"—paper presented at the 4th International Biometric Conference. Biometrics. 15:1, 144-145. March 1959.

OSCAR KEMPTHORNE: "Experiments versus surveys"—paper given at the 118th annual meeting of the American Statistical Association. Jour. Amer. Stat. Assn. 54:286, 498. June 1959.

OSCAR KEMPTHORNE, with George Zyskind (see Zyskind).

ROGER S. MCCULLOUGH and JOHN GURLAND: "Power and control of size of some optimal Welch-type statistics"—paper presented at the Cambridge, Massachusetts meeting of the Institute of Mathematical Statistics. Annals Math. Stat. 29:4, 1282. December 1958.

G. TINTNER: "La théorie des jeux stratégiques, les programmes linéaires et l'analyse input-output"—paper given at the 29th European Congress of the Econometric Society held in Luxembourg on August 28-30, 1957. Econometrica. 26:3, 458-459. July 1958.

GERHARD TINTNER: "An input-output model and other econometric studies for Austria"—paper presented at the American winter meeting of the Econometric Society held in Philadelphia, Pennsylvania, on December 27-30, 1957. Econometrica. 26:4, 610. October 1958.

GEORGE ZYSKIND (U. of North Carolina & Iowa State College) and OSCAR KEMPTHORNE: "The role of treatment error in comparative experiments"—paper given at the 118th annual meeting of the American Statistical Association. Jour. Amer. Stat. Assn. 54:286, 508-509. June 1959.

Book Review

GERHARD TINTNER: *Moderne Methoden in der Agrarstatistik*. Heinrich Strecker. Einzelschriften der Deutschen Statistischen Gesellschaft Nr. 8. Wuerzburg, Germany: Physica-Verlag, 1957. Pp. 141, 18 tables, 1 map. D.M. 17.50. Paper. Reviewed in Jour. Amer. Stat. Assn. 53:283, 756-757. September 1958.

Teaching

The Department of Statistics in the Division of Science[1] at Iowa State offers work leading to the degrees of Bachelor of Science, Master of Science and Doctor of Philosophy with majors in statistics. Each major is built around a common core of courses in theory and methods, with other courses being chosen to fit the individual student's background and interests. At all levels, the program in statistics is designed to emphasize the close relationship between sound applications and modern statistical theory. The Department also offers minor and supporting work in statistics. Where desired, a joint-major program may often be arranged between statistics and a substantive field of application for the Ph.D. degree.

Training facilities include two student laboratory rooms equipped with 53 electric calculating machines for course instruction and for other student use during nonclass hours. Use is also made of the high-speed computing equipment and electrical equipment for punched-card analysis of data which are located in the new Cyclone Computer Laboratory, the Statistical Laboratory Computing Service and the Business Office Data Processing Service.

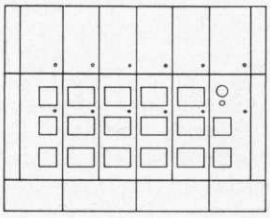
With the 1958-59 additions, the Department's collection of reprints now contains nearly 3,900 articles considered important in theoretical or applied statistics. These are kept for student and staff reference, along with graduate theses, various statistical journals, reference books and other publications obtained on an exchange, loan or gift basis.

In the summer of 1959 the Department and the Statistical Laboratory joined with the U. of Wyoming's Statistics Dept. in presenting a Summer Institute for College Teachers of Statistics, held on the Wyoming campus under National Science Foundation sponsorship.

[1] Renamed College of Sciences & Humanities effective July 1, 1959.

Course Offerings in Statistics

Interest in training in scientific machine computing methods was stimulated by the prospects of completion of the main unit of the Cyclone, an Illiac-type high-speed computer being built on the campus. During the spring Stat. 580 was offered in two sections: one, taught by H. O. Hartley, emphasizing programming for the IBM 650 and numerical analysis, the other, taught by Hartley and Ralph Schauer (assistant professor of electrical engineering), which placed more emphasis on programming for the Cyclone. Permission had been given by Dr. L. W. Von Tersch, head of electrical engineering at Michigan State U., for Iowa State to reproduce a Mistic programming manual for use as the first instruction manual for the Cyclone. The original manual was prepared by the Michigan State Computer Laboratory staff and issued in March 1958.



