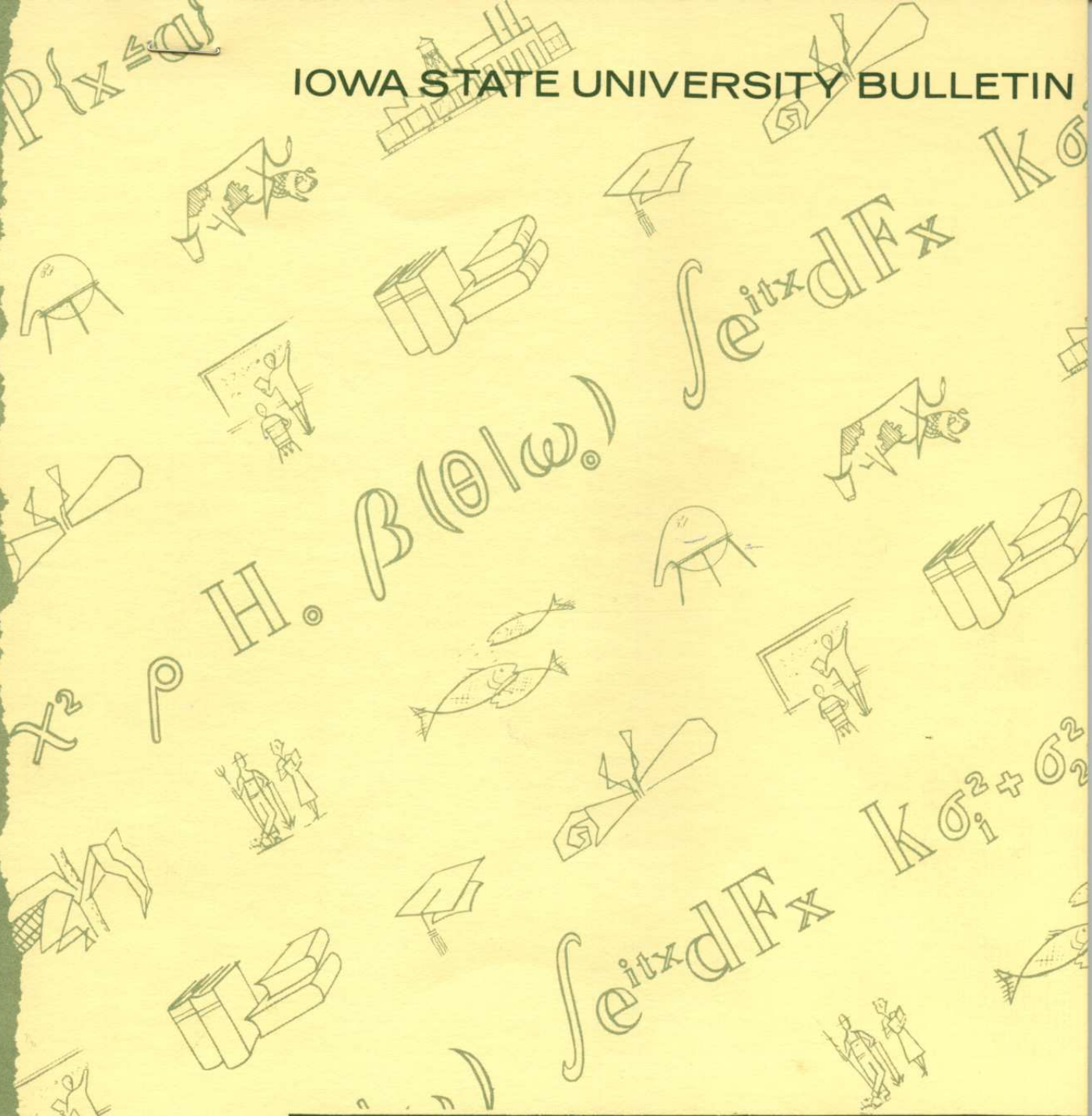
The Statistical Laboratory Established 1933 Iowa State University

IOWA STATE UNIVERSITY BULLETIN



ANNUAL REPORT

July 1, 1965 to June 30, 1966

President W. R. Parks
Iowa State University of
Science and Technology
Ames, Iowa

Dear President Parks:

This is the annual report of the Statistical Laboratory at Iowa State University for the fiscal year July 1, 1965, through June 30, 1966. It reports on the research, consulting, teaching and operational work of the staff of the university statistical center.

The statistical center is composed of:

(1) The Statistical Laboratory, a research and service institute under the president's office;
(2) The teaching Department of Statistics in the College of Sciences and Humanities;
(3) The statistics department of the Agricultural and Home Economics Experiment Station;
(4) The statistics participant in the Sciences and Humanities Research Institute and the Engineering Experiment Station; and
(5) The research field office of the Statistical Standards Division, Statistical Reporting Service, United States Department of Agriculture, which is located in the Statistical Laboratory.

The staff members of the Statistical Laboratory work in cooperation with many institutions and departments of Iowa State University. This annual report is a review of these activities as well as a record of the activities carried on solely by the Statistical Laboratory.

Respectfully submitted on behalf
of the Statistical Laboratory staff,

T. A. Bancroft

T. A. Bancroft
Director, Statistical Laboratory;
Head, Department of Statistics;
Head, Statistics Department,
Agricultural and Home Economics
Experiment Station

THE STATISTICAL LABORATORY

Iowa State University

ANNUAL REPORT 1965-1966

IOWA STATE UNIVERSITY BULLETIN
Ames, Iowa

Vol. LXV | October 19, 1966 | No. 10

Published semi-monthly by Iowa State University of Science and Technology, Ames, Iowa. Entered as second class matter at the Post Office, Ames, Iowa, under the Act of August 24, 1912.

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Personnel

The various components of the statistical center have a single director and share personnel. In fiscal terms, this means that a staff member's salary may be provided from several sources: the Department of Statistics in the College of Sciences and Humanities; the Statistical Laboratory, an institute under the president's office; a statistical project of the Iowa Agricultural and Home Economics Experiment Station or the Engineering Experiment Station; or a research contract by the Statistical Laboratory and the Sciences and Humanities Research Institute. The director of the Statistical Laboratory reports to the president of the university through the vice president for research.

The laboratory also has a number of research grants and contracts with federal agencies which provide funds for research for both staff and graduate students at all levels.

The members of the statistical center, including its affiliated fellows and graduate students, are listed here.

THE STATISTICAL LABORATORY STAFF FOR THE FISCAL YEAR 1965-66

Under the administrative direction of

W. Robert Parks, Ph.D.....President of the University
J. Boyd Page, Ph.D.....Vice President for Research; Dean of the Graduate College
Chalmer J. Roy, Ph.D. .....Dean, College of Sciences and Humanities; Director, Sciences and Humanities Research Institute
Floyd Andre, Ph.D.....Dean, College of Agriculture; Director, Iowa Agricultural and Home Economics Experiment Station
Theodore A. Bancroft, Ph.D.....Director, Statistical Laboratory; Head, Department of Statistics; Head, Statistics Department, Iowa Agricultural and Home Economics Experiment Station

Professors

T. A. Bancroft
C. Philip Cox
Herbert T. David
David V. Huntsberger
Oscar Kempthorne—Distinguished Professor, College of Sciences and Humanities
George W. Snedecor—Professor Emeritus—in absentia
Norman V. Strand
Leroy Wolins—joint appointment with Department of Psychology

Associate Professors

Om P. Aggarwal
Foster B. Cady
Wayne A. Fuller
Donald K. Hotchkiss
Howard W. Jespersen—joint appointment with Computation Center
Akio Kudô—visiting
C. C. Mosier—joint appointment with Computation Center
J. K. Sengupta—joint appointment with Department of Economics—on leave
George Zyskind

Assistant Professors

Barry Arnold—joint appointment with Department of Mathematics
Harold Baker
Edward J. Carney
Carol Edwards Fuchs
David Jowett
B. K. Kale—visiting
Edward Pollak
Joseph Sedransk
S. R. Srivastava—visiting, 1965 and 1966 summer sessions
David Thomas
James Walsh—joint appointment with Department of Psychology
Richard D. Warren—joint appointment with Department of Sociology

Visiting Lecturers

A. E. Foster
T. A. Ramasubban

Postdoctoral Fellows

Hans Peter Thöni
Francis Ward

Instructors and Associates

James S. DeGracie
Thomas Doerfler—summer session 1965
William Kennedy
Thomas C. Jetton—through fall quarter
Frank B. Martin—beginning spring quarter
Martin Rosenzweig—beginning spring quarter
Chang Sheng Shih
Donald Soults

Graduate Assistants

(The status of graduate students often changes. Students who have held the title of graduate assistant during the year are listed here.)

Joseph Atkinson
Nell Bruner
Leon Burmeister
Ralph Folsom
Richard Frauendorfer
Charles K. Graham
Irving Hall
Paul A. Johnson
Leon Jordan
Richard Lund
Mark Malone
Frank Martin
Ronald Mead
Richard Mensing
Peter O'Brien
James Olin
Paul Rackow
Martin Rosenzweig
V. B. Solomon
Douglas Splitstone
Jarilaos Stavrou
Ing Tzer Wey
Janet Zrubek

Other Graduate Students

NIH Trainees:

Patricia Conn
James Gebert
John Johnson
Donna J. Ruhl
Steven Selvin
Charles Sampson
James Veale

NASA Fellow:

John Meyer

NSF Fellows:

Gordon Booth
Justus Seeley
Mary Ann Smith
Philip Van Veldhuizen

Supported Students:

Joseph Abbey, AID, Ghana
Munir Ahmed, AID, Census Bureau, Pakistan
Carlos Brain, Government of Peru
James R. Davies, USDA Trainee
K. T. deGraft-Johnson, United Nations, Ghana
Audrey Duthie, Government of Canada
Omar Henriquez, Rockefeller Foundation, Chile
Paul Hurt, USDA Trainee
Ahmed Memon, AID, Pakistan
Syed T. M. Naqvi, AID, Census Bureau, Pakistan
Esmat Nouri, Government of UAR
Carl Z. Roux, Government of Union of South Africa
Ahmed Salem, Government of UAR
It-Thi Sawunkatat, AID, Census Bureau, Thailand
Nimnual Sriplung, Government of Thailand
Hermann Wiedenhofer, Government of Venezuela
Mia Mohammed Yusuf, AID, Census Bureau, Pakistan

Unsupported Students:

James Blinn
Geoffrey Boehm
Leroy E. Carver
Donald McElhone
Kenneth Mount
Sue Rowe
Robert S. Cochran—in absentia
Clayton Haugse
John W. Hazard—joint statistics-forestry
James Immordino
Louis Jensen
John Schlater—in absentia
Hans Schreuder—joint statistics-forestry
Franklin Wolf—joint statistics-industrial engineering

Special Students

Erol Farouk Karaglou, AID, Census Bureau, Turkey
G. S. Mebrautu, AID, Census Bureau, Ethiopia
Charles K. B. Tachie-Menson, AID, Census Bureau, Ghana

Student Assistants (Undergraduate)

Richard Chapman
Dean Harvey
Jan Shoemaker
Theola Sorenson

General Office Staff

Margaret G. Kirwin, Administrative Assistant
Kathleen Ringgenberg, Accountant
Susan Alice Brown, Technical Writer-Editor
Glenda Sampson, Secretary—through spring quarter
Carolyn Mindham, Secretary—beginning spring quarter
Janet Bates, Secretary—beginning fall quarter
Marian Bender, Secretary—beginning spring quarter
Judith Donald, Secretary
Avonelle Jacobsen, Secretary, Teaching Group
Iveta Zeliadt, Secretary, Experimental Design Group

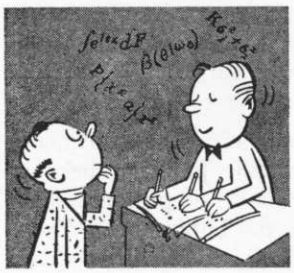
Numerical Analysis-Programming Group

Shirley Saveraid, Secretary
Patricia Barnett, Technician—beginning spring quarter
Mary Ann Carney, Technician
Gretchen Snowden, Technician

Survey Group

Anne Leicht, Secretary
Helen Ayres, Survey Supervisor
Marjorie Mason, Clerical Supervisor
Clerks:
Hazel Cook (Assistant Supervisor)
Ava Klopf(Assistant Supervisor)
Mabel Matthews
Marie Ostermann
Lucile White
Anna B. Woodrow

Consulting and Joint Research



The staff members of the Statistical Laboratory, through their consulting activities, participate in research being conducted in many departments of the University. This work is made possible by the budgetary allowance of the Statistical Laboratory and the financial support provided to some staff members by the Agricultural and Home Economics Experiment Station and the Engineering Experiment Station. Some staff members are budgeted to devote a great deal of their time to consulting activities while others are budgeted primarily on research projects or to fulfill teaching assignments.

Consulting services are available for statistical design of experiments, statistical design of surveys, statistical analysis and interpretation of data, numerical analysis and programming of a statistical nature, and the development and extension of new statistical methods and techniques.

Staff members who have provided consulting services during the year were asked to select the most interesting or most significant projects on which they worked to report here. This gives an indication of the consulting activities being carried out through the Statistical Laboratory but is not meant as a complete record of the work of each staff member involved in consulting.

Consulting problems vary, not only in the technical nature of the problem, but also in the amount of assistance needed by the investigator. Some problems may be fairly routine while others need modification of existing statistical methods and/or the development of new statistical theory and methodology. Often one important service performed by the consulting statistician is to encourage a research worker to examine his objectives carefully in view of his proposed experiment to ensure that it will answer his questions.

Frequently two or more staff members will be consulted, independently or jointly, on a single project, which may involve individual students, staff members or a group of researchers. The results usually appear in a thesis, are presented as a paper or are published. Sometimes the consultant's contribution is such that he is recognized as a paper's co-author.

During the year Dr. D. V. Huntsberger has consulted with graduate students in a number of areas concerning the statistical aspects of their research problems, most often in the area of multiple regression analyses and their interpretation. Students majoring in economics, home economics, chemical engineering and wild life management have requested such help.

Dr. Huntsberger also worked with a staff member from the Department of English and Speech on the analysis and interpretation of data. The project involved a study of the effect of sex of listener and sex of reader on the listeners' evaluation of the overall effectiveness of poetry readings.

Consulting in the Behavioral and Social Sciences

Dr. Leroy Wolins, who holds a joint appointment in statistics and psychology, continues to consult with social and behavioral science students and faculty.

Because of the change-over in the Computation Center from the IBM 7074 to the 360 system, the analysis of variance program was not operational from October to May. As a result, Dr. Wolins has been implementing data processing by using the regression program to do analysis of variance in his consultations. In problems involving repeated measurements on blocks or plots, the major portion of the computing is done when the covariances among the measurements are obtained. The variances and correlations are an auxiliary output.

Dr. Wolins' conclusion is that one can gain much from inspecting these correlation matrices and variances. These analysis of variance models specify a covariance structure. Inspection of these correlation matrices aid in interpreting significant interactions and the need for transforming data or analyzing data differently.

Dr. Wolins recommends that programs for doing analysis of variance be written to provide the user with the correlations and variances relevant to the model, so the user would be more likely to interpret his results appropriately.

Dr. Richard D. Warren, who holds a joint appointment in statistics and sociology, has consulted with faculty and graduate students on problems involving design and analysis of investigations in sociology and other social sciences.

He assisted in the planning and analyses of two surveys conducted by Dr. George M. Beal and Dr. Joe M. Bohlen, Department of Sociology, concerning the purchases and uses of chemical pesticides for home use in urban areas.

Dealers selling to the urban consumers were interviewed in the first survey and urban consumers were interviewed in the second. Areas in which information was obtained included: types of chemical pesticides for home use being sold and used, perceptions concerning the role of the urban dealer with the urban-consumer, perceptions regarding possible consequences of use or misuse of chemical pesticides in terms of danger to plants, animals and humans, knowledge and opinions about chemical pesticides and their use, sources of information used, and decision making regarding the purchase and use of chemical pesticides.

Dr. Warren assisted with developing the field schedules; offered suggestions on determining the popula-

tion, sampling and techniques of data collection; and has made recommendations concerning the analyses of data.

Dr. Warren is co-leader of a project with Drs. Beal and Bohlen. The project is an attempt to determine the characteristics of managers and local agribusiness firms that will permit prediction of their success and ability to adjust to innovations and change.

The work this year has centered on the development of the conceptual model and the development of specific empirical measures for each of the variables in the conceptual model. A sample of 100 managers of local agribusiness firms will be interviewed during the summer of 1966 in the exploratory phase of the project.