The courses given at Iowa State by the Dept. of Statistics during the 1958-59 school year are listed below. Enrollments in the introductory undergraduate course, Stat. 201, continued to grow. Over 380 students completed the five-credit course within the year. Thus, enrollment in this beginning course has more than doubled since the 1956-57 year.

For Undergraduate Students Only

201	Principles of Statistics (3 sections each; all with labs)	FWS[2]	Dorff, Huntsberger, Krane (WS only)
327	Elementary Business Statistics (with lab)	F	Jebe
341,342	Introduction to Theory of Statistics[3]	FW	Huntsberger

Primarily for Graduate Minors and Undergraduates

401,402	Statistical Methods for Research Workers (with labs)		
	A&B. Animal sciences and plant sciences	FW	Bancroft (401); Weaver (402)
	C&E. Physical sciences, math., engineering and undergrad. section	FW	Dorff (401); Huntsberger (402)
	D. Economics	FW	Krane
	F. Behavioral sciences (psych., soc., child development, voc. ed.)	FW	Wolins
401,402	Same (2 sections each, with labs)	WS	Jebe (401); Bancroft (402)
411	Experimental Design for Research Workers	S	Huntsberger
421	Survey Designs for Research Workers	S	Jebe
431	Elementary Statistical Quality Control	S	Richards (Dept. Ind. Engr.)
446,447, 448	Statistical Theory for Research Workers (W 2 sections)	FWS	David; Bancroft (447 only)
480	Processing of Data	F	Mosier
481,482	Processing of Data	WS	Mosier
499	Special Problems	F	Bancroft
499	Special Problems	W	Krane, Weaver

Primarily for Graduate Majors and Minors

501	Intermediate Statistical Methods	F	Snedecor
505	Psychological Statistics	S	Wolins
511,512	Design of Experiments	WS	Kempthorne
521,522	Design of Surveys	WS	Hartley & Krane (521); Hartley (522)
531	Industrial Statistics: Sampling Inspection	F	David
535	Biological Statistics	S	Gurland
536	Genetic Statistics	F	Kempthorne
538	Elementary Econometric Statistics	F	Tintner
541,542, 543	Theory of Statistics	FWS	Buehler
580	Scientific Machine Computing		
	A. IBM 650 section	S	Hartley
	B. Cyclone section	S	Hartley & Schauer (Dept. Elect. Engr.)
599A	Special Topics (approximations to statistical distributions)	WS	Hartley
599B	Special Topics in Methods		
	(for bioassay)	FWS	Gurland
	(for fisheries research)	FW	Bancroft
	(for scientific computing)	S	Hartley
	(general)	S	Kempthorne
599B	Special Topics: Operations Research	W	Tintner
599D	Special Topics in Design of Surveys	F	Bancroft

Primarily for Advanced Graduate Majors

601	Advanced Statistical Methods	F	Hartley
611,612	Advanced Design of Experiments	WS	Kempthorne
616,617	Probability	WS	Langenhop (Dept. Math.)
641	General Theory of Linear Hypothesis	F	Kempthorne
642	Distribution Theory	F	Buehler
643	Theory of Estimation and Testing of Hypotheses	W	Gurland
647	Multivariate Analysis	S	Gurland
699	Research	FWS	Bancroft, David (FW only), Gurland, Hartley, Jebe (FW only), Kempthorne

Summer quarter

The summer quarter is comprised of two six-week sessions such that students may register for either one separately or for both. The following courses were given in sessions beginning within the fiscal year—i.e., as parts of the 1958 and 1959 summer quarters. (Those given in the second half of the 1959 summer quarter will be listed in the next Annual Report.)