Dr. C. Phillip Baumel, Department of Economics, has been doing research closely related to the above project and Dr. Warren has served as project consultant. This work is an attempt to determine the goals and objectives of different levels of management in local agribusiness firms and their impact on efficiency of the firm.

Dr. Warren has consulted with Dr. Harold Dilts, Department of Education, and is serving on an interdisciplinary committee to develop a program and research experience plan for the preparation of educational researchers, leading to a Ph.D. degree.

Other projects, typical of Dr. Warren's consulting activities, include assistance with data analyses and interpretation for a study of the impact of a short course training program for farmers; consultation on appropriate statistical tests and their interpretation in connection with research on value consensus and partner satisfaction of dating couples; and advice on the use of multiple comparisons in a study on the impact of an educational exhibit. Multiple regression and correlation was used on a study to determine the value and attitude complexes, and their interrelationships, that will predict the reactions of individuals to agricultural adjustment and policy.

Consultation work of Dr. H. T. David has included discussion with a staff member in economics of the interpretation of the Kuhn-Tucker regularity conditions for specific programming problems, and with a graduate student in economics of problems arising in the aggregation of programming solutions for individual farm enterprises.

Dr. Om P. Aggarwal worked with a graduate student in education on the design of a sample for a study to determine the effect on Iowa schools of the Supreme Court ruling on religious training.

Consulting and Research in Numerical Analysis-Programming

The change of computers at the Computation Center left the university with no linear programming system. Donald Soults developed an advanced system which is able to handle a wide variety of problems which had previously been solved by several separate programs. Several versions of the program are available in order to satisfy different size and time requirements.

The linear programming system is currently being modified so that the user can solve a series of related linear programming problems in an efficient manner. The program is used extensively for thesis work in economics.

Soults also worked with Dr. Plessner, Department of Economics, and graduate student Janet Zrubek in the preparation of a large-scale quadratic programming system. This project constituted the bulk of Miss Zrubek's masters thesis, which is abstracted in the publications section of this report.

The program has been tested and is now being used to solve large ($n+m \leq 1000$) economic models with quadratic objective function.

Dr. A. E. Foster was also involved with research in the area of numerical analysis-programming. He assisted William Kennedy and a chemistry senior in developing a general purpose computer program for making multiple comparison tests.

E. J. Carney has continued research on his doctoral thesis. This has included a study of response structures and computation of generalized polykays for the purpose of computation of variances and covariances of variance component estimates by electronic digital computers.

The Numerical Analysis-Programming Group provides consulting services in numerical analysis and computer programming of statistical problems, consultation in statistically-oriented computer techniques, computer programming, and processing of data requiring the services of an analyst-programmer. Group members function in a liaison capacity between the researcher and the computer.

Carney has consulted with Dr. Roger Bachmann, Department of Zoology and Entomology, and Dr. D. K. Hotchkiss on a project to determine prediction equations for water temperature in Clear Lake in northern Iowa. Computer programs will be prepared to get the necessary information which will be used to interpret biological data collected at the lake during the past 20 years. It is expected that the results will help determine the influence of water temperature on fish population dynamics and predict water temperatures in proposed reservoirs.

William J. Kennedy wrote a computer program for Dr. Vonhohenbalken, Department of Economics, to evaluate costs in a transportation system. In another project, he wrote a program for Dr. Akio Kudô to evaluate the percentage points of a bivariate analogue of the power function for a one-sided test of hypothesis.

Kennedy also worked with a chemistry senior to develop a program which uses any one or all of five different multiple comparison tests to analyze a given set of mean values.

Consulting in Engineering and the Physical Sciences

Dr. H. T. David, who holds a joint appointment in engineering and statistics, and his associates, do much of the consulting in engineering and the physical sciences. Some of the typical problems in this area are described.

Dr. David consulted with a staff member in soils engineering on setting confidence limits for, and obtaining minimum variance unbiased estimates of, certain geometric indices involved in the formation of drainage basins. With a staff member in geology he discussed statistical problems arising in the automation of shape and configuration analyses of rock cross-sections, and he consulted with a staff member in agricultural engineering on various alternative parameter estimates for a three-parameter Weibull distribution.

Dr. David worked with an industrial engineering staff member and two graduate students on statistical problems arising in the fitting of retirement curves for industrial properties. He discussed a similar problem, arising in the fitting of missile reliability "growth curves," with another industrial engineering graduate student.

With a graduate student in physics, Dr. David consulted on the setting of confidence bands for calibration curves, and the smoothing of observed frequencies in computing empirical spectra.

Dr. David discussed several combinatorial occupancy problems arising in the analysis of industrial systems with an industrial engineering graduate student. With an electrical engineering staff member and graduate student he worked on the selection of independent variables for the prediction of peak loads.

Dr. T. A. Bancroft and William Kennedy consulted with Dr. Alexander Lisenkov, exchange scientist from Russia visiting the Agricultural Engineering Department, regarding the use of stepwise analysis in building a regression model involving effective exposure time on free moisture ratio and various temperature levels in alfalfa drying experiments. There were three independent variates and one dependent variate:

x_1 = equal temperature
x_2 = time in minutes
x_3 = initial moisture content
y = free moisture ratio = $\dfrac{\text{dry wt.} - \text{oven dry wt.}}{\text{wet wt.} - \text{oven dry wt.}}$

In building the model it was decided in advance to limit the degree of the fitted expression to no higher degree than quadratic terms in the x's and linear in y.

Dr. D. V. Huntsberger consulted with a highway engineer on problems concerned with the establishment of tolerance limits on materials to be used in asphaltic concrete and other pavings.

Dr. Oscar Kempthorne worked with a graduate student in chemistry on an iterative program for least squares fitting with non-linear models.

Dr. D. K. Hotchkiss was consulted by a geology researcher. Assistance was given in tabulating the complexity of a stream system in a large water shed.

Consulting in the Biological Sciences

Professor C. Philip Cox consulted with Dr. W. R. Klemm, Department of Veterinary Physiology, on the analysis of two experiments. The first was an investigation into the effects of various drugs on blood coagulation time. Unequal numbers of observations were recorded and these indicated variance heterogeneity. An appropriate method of analysis was outlined.

In the second experiment the drugs dianobol and heparin were compared with a saline contrast for effects on wound healing. Observations, unequal numbers, were taken on skin tensile strength after four days of healing in a 2(wound sites) $\times$ 2(sexes) $\times$ 3(treatments) experiment. An appropriate analysis was outlined.

Professor Cox also consulted with Dr. Klemm on the analysis of experiments investigating the effects of hypnosis on the heart rates of rabbits, with particular reference to the determination of a response giving suitable and sensitive discrimination between the treatment groups.

Dr. T. A. Bancroft and Dr. A. E. Foster worked with Dr. Loyd Quinn, Department of Bacteriology, and Dr. Richard Oates, a former statistics-bacteriology postdoctoral student, on the analysis and evaluation of an experiment to study the growth requirements of rumen protozoa. A further experiment was designed and conducted, using the information from the first as a guide.

Dr. Edward Pollak, working under the support of Agricultural Experiment Station Project 1448, continued to provide consultation on statistical aspects of genetics and breeding research.

Specific problems included the study of the joint effects of selfing and selection, analysis of data for testing effects of radiation on rate of production of abnormal pollen cells in oats, the study of the effect of selection on a bivariate normal distribution, the progress of selfing and sibbing with autotetraploids, and variance components in diallel and triallel crosses.

Dr. D. K. Hotchkiss assisted with the preparation of data for a multiple regression analysis in which the effect of environmental factors on fish populations were studied.

Consulting in Physiology and Nutrition

Much of the consulting in the animal sciences and in home economics and human nutrition is done by Dr. D. K. Hotchkiss under the support of Agricultural Experiment Station Project 101. Graduate student Ralph Folsom and others have provided valuable assistance in resolving questions on the design and analysis of experiments. Dr. Hotchkiss also has spent considerable time consulting with staff members and graduate students in veterinary medicine.

The problem of fitting response surfaces to data using polynomials and/or exponential functions has

demanded considerable attention this year. In one project blood volume was estimated by fitting an exponential function (using the Tarsier non-linear regression program) to the concentration of a marker in the blood stream which is metabolized at a rate approximated by the exponential function. Prediction of the intercept of the function at time of injection gave an estimate of blood volume, which in turn was used as a response to measure the effect of iron injection on the volume of blood in baby pigs from birth to six weeks.

The dairy science researchers requested assistance in measuring flow rate of blood in calves by measuring marker concentration at a point several centimeters below the point of injection. The initial marker concentration was approximated to increase as a linear function followed by an exponential decline. After obtaining a least squares fit to the data, the area under the curve was used to express blood flow rate. Dr. A. E. Foster, Joe Atkinson and Ralph Folsom adapted the present computer programs to fit the functions simultaneously.

Fitting polynomials to the increase in objectionable flavors, tallowy and oxidized-metallic, in butter oil was accomplished on fat stored at differing temperatures. The relationship between the different temperatures was determined so more rapid deterioration of a product at the high temperature could be used to predict a reasonably safe storage period for the same product stored at below zero temperatures. A variety of polynomials and exponential functions were fitted to the data by least squares and through pre-selected intercepts.

The consistency of power generated in electronic ovens was evaluated for the staff in household equipment by a trend analysis. The differing lengths of exposure of dogs to rare earth dust was also approached using a trend analysis.

Dr. Hotchkiss is consistently called for help when disproportionate sub class numbers crop up, due to a missing observation, missing treatment or the result of survey type data.

When two periods (rows) of information on fat content of milk were accidentally destroyed in a 4×4 crossover design for estimating residual effects, a least squares fit was made to the data to estimate treatment and residual effects. One treatment was not recorded in a 6×6 latin square and the researcher was given assistance in using the procedure proposed by Yates to handle missing treatments.

A study of nutritional factors affecting adult females was conducted to determine differences in consumption and use of nutrients with age. Each person was used two or three times during the study and was observed in 1948, 1950 and 1960. As a result, the subject's age was highly confounded with year and individual effects. The data ultimately had to be interpreted as age effects beyond those effects explained by years since it was impossible to separate the two factors.

Missing data occur in many different ways in split plot experiments. When a poultry study had different numbers of layers (sub plot) within each pen (whole plot), a least squares analysis of the data was made using the regression program. The same statistical approach was used when a complete sub plot was missing in a corn borer study. In a study of reproductive cycles in rats when portions of the uterus were removed, differing numbers of rats (whole plot) were used for each treatment but were all observed over four periods (sub plot). The analysis of unweighted means was used here to study the main effects and interaction.

Data which violated the assumption of homogeneity of variance were handled in three separate ways. Differences in blood clotting times were observed before and after the injection of five drugs which were claimed to reduce clotting time, when compared to a control group. The more effective drugs demonstrated less variability than the others. The researcher partitioned the treatments into two groups and used the respective error estimates to compare the drugs to the control, within and across groups.

A nutrition study measured vitamin levels in liver tissue when the animals were on different stress rations. A log transformation stabilized the wide variability of the data among treatment groups so an appropriate analysis could be accomplished.

A hedonic scale was used to score acceptability of the different servings in TV dinners. The judges tended to cluster observations near the end of the scale, therefore, in an attempt to normalize the distribution of scores, log $(x + 1)$ was analyzed.

The dairy industry researchers investigated the preference of cheeses made with four different levels of fat using a balanced incomplete block in which consumers expressed a preference for one of two cheeses offered to them. Because of the size of the experiment it was possible to use a normal approximation in the analysis of the results.

Another home economics project on which Dr. Hotchkiss was consulted involved the analysis of the effect of detergents on brightness of sheets. He assisted in specifying the measure of response, and the analysis.

Professor C. Philip Cox consulted with a graduate student in animal science on experiments for stilbestrol in the livers of pregnant heifers. Some difficulties with the formula being used in the analysis were removed.

E. J. Carney also did some consulting in the animal sciences. He worked with Dr. Donald Wetzel, National Animal Disease Laboratory, on the analysis of experimental results of research on the relation of plasma glucose level and SGOL on morbidity of swine erysipelas.

Consulting in the Plant Sciences

Dr. Foster Cady and Dr. David Jowett, working under the support of Agricultural Experiment Station Project 101, provided consulting services in the plant sciences. Graduate students Chang Sheng Shih and Paul Johnson assisted on some of the projects.

A major need of the field crop seed industry is a rapid simple test to determine whether a lot has, or has not, been adequately blended. Dr. Cady has been working with Daniel Niffenegger and Dr. L. E. Everson, Department of Botany, on a project to develop methods for expressing, in statistical terms, the degree of homogeneity to which a lot has been blended; to establish procedures for rapidly assaying large numbers of samples with respect to particle distribution; and to gain preliminary information on factors which affect particle distribution in blended seed.

Information obtained from this research can be used as a basis for recommending sampling and mixing procedures which will lead to reduced variations among analyses of seed lots, and for making recommendations to improve present Association of Official Seed Analysts tolerance tables.

Dr. Cady also consulted with a graduate student majoring in soil fertility on a study of the use of non-polynomial function to describe yield curves and compare its performance with that of the second degree polynomial. Fifteen data sets, each including the response of oat dry matter to phosphorus rates were used.

Two models by Hartley and Nelder were considered as alternatives to the polynomial. Nelder's model, recently proposed in Biometrics, is an exact procedure but assumes that the variance of Y is proportional to the square of the expected value of Y. However the nonsymmetry of this model is biologically appealing to agronomists.

Models were compared by the use of R^2, lack of fit mean square and by plotting the slopes of the different fitted responses against the fertilizer level. The results were not conclusive but the straight line slope of the quadratic polynomial failed to fit the slope of the data in the case of asymptotic or increasing and decreasing yield curves as well as the Nelder model.

Dr. Cady consulted with a graduate student in agricultural engineering on the techniques of multiple regression used to evaluate the effect of reservoir and watershed variables on reservoir sedimentation and to develop equations for prediction of sediment deposition in reservoirs in the Missouri Basin loess hills area.

Multiple regression also was used in a project with another graduate student in agricultural engineering on evaluation of the handling and storage characteristics of hay wafers produced in Iowa. A study of factors affecting mechanical damage was carried on while a silo was being filled with hay wafers, the most dense form of field harvested forage.

With the computer, different nonorthogonal models involving interactions were run and it was found that a main effect model would adequately describe the data and consequently provide an estimate of the percent fines that will occur during the filling of a storage structure.

Dr. Cady consulted with a graduate student in forest management on the statistical aspects of a forest growth measurement study. Forty Iowa forest survey plots, originally measured in 1954, were selected at random from all plots of the oak-hickory type in the Southeastern Forest Survey region of Iowa. A prediction of basal area growth per acre per year was made by one standard and three potentially useful methods.

The three potential techniques were compared with the standard on the basis of the average growth prediction over all 40 plots using the combined criteria of bias and precision. Point center extension techniques compared favorably with the standard when the 10-factor prism was used. The low cost and flexibility of the point center extension techniques make them useful for predicting growth in upland hardwood stands of Iowa even though some statistical accuracy and precision must be sacrificed.

In another forestry experiment, confidence intervals for the independent variable which corresponded to the minimum value of the dependent variable were estimated, where the assumed model was a quadratic polynomial.

Interpretation of higher order interactions in a complex factorial presented a problem in an experiment examining the contribution of laminar and non laminar tissue to yield of oats. In another agronomic experiment, Dr. Cady assisted in the design of a rotation experiment attempting to determine the nitrogen contribution of a soybean crop to the succeeding crops of corn. The experimenter sought information as to whether the nitrogen response curve for corn following soybeans is of the same general shape as that for corn following corn. Major consideration was given to the manner of starting the different plots in the rotation experiment.

Students from several departments have brought Dr. Jowett ecological data for analysis. In some cases analysis was difficult because large quantities of rather intractable data were collected without adequate attention to randomization procedures. Although it was possible to proceed with the analysis and summarization of such data, interpretation was inevitably made hazardous. Consultation prior to data collection could eliminate such problems.

Relationships between populations of mosquito larvae and environmental characteristics of Iowa ponds and streams were studied. The dates of flowering at Ames of North American populations of a common weed species were related to the latitude in which collected. Relationships were calculated between numbers of several invertebrate groups and leaf area of aquatic vegetation in Clear Lake, Iowa. Preliminary discussions were held on a project to investigate the numbers of species of diatoms in relation to water pollution in Iowa streams.

An interesting problem in this category is a continuing study of pothole complexes in North Dakota. Extensive data have been collected on physical characteristics, chemical composition, density of plant species and wildfowl populations of 64 ponds. The interrelationships of all features of ecological interest are

being studied by techniques of multivariate analysis. In this case scrupulous attention has been paid to randomization, and some interesting results should accrue.