Second Summer Session 1958

402	Statistical Methods for Research Workers (with lab)	Jebe
411	Experimental Design for Research Workers	Homeyer
421	Survey Designs for Research Workers	Williams
448	Statistical Theory for Research Workers	Buehler
499	Special Problems	Jebe
599A	Special Topics	Gurland
699	Research	Gurland, Kempthorne

First Summer Session 1959

401	Statistical Methods for Research Workers (with lab)	David
447	Statistical Theory for Research Workers	Larson
499	Special Problems	David, Mosier
699	Research	Bancroft, Gurland, Hartley, Jebe, Kempthorne

Postdoctoral Studies

During the 1958-59 year R. O. Collier, associate professor of educational psychology at the U. of Minnestoa, was at the Statistical Laboratory under a National Science Foundation postdoctoral fellowship for the purpose of working with O. Kempthorne on the relevance of experimental design concepts to psychological experimentation and to broaden his knowledge by auditing statistical courses of relevance to psychology. C. R. Weaver, Ohio Agricultural Experiment Station statistician and associate professor, Ohio State U., on sabbatical leave, resumed postdoctoral studies during the winter

[2] F—fall quarter 1958; W—winter quarter 1959; S—spring quarter 1959.

[3] Certain courses were double-listed as available to students for credit under either the Dept. of Statistics or another department as each individual preferred. Stat. 341, 342, 541, 542, 543, 580, 641, 642, 643, 646, 647, 649 and 688 had primary listing in Statistics but were also listed by Mathematics. Similarly, Stat. 438, 538, 638 and 646 were also listed by Economics; Stat. 505 by Psychology and Stat. 536 by Genetics. However, Stat. 616 and 617 had primary listing by Mathematics.

quarter for a program which he began in the 1957 spring term. This statistical training program, a cooperative arrangement by Iowa State College and the Ohio station at Wooster, is directed toward meeting the statistical needs of an agricultural research station.

Degrees Granted and Positions Taken

Ph.D. degrees with statistics major or joint major were granted to three students during the 1958-59 year: i.e.,

George Zyskind (August 1958, under O. Kempthorne), who went to the U. of North Carolina for a year of postdoctoral research in the Dept. of Statistics.

Marion R. Bryson (August 1958, under H. O. Hartley), who had already been engaged on a research appointment with the Office of Ordnance Research, U.S. Army Ordnance Corps, arranged through Duke U. (see p. 5).

Howard L. Taylor (joint major in statistics and economics, November 1958, under H. O. Hartley and Gerhard Tintner), who had taken an appointment as mathematical analyst with the Gulf Research & Development Co., Pittsburgh, Pennsylvania, starting on the 1st of the preceding month.

M.S. degrees were awarded to the following in the 1958-59 period:

T. Neil Throckmorton (August 1958, under E. H. Jebe), who remained at the Statistical Laboratory for doctoral studies.

Rodney P. Basson (February 1959, under O. Kempthorne)—biometrician, Dept. of Agriculture, Union of South Africa—who continued graduate study in statistics at Iowa State for another quarter and then, after a short period of additional study at North Carolina State College, returned to South Africa where he was assigned by the Union Dept. of Agriculture to the U. of the Orange Free State, Bloemfontein, as lecturer starting in January 1960.

Ilbok Lee (May 1959, under John Gurland), who remained at the Statistical Laboratory to work toward a Ph.D.

Titles and summaries of the six masters' and doctoral theses are given in the next section of this report.

Six students were recipients of B.S. degrees with statistics majors during the year: i.e.,

Thomas D. Roseberry (July 1958), who accepted a biostatistics traineeship here supported by a National Institutes of Health training grant and began M.S. studies in statistics in September.

Richard W. Swanson (July 1958), who accepted a position involving statistical work with the Stanford Research Institute in California after graduation.

Gilbert B. Brook (November 1958), who accepted temporary employment in Rochelle, Illinois, until called into naval service.

Daniel E. Wiese (November 1958), who was on military active duty for six months and then accepted a position, beginning in November 1959, with Connecticut General Life Insurance, Hartford, Connecticut.

John W. Horch (B.S. May 1959), who joined the Finance Dept., Boeing Airplane Co., Wichita, Kansas.

Richard W. Hunt (May 1959), who started work on June 15 as statistician in the Materials Engineering Division, Westinghouse Electric Corp., Youngwood, Pennsylvania.

A certificate was awarded by the Statistical Laboratory in August 1958 to Pedro R. Altemir, FAO fellow, for completion of a 10-month training program in agricultural statistics. This program included academic course work in theoretical and applied statistics, combined with observer participation in the Laboratory's survey work. Altemir then worked until December as part of the Survey Group. Subsequently he returned to Buenos Aires, Argentina, to a position as research worker in the Division of Special Studies, Direccion Nacional de Estadistica y Censos.