In consultation with students in horticulture, Dr. Jowett assisted with the analysis of experiments investigating the effects of surfactants on drought resistance in turf grasses. Assistance was given in the design of an experiment to investigate the effect on plants of atmospheric pollution and the interaction of atmospheric pollutants with 2,4,D. Advice was also given on an experiment to investigate the effects of intervarietal grafts on tomatoes.

A continuing investigation on the effect of soil injection of propane gas on corn has been of interest. In field experiments F values of less than one were frequently encountered in testing treatment effects. The effect of propane may depend on soil microorganisms, which may not be uniformly distributed over the experimental area. Therefore it was suggested that in future experiments a block $\times$ treatment effect be included in the model. Dr. Jowett also has given advice on the design and analysis of laboratory experiments on the uptake of propane by soils.

Many statistical problems continue to be generated by students in plant breeding. One problem on which Dr. Jowett was consulted concerned a selection experiment for winter hardiness in grasses. Extensive winter-kill was anticipated, so a completely random design was adopted in spite of there being 250 entries. Other projects involved selection for seed weight in Smooth Brome Grass and evaluation of visual selection techniques in oats.

Dr. Jowett and Dr. A. E. Foster assisted a graduate student in horticulture with setting up a greenhouse experiment to evaluate the effect of level of osmotic concentration and level of sodium salts on the growth of two species of grass.

Dr. H. T. David consulted with a staff member in agronomy on the least squares fitting of ellipsoidal equicontours to meteorological and geological observations at volcanic crater sites.

Dr. Oscar Kempthorne consulted on several problems involving corn. One project was concerned with the interpretation of data in research on the drying out of field corn. Another involved analyzing data and designing a study on the measurement of the proportion of cracked, chipped and damaged kernels in corn. A third was with a graduate student in plant breeding concerning experimental data on number and type of testers for corn hybrids.

Off Campus Consulting and Advisory Assignments

In addition to their regular consulting duties for campus departments and individuals, staff members frequently are called upon to serve in an advisory capacity to professional groups elsewhere. The person involved with the consulting may travel to the project, the group seeking advice may visit the campus or the consulting may be done by mail.

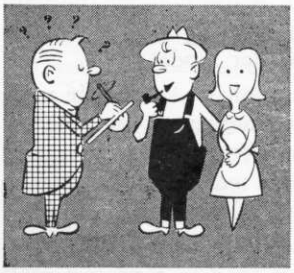
Among off-campus projects, Dr. David Jowett and Dr. Oscar Kempthorne collaborated on the composition of a questionnaire to accumulate data on endangered species of wildlife in a form suitable for machine tabulation. The questionnaire may be used in connection with the International Biological Program for which Dr. Kempthorne is serving as a member of the Human Adaptability Sectional Committee of the United States Planning Committee.

Dr. Jowett also answered a query from India concerning the use of chi-square in a $2 \times n$ table where half the cells had expectations around unity. A transformation was suggested, but it was also pointed out that R. C. Lewontin and J. Felsenstein had published data indicating that the ordinary chi-square test was adequate in these circumstances. This is in line with results by Kempthorne on the use of the chi-square goodness-of-fit procedure, but contrary to earlier opinions.

Donald Soults has done some consulting for the Staley Manufacturing Company, Decatur, Illinois. The work has been in the area of mathematical programming. One particular application of interest is the marginal cost analysis which is used to set prices on materials sold by the company. Soults has also worked on plant location and optimal feed mixes projects.

Dr. Wayne Fuller, with Dr. Raymond Beneke, Department of Economics, spent three weeks in Mexico during April as a consultant to the Ford Foundation. The two participated in the design of a three-year evaluation study of certain Mexican agricultural extension programs. Future trips in connection with field work and analysis are planned.

Survey Group



The Survey Group of the Statistical Laboratory provides direct operational services to the rest of the campus on all aspects of sampling, surveys and census-type studies. Consulting services are combined with operational work through the financing of the Statistical Laboratory, the Statistics Department, the Iowa Agricultural and Home Economics Experiment Station and the Sciences and Humanities Research Institute.

The Survey Group annually participates in a number of studies administered jointly by the Statistical Laboratory and some other university, institute, state or federal agency. The United States Department of Agriculture and the Bureau of the Census have had long term agreements for survey and statistical services on a number of projects.

Working under the auspices of Agricultural Experiment Station Project 113, Statistical Services for Sampling Investigations, the Survey Group provides advice and consultation on the design and analysis of various

studies for many departments on campus. Professor Norman Strand and Dr. Wayne Fuller direct the project.

During the year statistical services were provided within the areas of agricultural economics, agricultural engineering, agronomy, animal science, child development, entomology, food and nutrition, forestry, home economics education, home management, household equipment, institution management, rural sociology, textiles and clothing and veterinary parasitology and pathology. In some projects samples were drawn and field collection of data was performed.

Included in the projects were preparations of samples for a market study in Cass County, construction of a questionnaire to predict future earnings in certain occupations, analysis of pig feeding data, analysis of an experiment to associate shear strength of soils with type of soil, and analysis of flood and watershed data.

Also work was conducted on studies of the effectiveness of a lamb promotion program, the effects of noise on tenant satisfaction in garden apartments, teacher effectiveness as related to indexes of personal attributes and training, food service establishments, trichinosis in human lungs, the used clothing market, the economic role of the housewife, and pesticide residuals in milk.

The five year study of nutritional characteristics of Iowa high school students, conducted in cooperation with the Department of Internal Medicine, University of Iowa, moved into its third year. A sample of students in grades 5 through 8 was added to the study in the fall of 1965.

The current field work and the processing of the previously collected data are proceeding under the direction of Professor Norman Strand, with the assistance of Mrs. Marjorie Mason and Thomas C. Jetton.

In the fall the Survey Group supervised the interviewing and collection of data for a survey of factors relating to diets of preschool children. The study, planned in cooperation with researchers from the United States Department of Agriculture, is being conducted in 12 north central states by home economists of the nutrition research departments of Agricultural Experiment Stations at Iowa State University, the University of Illinois, Kansas State University, the University of Nebraska and Ohio State University.

The 12 north central states were selected because extensive studies with school age children living in this region have shown many to have poor food habits which may have had their origin in the preschool years. Studying the dietary intakes for children from 0 to 6 years of age will provide valuable insight into the transition from the diet of infancy to the child's participation in family meals. Frequency of eating and the use of vitamin and mineral supplements by this age group will be other pertinent findings.

Previous dietary studies have emphasized quality of diet with little attempt to identify circumstances responsible for eating behavior. The present study is unique in its attempt to combine accurate estimates of dietary intake with pertinent economic, sociological and psychological data which may help to explain the dietary findings. An understanding of the environmental factors which affect eating behavior and nutrient intake will assist in providing a sound basis for nutrition education programs.

In the spring of 1966, under the supervision of Professor Strand and Mrs. Helen Ayres, a school census for the Ames Community School District was conducted for the fifth time. The main objectives of the study were to enumerate (1) all persons under 21 years of age who reside in the district, (2) people with certain physical and mental handicaps, and (3) blind people over 21 years of age.

In cooperation with the Department of Economics, the Survey Group conducted a study of payers of property tax in Iowa. The sample was drawn from county tax assessment rolls. The purpose of the study was to investigate characteristics of taxpayers and their attitudes toward the present tax structure in the state.

In addition to designing and drawing the sample, the Survey Group also trained and supervised the interviewers, edited and coded the completed schedules, and is assisting in summarizing the data for analysis. Dr. Arnold Paulsen and Dr. James Prescott are the economists working on the study.

In cooperation with the Department of Institution Management and under the direction of Dr. Marjorie McKinley, a survey was conducted of food service establishments in Iowa. Included in the sample were 396 restaurants, 73 hospitals and 127 nursing homes. Establishments selected for interview were randomly drawn so that state estimates could be made for these types of food service establishments.

The data collected will be used as a basis for determining food service education programs. Mrs. Helen Ayres and Mrs. Hazel Cook supervised the field work, assisted by Barbara Bobeng of the Department of Institution Management.

The Survey Group began a study of clothing acquisition and use in cooperation with the U.S. Department of Agriculture and under the direction of Dr. Geitel Winakor, Department of Textiles and Clothing. A questionnaire was developed and pre-tested and a sample of 400 households in Des Moines was drawn. Interviewing was completed in late June, with coding and analysis scheduled for fall and winter of 1966.

The purpose of the study is to obtain data for use in preparing better clothing budgets for extension programs and teaching. Mrs. Ayres and Mrs. Cook supervised the field work.