During the 1958-59 fiscal year, 16 students at Iowa State received doctorates with minors in statistics and with majors in other fields.

Summaries of Unpublished Theses

Rodney Peter Basson: "Incomplete block designs augmented with a repeated control." M.S. thesis. Iowa State College Library. February 1959.

The use of incomplete block designs is indicated when it is desired to compare a number of treatments, t say, with groups (or blocks) of k experimental units, where k is less than t. In some situations there may be, in addition to the treatments(or varieties) to be compared, a standard treatment with which the "new" treatments are to be compared. One may be interested also in more precision for comparisons of "new" treatments with the standard treatment than for comparisons among new treatments. This can be accomplished in various ways, a fairly obvious one being to include the standard treatment in each block. If, for example, one has a standard variety and 16 new varieties one may set up a balanced lattice in blocks of four for the new varieties and then put the standard variety in each block.

This thesis is concerned with the analysis and efficiency of standard incomplete block designs augmented with a repeated control in each block. The standard incomplete block designs considered are the partially balanced incomplete block (p.b.i.b.) designs of Bose and Nair with two associate classes and three associate classes. Analytical procedures for augmented two-dimensional lattices, cubic lattices, balanced incomplete block designs and simple rectangular lattices arise as particular cases. Some of the consequences of the use of these designs are discussed. The intuitive impression that they lead to better comparisons with the standard or control is, of course, borne out, but the use of the control in each block does not increase the precision of comparisons of nonstandard treatments to an appreciable extent.

Marion Ritchie Bryson: "Analysis of farm-and-home-development benchmark survey results and associated statistical problems." Ph.D. thesis. Iowa State College Library. August 1958.

This study is the outgrowth of some problems which arose in connection with a research study, the purpose of which was to measure the effectiveness of a farm-and-home-development extension program. In order to make

the desired measures, a benchmark survey was conducted on 442 young farm families in ten Iowa counties. Farm families in five of these counties were to receive the farm and home development, and those in the other five were not. After a period of four years, the same families were to be interviewed again and the progress of the farm-and-home-development families, with respect to several criteria, was to be compared with the progress of the control group.

Within each county a stratified two-stage sample with one primary per stratum had been taken. The primaries were chosen with equal probability, and the farms within the primary were chosen at a fixed rate. It was impossible to determine prior to a visit whether or not a farm fell into the eligible population, defined by restrictions on age, marital status and size of operation. Therefore, in order to estimate the appropriate size of a primary, a pilot sample had been drawn, which provided an advance estimate of the proportion of total farms which were eligible.

The first problem considered in the thesis was that of estimating the population number of eligible farms in each selected primary. From this estimate, the sample proportion of eligible farms in each primary was computed. The variance of the variable sample size was worked out, along with the covariance of the sample sizes in two primaries. The covariance is negative since the total sample size in a county is a fixed constant.

The second problem was that of comparing the benchmark counties, using benchmark data, on several criteria. The principal statistical problem here was the estimation of the variances when only one primary was drawn in each stratum. It was impossible to evaluate the program at the time of writing of this thesis since the follow-up survey had not been done. The third problem was a comparison of the characteristics of these families who cooperate with the farm-and-home-development program and the characteristics of those who do not.

The fourth problem was a study of inverse binomial and hypergeometric sampling. The work in this area was reviewed and enlarged upon. Both the problems of the distribution of sample size and the estimation of proportions were considered. The correspondence of the results for finite and infinite populations was checked. The final problem considered was that of estimating the proportion of a population which fell into a given class by observing the class into which each element was placed by each of two classifiers. It was assumed that each element was subject to classification error, depending upon who was classifying and into which class the element fell.

ILBOK LEE: "Some aspects of biological assay of insecticidal residues." M.S. thesis. Iowa State College Library. May 1959.

This study considered principally an application of statistical techniques to the analysis of bioassay data in the case of a trichotomous response of houseflies exposed to an insecticide. The three possible outcomes are alive, moribund and dead. The main problem involved a comparison of techniques in current use with new techniques based on utilization of the counts of moribund flies. The assumptions underlying these procedures were discussed in the cases of both dichotomous and trichotomous responses.

Results of the analyses show that the estimated variances of parameter estimates are consistently smaller in the case of a trichotomous response using all the information in the data than in the case of a dichotomous response based on pooling the numbers of moribund and dead flies. A method based on the use of a linear discriminant function of moribund and dead flies was also employed, and the asymptotic variance of the log relative potency so obtained was found to be very similar to that of a weighted estimate based on pooling moribund with dead flies and moribund with alive flies.

HOWARD LEWIS TAYLOR: "Statistical sampling for soil mapping surveys." Ph.D. thesis. Iowa State College Library. November 1958.

The problem considered in this study was the determination of an optimum sampling design to provide the basic information required for a national inventory of soil and water conservation needs. In particular, the optimum size of sampling unit was determined and methods were developed for estimating acreages of various soil classifications for each county.

The decision regarding the optimum size of sampling unit was based primarily on evidence about the variability of different-sized units and information about the cost per unit. The approach taken in regard to an optimum sampling unit was to establish a variance function showing the relationship between variance and size of unit and a cost function indicating how costs change with size of unit. Based on these two functions, an expression was obtained for the optimum size of unit. The procedure used was to determine the size of unit which gave estimates with minimum variance for a certain fixed expenditure. In this connection, certain homogeneity considerations were also examined. The recommended size of sampling unit was different for different types of land. For irrigated land a 40-acre unit was the optimum. For general farming and dry-farming land a unit of 160 acres was preferred. A 640-acre unit was recommended for range land.

Several estimators were considered for possible use in the estimation and tabulation phase of the project. The one suggested for general use was a ratio estimator having total acreage as the auxiliary variate. Various others were considered for special problems. Two types of problems involving the pooling of data from "similar counties" were considered. One estimator based on a pooling procedure appeared to offer considerable reduction in the variance of county estimates. Other estimation problems which were examined included utilization of information from outside the sample, estimation of the acreage of present land use when complete data from a previous mapping were available, and a special problem regarding subsampling. Although complete variance formulas for the estimators were developed and evaluated in key examples, a short-cut method in graphical form, giving approximate values for relative standard errors, was presented for general use.

THOMAS NEIL THROCKMORTON: "An analysis of a modified cross-over design." M.S. thesis. Iowa State College Library. August 1958.

This study deals with the analysis of an experiment in which treatments are applied in sequence. With four observation periods and two treatments there are six

possible sequences in which the two treatments are equally represented. This set of six sequences gives us the basic layout of the design as devised by Professors Kempthorne and Jebe.

The specific experiment discussed in the thesis is one conducted by the Iowa Agricultural and Home Economics Experiment Station and supported in part by the Carpet Institute, Inc., of New York. Its purpose was to investigate the differences for carpeted floors versus smooth floors in terms of time, materials and costs required for cleaning and maintenance. The notation and terminology used refer to this specific experiment but the analysis presented for the design would be valid in other areas of experimental work.

In experiments of this type, biases may exist in the estimates of treatment effects if the presence of residual, or carry-over, effects from the previous treatment is ignored. Therefore, the analysis of variance is presented for each of four different models. One model assumes complete additivity and ignores residuals while the other three models account for period-treatment interactions and various types of residual effects. Another problem encountered in this type of design is the presence of correlation among errors. Although least squares still gives us unbiased estimates, the error mean square in the analysis so obtained may not provide an unbiased test for treatment effects. Therefore the finite model is derived and used to investigate the error content of the various mean squares.

GEORGE ZYSKIND: "Error structures in experimental designs." Ph.D. thesis. Iowa State College Library. August 1958.

The primary objective throughout the thesis has been the general formulation of certain basic aspects of problems of experimental designs to which the application of variance analysis is appropriate. The thesis begins with some consideration of the relationships of nestings and crossings. A method for expressing the typical response as a sum of uniquely defined and physically meaningful linear functions of partial means, called population components, is specified and a proof is given that for any given arbitrarily general type of population structure such decomposition is always identical. Balanced population structures are then defined and a number of general properties of such structures proved.