Data has been processed for a study of the number and characteristics of farming opportunities in Iowa, under the auspices of Agricultural Experiment Station Project 1477. Dr. Donald Kaldor, Department of Economics, and Professor Norman Strand are project directors.

The processing of data has been completed for a statewide sample of two groups of farm operators who

quit farming during 1959-61. One group quit to take nonfarm jobs, the others to retire from active employment.

A manuscript has been completed reporting the findings of a study of persons entering Iowa farming during 1959-60. Revised estimates have been prepared of the components of change in the number of Iowa farm operators.

A survey of farm record and business analysis systems of Iowa farmers was conducted in 22 Iowa counties in cooperation with the Department of Education. The major objective of the study is to investigate factors relating to the type of farm records kept by farm operators in Iowa and the degree to which the records were used in making management decisions.

The sample, drawn by the Survey Group, included farm operators whose gross farm income in 1965 was at least $2500. Mrs. Helen Ayres supervised the interviewing and collection of data and Dr. Wayne Fuller provided consulting services on sampling and methods of analysis. The data collected will be used for a doctoral thesis by Roy Hickman.

Professor Norman Stand continues as project director of a field study, jointly sponsored by the Epidemiology Branch, Division of Dental Health, and the Division of Vital Statistics, National Center for Health Statistics, concerning the reporting of congenital malformations at birth.

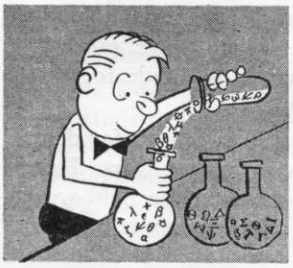
Mrs. Marjorie Mason has recruited and trained interviewers and has supervised the collection of data. Interviewers contacted each participating hospital in Iowa to review birth records and complete an abstract for each record mentioning a congenital anomaly.

The study is viewed as a means of learning more about the true incidence of malformations, and of compiling data which may result in improving vital statistics registration on a national basis.

In addition to consulting with university and government personnel, the Survey Group provides services to industry as time permits and when the project is of interest to the University.

An example of such work involves a study done this year for a chemical company. Samples were drawn of approximately 400 farms in Ohio, Indiana, Illinois, Southern Minnesota, Iowa and Northern Missouri for use in a study of herbicides. In a companion study, samples were drawn of 125 farms in the Red River Valley area of Minnesota and North Dakota, and other parts of North Dakota, for use in a study of herbicides relating to the control of wild oats.

Current Research



In the research program of the Statistical Laboratory, both the development and extension of basic theory and its application to new statistical methods and techniques are emphasized. The Laboratory cooperates with other research institutes and experiment stations on the campus to arrange programs of statistical research and obtain support through joint grants and projects. Many studies of a fundamental nature are supported by such grants and contracts with off-campus agencies. In most instances they provide for supervised graduate research on topics proposed by the staff. The Statistical Laboratory budget, however, supports only projects which are of specific interest to regular university research programs.

Professor C. Philip Cox has continued research work on sequential covariance analysis in collaboration with Dr. T. D. Roseberry and James Olin, with particular reference to sequential procedures based on weight function test statistics. Computer programs have been devised to evaluate the performances of various test statistics for different specifications of parameters in bivariate normal distributions.

The results show that appreciable reduction in sample number to decision can be achieved by the incorporation of concomitant information. Papers describing the derivations of the tests and results of the Monte Carlo evaluations are being prepared.

Professor Cox also has examined some results on the variance of observed sample numbers in sequential probability ratio tests. The fact that the sample number in sequential probability ratio tests is itself a random variable has important relevance to the theory and application of sequential experiments. However few theoretical results are available in the literature on the distribution of sample number.

Empirical information on the variance of sample number was obtained from Monte Carlo results on the evaluation of a large sample sequential covariance test procedure and a paper by Cox and Dr. Roseberry has been published in the Journal of the American Statistical Association. An abstract appears in the publications section of this report. Examination of the results strongly suggests the inference that the variance of sample number is approximately proportional to the square of the average sample number. A note reporting the detailed results is to be published in Technometrics.

The initiation of research on the analysis of log-dose response line assays when divergent rather than parallel lines are obtained for the standard and test preparations was reported in the 1963 Annual Report. The results of research on this topic by Cox and Paul Leaverton are described in a paper to be published in the Journal of Pharmaceutical Science.

With Hermann Wiedenhofer, Professor Cox is conducting further research to develop another analysis

for the case in which divergence is obtained in replicated single subject assays. The main objective is to achieve narrower confidence intervals, based on the within subject variability, for the estimation of equipotent concentrations.

Dr. B. K. Kale has been working on minimum variance unbiased estimation when the class of probability measures contain countably many probability distributions.

It is proved that if the family contains finite number of non-atomic measures then it is not complete. For the sub-family of distributions belonging to exponential families, it is proved that if the restricted parameter space has a limit point which is an interior point of the natural range of the parameter space, then the family is complete. It is further shown that the normal distribution with unknown mean restricted to integers (known variance) is not complete. By way of examples it is shown that in such a problem there may not exist UMVUE. The main question in such a case is to characterize the cases in which UMVUE exists.

Professor C. Philip Cox and Dr. Kale have been collaborating on research on the development of simple asymptotically valid tests for the detection of non-normality in sample data using order statistics. A family of test statistics has been described from which particular statistics may be chosen for sensitivity to designated types of non-normality such as the common ones of skewness and kurtosis. It may be noted that some of the results have been anticipated by independent research recently reported by Shapiro and Wilk (1965).

Dr. Kale also is progressing with research on tests of goodness of fit based on discriminatory information. A new test based on $\Sigma c_i \log c_i$ where c_i are sample coverages is being studied in greater detail. It is shown that this test provides an analogue of chi-square test of goodness of fit in case of continuous distribution function.

Dr. T. A. Ramasubban has been involved in research centering around theoretical and methodological problems connected with serial and autocorrelation coefficients present in economic time series data.

A paper has been written on the sampling distributions of serial correlation coefficients. Briefly, this paper attempts at deriving a "smoothed" probability distribution for the serial correlation coefficient of lag one, when this coefficient is given a more realistic definition of non-circularity. The method of smoothing is based on a technique suggested by Koopmans and Dixon for handling the distributions of circular serial coefficients. The analytic expressions obtained in this paper are compared with the only other known approximation obtained by Daniels through the saddle-point approach. Also, the points of similarities and differences between the above distributions and those relating to circular coefficients have been examined.

A related question under investigation was of moment properties, particularly the first and second, of the various distributions of serial coefficients, including the ones already derived by Dr. Ramasubban. A few exact results for these moments have been obtained for circularly defined coefficients. They have been compared both analytically and numerically with their "smoothed" counterparts.

Yet another research area intimately connected with the above is the study of regression analysis in the presence of autocorrelated errors. The economic models of demand, production and the various regressions having lagged economic variables pose the problem of serially dependent errors.

A paper is being prepared investigating the extent of bias in estimating the parameter ρ of the model: $x_t = \rho x_{t-1} + \epsilon_t$ by estimates which lead to least squares values asymptotically. Also, a methodological procedure has been studied to handle the maximum likelihood estimates for lagged regressions in the presence of autocorrelated errors. These have been experimentally tried on a limited scale on empirical demand and production relationships.

Dr. Ramasubban initiated a move to consider, on a sufficiently elaborate scale, the theoretical and practical issues involved in the statistical analysis of lagged regressions. It was thus suggested, and project proposals were drafted for undertaking, Monte Carlo type of investigations on a few different kinds of lag models commonly encountered in econometric practice.

Another problem considered by Dr. Ramasubban, not connected with time series but of interest in the field of economics, is the statistical distribution of Gini's Coefficient of Mean Difference. Dr. Ramasubban has been able to extract, from some of the theoretical results obtained earlier for the fourth absolute moment of a multivariate normal distribution, the fourth moment of this coefficient; and with the help of the computational facilities, evaluated the numerical values for the β_1 and β_2 measures for a range of values of sample size. With the help of these values, he proposes to examine the distribution of this coefficient.

Under the direction of Dr. J. Sedransk, and Dr. Kenneth Ware of the Forestry Department, graduate student Hans Schreuder has considered unequal probability and double sampling designs appropriate for forestry applications.

In the area of unequal probability sampling, "point" and "3-p" sampling designs are investigated. Point sampling can be viewed as cluster sampling where a unit can belong to more than one cluster. An alternative, more informative, method of obtaining the error variance for a standard one-phase estimator is employed. An unbiased estimator of the variance is also derived. The results are extended to two-stage sampling where simple random sampling is used within each of the selected clusters.

A technique called "3-p" sampling, useful in selecting trees with probability proportional to their estimated "sizes" is investigated. The properties of two estimators are considered, and this sampling scheme is compared with several alternative procedures.

Double sampling procedures for selecting ground plots (using aerial photographs) with simple (or stratified) random sampling at the first stage, are considered. The use of such schemes is motivated by considerations of cost, and the availability of relevant information about the units in the population. Information on a concomitant variable is obtained for all units in the first stage sample, and this is used to improve the sampling procedure (estimator and/or design) at the second stage. In particular, selection with probability proportional to "size" is considered at the second stage. Results are obtained for sampling with and without replacement. A "post-stratification" sampling scheme is also investigated.

Dr. Sedransk also has been directing the research of K. T. deGraft-Johnson, a graduate student who has examined some of the factors which contribute to measurement errors. This work covers the use of interpenetrating or replicated subsamples, linked samples, external and internal consistency checks and analytical methods to gauge the error in survey data.

Particular attention has been paid to an Index of Inconsistency proposed by Hansen, Hurwitz and Pritzker. Such an index measures the proportion of total variability which can be attributed to "response" variability. This method has been extended so that continuous as well as discrete variables can be treated. In addition, an approach using the usual methods of the Analysis of Variance has been employed.

Using data from the 1960 Ghana Population Census and the Post-Enumeration Sample Survey (P.E.S.), various indices of response variance and bias were obtained. Such computations were feasible because a person to person matching of individuals selected for the P.E.S. was carried out as a part of the Census program. That is, there were two measurements on each individual in a random subsample of the entire population. Comparisons were made with the relevant indices calculated from U.S. data pertaining to the 1960 Census.

The indices computed for Ghana show, as was to be expected, that the data on age were the most inconsistent of all the variables considered. The tables on school attendance, tribes and types of activity were fairly consistent.

Further work remains to be done on the bias of the estimator for the index of inconsistency and of its distributional properties. Other areas of work which will be explored include a scheme for measuring response errors in developing countries during the 1970 round of world Population Censuses.

Dr. Om P. Aggarwal has been conducting research on Bayes and minimax procedures for estimating the mean of a population with two-stage sampling.

In the current practice of choosing a survey design, the statisticians use one of the two principles: (i) to get an estimator of maximum precision for a given total cost of the survey, or (ii) to get an estimator of a given precision for a minimum total cost of the survey. The allocation of the resources for a given survey is usually carried out keeping one or the other of the above two principles as the guide.

In 1959 Dr. Aggarwal considered jointly the losses resulting from the errors in the estimators and from the cost of sampling and obtained Bayes and minimax procedures for the estimation of mean in the case of an infinite population as well as a finite population. The loss function was taken as the sum of two components, one proportional to the square of the error of the estimator and the other proportional to the cost of obtaining and processing the sample. Both the case of a simple random sample and stratified random samples were discussed and a formula was obtained for the optimum allocation of the resources with a simple cost function.

Dr. Aggarwal has been considering two-stage sampling, treating the two cases, infinite and finite populations, separately. He has first investigated the case where the clusters are of equal size and later extended the results for unequal size clusters. This research resulted in a paper at the statistical society meetings in Philadelphia, and has been accepted for publication in the October 1966 issue of the Annals of Mathematical Statistics.

By using a similar approach, conditions have been derived under which the usual ratio method of estimation is a minimax procedure. It is further shown that if X and Y are distributed jointly, and only their variances, the covariance between X and Y, and the mean of Y are known, then a minimax estimator for the mean of X is the usual regression estimator. The results are extended to the case of sampling from finite populations in each case.

This further work was presented as a paper at the Brookhaven statistical society meetings, and it is expected that it will be published in the near future.

Post Office Research

Dr. Leroy Wolins has been assisting with research for a Post Office Department study involving mechanical handling of mail. A year-long study of some 400 postal employees has resulted in collection of data totaling about 100 IBM cards for each individual. Dr. Wolins has been working with the organization of this data to permit analysis.

The postal employees were given training on an elaborate machine which automatically handles mail. It displays each letter to the operator and when the operator presses the right buttons, automatically places each letter in the correct place. A skilled operator can sort mail with the machine much faster than by hand. However a high level of skill is required, which might be compared to a pianist with the ability to sight read Beethoven.

Data were obtained on these 400 employees prior to training, during training and after training. The "before training" data were intended for use in predicting the kinds of employees who benefit most from the train-

ing. The "after training" data were intended for determining how performance in training was related to performance on the job.

The results suggest that most of these employees were not able to learn to handle the machine effectively. However it appears that through the proper use of predictor information, groups of trainees could be selected who would benefit from training more than the training group used in this study.

USDC, Bureau of the Census Research Project

Dr. Wayne Fuller returned as principal investigator of Census Project Cco-9165, a continuing cooperative program of basic research in sampling, response errors and other fields of joint interest.

Research was continued on post stratification and regression estimation. Alternative sample estimators were developed for two post strata and compared with pooling or collapsing procedures commonly employed in practice. The new estimators are not necessarily conditionally unbiased for a particular sample split, but their conditional M.S.E. may be smaller than that of the common post stratified estimator.

It has been proven that it is always possible to construct an estimator superior to the practice of combining two post strata when one contains few sample elements. A procedure for generalizing the two strata procedures to any number of strata has been developed. This permits the construction of unbiased estimators for populations divided into a large number of small post strata.

Research was initiated on the estimation of parameters of extremely skewed populations. Some properties of the order statistics have been investigated and a small Monte Carlo study of estimators for two real populations conducted.

Research in the area of multi-factor analytical studies, initiated under the support of this contract last year by Dr. J. Sedransk, resulted in papers at statistical society meetings in Philadelphia and Brookhaven. It is expected that the work will be published during the coming year.

The research considers the designing of some multifactor "analytical" studies of survey data. It is assumed that, for each factor, there are two categories of interest and these are to be compared. The main objective is to allocate the sample so that the desired precision for the specified contrasts is obtained at minimum cost. It is assumed that one may sample independently in each of the sub-populations under investigation.

A model is employed to facilitate designing and analyzing such a survey. The relevance of this model for "analytical studies" is discussed, and an example (from sociology) is presented.

Several survey objectives are explored, and an optimal allocation is obtained for each. Two, three and four-factor studies are considered explicitly, and some generalizations for n-factor studies are given.

NIH Research

Six graduate students have been supported by the National Institutes of Health graduate training grant program during the year. A seventh, James Veale, who received his M.S. in May 1965, was supported by the program during the summer. He and Patricia Conn and Charles Sampson attended the 1965 Graduate Summer Session of Statistics in the Health Sciences at Yale University.

Professor C. Philip Cox taught Statistical Methods of Biological Assay at the 1965 session and was invited to return in 1966. The Summer Session, supported by NIH, is designed to meet some of the educational and training needs of men and women engaged in work in health and health-related agencies, and those preparing themselves for such work.

During the year Mrs. Conn has continued her doctoral research under Dr. H. T. David. The research involves the asymptotic distribution of unabsorbed paths in random walks between two absorbing barriers. It is generally concerned with establishing restrictions on non-stationary walks sufficient to yield some type of ergodic behavior, specifically a non-stationary normal walk between parallel boundaries. Applications can be made to problems in sequential analysis.

Premasters student Steven Selvin and predoctoral student Sampson have been fulfilling the requirements for their degree candidacy. Selvin will be working under the supervision of Dr. Edward Pollak and Sampson is working with Professor Cox.

During the first half of the year Donna Ruhl continued her research under Professor Cox. Different approaches were investigated for finding a fixed length confidence interval on the ratio of two normally distributed random variables, with particular application to parallel-line and slope-ratio assays. A paper was published and an abstract appears in the publications section of this report. Mrs. Ruhl is now continuing her doctoral research under the supervision of Dr. J. Sedransk.

During the year James Gebert has investigated topics for his Ph.D. thesis and has decided to do his research on nonparametric tests based on discriminatory information. Dr. B. K. Kale will supervise his work.

Predoctoral student John Johnson has worked under Dr. T. A. Bancroft on investigating the size and power of the analysis of variance procedure for model I after a preliminary test of significance when there is one doubtful error term. The power function for this test procedure has been tabulated and size and power curves are now being drawn to aid in making recommendations as to what size the preliminary test should be in order to maintain a size of .05 for the final test.