With balance, the notion of subscripts belonging to the rightmost bracket becomes an especially convenient one. A subscript belongs to the rightmost bracket of a group of subscripts if no subscript of the group is nested in it. The special properties which these subscripts satisfy induce certain "nice" properties in the population components and hence ensure the possibility of construction of "complete" analysis of variance tables. Further, they are also at the root of the lack of correlation between induced sample means in the different types of population components when the actual experiment is carried out; and so they are instrumental in giving rise to simple forms of expected values of squares of sample means.

Balanced samples from balanced population structures are investigated. Results for expected values of squares of sample means are obtained in both the σ^2 and Σ forms. The Σ's are special linear functions of σ^2's, and are defined in terms of excess rightmost bracket letters of the σ^2's. The finite population corrections in expectations of squares of sample means are induced only by the type of samples taken in the rightmost brackets of the various population components. The role of the Σ's is that they formally and automatically remove all the finite population correction factors involved.

The above property of the Σ's is retained when, instead of pure sampling, one considers actual experimental design situations, and hence the additional relationship of random confounding. Thus, the Σ forms of expected values of squares of sample means are essentially invariant under a wide variety of experimental situations, and in this sense the Σ's may be said to form a "canonical" set of parameters.

With randomized experiments various types of relationships may exist between the sample and population sets of subscripts. The notion of ambivalence is introduced to characterize the various possibilities. It is shown that, when the ambivalence relation is complete, simple and well-defined Σ forms of mean squares for the lines of the sample analysis of variance result. This is the case with the usual analyses of variance of various generalizations of the completely randomized, the randomized block and the split plot designs.

Investigation of experimental situations in which the application of treatments is explicitly envisaged to be subject to error shows that here also under many circumstances the standard Σ forms for expected values of squares of sample means are retained. Hence, with complete ambivalence, i.e. proper sample notations, the expected values of mean squares of the sample analyses of variance have simple and easily specifiable Σ forms which follow immediately from the general development given in the thesis.

Graduate Appointments and Fellowships

Able graduate students who are interested in statistics as it may be applied in the fields of public health and medical research may apply for biostatistics traineeships, which are made available each year for study at the M.S. or Ph.D. level. These appointments permit carrying essentially a full course load and include an annual "experience" period at an off-campus medical or public health research center. They are supported by a National Institutes of Health grant to the Dept. of Statistics which extends into 1963.

A General Electric fellowship in statistical methods, which provides for a stipend of between $1,750 and $2,500 (varying with the recipient's marital and dependency status) and for tuition, was offered for a third year, for 1959-60. Outstanding students not already enrolled at Iowa State are also eligible for annual Alumni Achievement Fund fellowships at $2,500.

In addition, as earlier sections of this report indicate, there are quite a few graduate appointments in statistics open to graduates of sufficient standing from any college or university. Duties may involve teaching, fundamental research in theory and methods, computer programming, or research and consulting in applied areas. A varying number of appointments relate to the Survey Group's contractual projects.

More detailed information and application blanks are available from the Director of the Statistical Laboratory. Ordinarily, advanced appointments as associates or instructors are open only to students already working beyond the master's level.

Seminars

Each year the Laboratory sponsors a series of weekly seminar talks, offered on a noncredit basis and open to students and faculty from other departments as well as those of the statistical center. Hot tea and talks on current staff or graduate research projects and on more general developments in particular areas of statistics precede informal discussion. The 1958-59 program was composed of the following topics and speakers:

Fall Quarter

September 17: Status of research and consulting projects: T. A. Bancroft.
September 24: Analysis of a modified cross-over design: Neil Throckmorton.

October 1: A simple description of factor analysis: Leroy Wolins.
October 8: The concordance between three or more judges in paired comparisons: J. Arthur Greenwood.
October 15: (American Statistical Association Central Iowa Chapter meeting, held in lieu of regular seminar) Discussion of problems presented by Des Moines area members.
October 22: Stochastic models of failure: C. W. Clunies-Ross, associate professor, Dept. of Statistics and Statistical Laboratory, Virginia Polytechnic Institute.
October 29: Some problems at Navy Electronics Laboratory: George W. Snedecor.

November 5: Some families of contagious distributions: Shriniwas K. Katti.
November 12: Acceptance sampling by variables when the measurements are subject to error: Herbert T. David.

Winter Quarter

December 3: Unbiased ratio estimators in stratified sampling: José Nieto de Pascual.
December 10: (Seminar held in conjunction with meeting of Central Iowa Chapter, American Statistical Association) Applications of linear programming: H. O. Hartley.
December 17: Statistical consulting at the Utah Agricultural Experiment Station: Rex L. Hurst, experiment station statistician and director, Statistical Laboratory, Utah State U.

January 7: Nonlinear programming: H. O. Hartley.
January 14: Incomplete block designs with extra controls: Rodney Basson.
January 21: Statistical methods in Indian forest surveys: J. N. K. Rao.
January 28: Experiments versus surveys: Oscar Kempthorne.

February 4: Statistical aspects of epidemics: John Gurland.
February 11: (Seminar held in conjunction with meeting of Central Iowa Chapter, ASA) Playing a management game: C. M. Daniel, Applied Science representative, International Business Machines Corp., Des Moines, Iowa.
February 18: Debugging bug data: C. R. Weaver.

Spring Quarter

March 11: The absolute difference and absolute deviation of discrete distributions: Shriniwas K. Katti.
March 18: The meaningfulness of applying statistical operations to measurement data: the set theoretical approach: Richard F. Robinson, assistant professor of philosophy, Iowa State College.
March 25: Univariate analysis of multivariate data: Oscar Kempthorne.

April 1: Wind distributions: H. O. Hartley.
April 8: The forecasting of corn crops: José Nieto de Pascual.
April 15: Measurement of uncertainty: Robert J. Buehler.
April 21: (Joint Statistical Laboratory—Dept. of Mathematics seminar) The importance of the form of lags in economic dynamics: R. G. D. Allen, professor of statistics, London School of Economics, London, England.
April 29: Three "normal" distributions on the circle: J. Arthur Greenwood.

May 5: (Seminar sponsored jointly by the Statistical Laboratory, Dept. of Industrial Administration, and American Statistical Association's Central Iowa Chapter) Expert misuses of statistics: Harry V. Roberts, associate professor of statistics, School of Business, U. of Chicago.
May 13: The role of sex-linked genes in qualitative inheritance: Neeti R. Bohidar.
May 20: Some convariance structures in a two-way classification: Raymond C. Collier.

June 9: (Joint Sigma Xi—Statistical Laboratory seminar). The effects of hot climates on man: J. O. Irwin, biometrician, London School of Hygiene & Tropical Medicine, England—in the U.S. as visiting professor, Dept. of Biostatistics, U. of North Carolina.

Also, during the winter quarter, the following seminar talks were presented as part of the National Institutes of Health-sponsored training program in biostatistics:

December 18: Is smoking a cause of lung cancer? Roger R. Connelly.
January 8: Concepts of accident proneness: Carol B. Edwards.
January 22: Statistical study of maturation of children: Thomas D. Roseberry.

A seminar series on sampling surveys was given by members of the Survey Group during the fall quarter. The following topics were discussed:

September 18: Sampling for soil mapping surveys: Howard L. Taylor.
September 26: The Corn Production Study: José Nieto de Pascual.

October 9: The Master Sample of Agriculture: Emil Jebe.
October 17: Scope and procedures of the sampling section, Statistical Laboratory, ISC: N. V. Strand.
October 24: The 1955 "Sources of Information" survey (Wallaces' Farmer study): Scott Krane.

October 31: Area sampling in Canada: Jack Graham.
November 7: The Benchmark Study: Al Orman, assistant professor of sociology.
November 21: The 1954 livestock survey: José Nieto de Pascual.

In October 1958 Gerhard Tintner gave a talk on "The economics of Mr. Galbraith" at an Economics seminar. On November 17, T. A. Bancroft spoke on the topic, "What can we do in the Division of Home Economics to take appropriate advantage of statistical resources?" for a Graduate Council Panel Discussion on Cooperative Research. H. O. Hartley spoke on "Nonlinear programming" at a Mathematics colloquium on January 13, 1959. Then on April 17 he gave a talk on "Monte Carlo calculations and simulation" to the student Atomic Nuclear Society. Talks on the IBM 650 have been mentioned in the Computing Service section. Herbert T. David spoke on "Curve fitting" at the April 28th Forestry seminar.

A publication of the Statistical Laboratory of
Iowa State University, Ames, Iowa.
Jauvanta M. Walker, editor.