Johnson also has investigated the bias and mean square error in the estimation of one of two population regression coefficients from two independent samples after a preliminary test that the population regression coefficients of the two samples are equal. Expressions

for both the bias and mean square error have been obtained.

Research in Mathematical and Statistical Genetics

Dr. Oscar Kempthorne is principal investigator of National Institutes of Health Research Grant GM 13827-01A1, which began May 1. Dr. Edward Pollak and various postdoctoral workers will also be involved in this research.

The broad objective of the project is to develop the theory of the dynamics of real Mendelian populations.

The importance of the mathematical and statistical behavior of genetic populations has been exemplified by the early work of Wright, Fisher, and Haldane, and by more recent work by Kimura, Crow, Lewontin, Kojima, Bodmer, Levene, Karlin, McGregor, Moran, Morton, Cockerham, Kempthorne and others. The need for development of more realistic models has been emphasized by leading biologists, such as Dobzhansky, Mayr, Neel and Schull.

Deficiencies of present theoretical developments and knowledge revolve around the definition and use of concepts of fitness, the lack of a detailed model involving several components of fitness (fertility of mating, viability of young etc.), the role of inbreeding and mating system, the effects of overlapping of generations on theoretical conclusions.

The work involves the use and development of probability models of a wide range of difficulty. Some of the models to be considered involve quite elementary probability arguments. Others involve Markov chains, branching processes and even more complicated stochastic processes. Stochastic models which are density dependent and dependent on the population composition have to be considered. Competition between genetic types must be incorporated.

An attempt will be made to obtain solutions to more realistic problems than have hitherto been dealt with. If analytic solutions prove impossible to obtain, approximate solutions will be sought, if necessary by the use of high speed computers.

Statistically Oriented Computer Languages

Dr. T. A. Bancroft replaced Dr. William Hemmerle as over-all director of National Science Foundation Project GP-3239. In connection with the project Edward J. Carney has been working on a study of variances and covariances of estimates of variance components.

Eugene Dayhoff developed a method of obtaining expressions for variances and covariances of variance components for simple random sampling from balanced complete population structures. This method allows the formulation of the variances and covariances in terms of generalized polykays and generalized symmetric means of degree four. Direct application of the method to obtain numerical results is not practical because the amount of computation is so great as to be impractical.

Current work is aimed at reducing the amount of computation to an amount which can be performed at reasonable cost and at the preparation of programs to obtain the necessary formulas and evaluate them for given model structures. In addition it is hoped to extend the application of the results to more general sampling schemes, in particular to those arising in designed experiments.

Donald Soults has been working on a quadratic programming project. A quadratic programming algorithm has been developed which is based on the work of C. Van de Panne and A. Whinston (1964). The algorithm is completely general and has been rigorously defined mathematically. A detailed proof of convergence has also been constructed.

It is planned to develop an operational computer system which will give explicit numerical solutions to any quadratic model (quadratic objective under linear constraints). The computer system will also efficiently handle strictly linear models (not as degenerate quadratic models but specifically as linear models).

During the preparation of the mathematical algorithm, care has been taken to ensure that it will be extremely efficient in terms of the envisioned computer system. The computer program will be written in FORTRAN for the IBM 360 computer.

Inference Theory for Certain Incompletely Specified Models

A new National Science Foundation project, Grant GP-5688, has been approved with Dr. T. A. Bancroft as principal investigator. The work will involve a further study of inference theory started under NSF Grant GP-274, which ended in September. Dr. B. K. Kale and S. R. Srivastava are co-investigators.

The problem of specification, involving the choice of an appropriate statistical-mathematical model to be used in making inferences about the parameters of the model from observations of some investigation when a priori knowledge is insufficient to define the model, has not been completely solved.

One of the procedures commonly used is to assume a set of admissable statistical-mathematical models and then use the data from a single investigation to perform preliminary test(s) of significance to choose the most likely of the set and subsequently to test hypothesis or construct confidence intervals for the unknown parameters in the model selected by the preliminary test(s).

This project will continue research on the theory and analysis aspects of inference for incompletely specified models. Specifically, research will be carried out on three problems:

1. Power and size of a testing procedure involving a particular mean square in an analysis of variance, assuming an incompletely specified fixed model incorporating one preliminary test of significance.

2. The problem of testing an outlier involving regression.

3. Bias and mean square error of an estimation procedure involving two preliminary tests of significance.

An invited paper was presented by Dr. Bancroft on "Inference for Incompletely Specified Models in Physical Sciences" at the 35th Session of the International Statistical Institute, Belgrade, Yugoslavia, September, 1965. The theory and methodology for using data from a single experiment to determine a choice of a specific model from among those of an admissible set and subsequent inference problems regarding the parameters in the chosen model was discussed. Illustrations were given using data from physical sciences and engineering experiments.

Research was completed and a paper prepared on "Inference for Some Incompletely Specified Models Involving Discrete Data" by Dr. Kale and Dr. Bancroft, which was presented as an invited paper at the IMS-ENAR session of the spring meetings at Brookhaven. A discussion was given involving the inference problems concerning a population mean from a discrete distribution subsequent to a preliminary test of significance.

A paper was prepared on "Inferences Concerning a Population Mean from a Single Sample Subsequent to an Outlier Test" by Dr. Florence Tetreault and Dr. Bancroft. This paper presents a univariate outlier theory from a different point of view from that usually given. It is partially based on results obtained by Dr. Tetreault in her recent Ph.D. thesis.

A paper was prepared by Srivastava and Dr. Bancroft on "Inferences Concerning a Population Correlation Coefficient from One of Possibly Two Samples Subsequent to a Preliminary Test of Significance."

Multivariate Analysis and Multiple Inverse Sampling

Research on problems in theoretical statistics has been completed by Dr. Akio Kudô, principal investigator of National Science Foundation Project GP-3918.

One of the topics of this research is a generalization of the result by Wolfowitz (1946) on the uniqueness of unbiased estimates of probabilities in sequential multinomial sampling. Dr. Kudô has been able to generalize the notion of strong simplicity defined by Wolfowitz. The closeness along with this generalized condition has been found to be sufficient for uniqueness of the unbiased estimate of probabilities.

The power function of a bivariate analogue of two-sided test was investigated and a paper read at the International Symposium on Multivariate Analysis will be published in its proceedings. The conclusion is that it is recommended to use this test in case of negative correlation. The scope of generalization to higher dimension also has been discussed. In order to compute the tables necessary for higher dimension, it has been realized that more time and funds are needed.

Some Problems in Multivariate Analysis; Symmetric Multiple Decision Problems

Dr. Akio Kudô will be the principal investigator of this new National Science Foundation Grant GP-6149. The research will include a continuation of the studies made under Grant GP-3918, concerning multivariate analysis and multiple inverse sampling.

Dr. Kudô already has investigated the tests of multivariate normal means with restricted alternative hypothesis. Underlying assumptions are that the correlation matrix is known, but common variance is not known. This assumption is valid in case of an analysis of variance with an ordered alternative proposed by D. J. Bartholomew (1961). He worked out the approximate percentage points, and Dr. Kudô worked out the general method to compute the values of test statistic, and also examined the power function in the bivariate case.

In case the variance matrix is not known, there is a paper by Nuesch (1966), but unfortunately this paper fails to provide a solution as the distribution of test statistic depends on an unknown parameter. This grant will permit investigation of these problems in more detail.

It is sometimes noticed, but much attention has rarely been given, that in the application of multivariate analysis, higher dimensionality merely inflates the residual variation and as a result the power of the test is less. Dr. Kudô has developed an algorithm for computing Hotelling's T^2 statistic for all possible combinations of components to ascertain the relative importance of the combinations. The theoretical background, however, is much behind the practice, and further investigation in methods, as well as theory, is proposed.

The invariant decision functions have played an important role, especially in symmetric multiple decision problems such as the slippage problems, the classificatory problem, test of outlier, etc. Recently Dr. Kudô and a graduate student, Irving Hall, realized that in some problems the condition of invariance can be removed. It is proposed to investigate, at first, these problems without assuming invariance of the decision function.

The final aim of this research on multiple decision problems is to approach some problems in incompletely specified models from the standpoint of symmetric multiple decision theory. One particular problem is to study the estimation of normal mean after testing outliers.

Problems in Random Walk and Sequential Decision-Making

A new National Science Foundation research grant, GP-6013, has been approved with Dr. Herbert T. David as principal investigator and Dr. David Thomas as co-investigator.

One objective of this grant is to support research continuing the work completed by Dr. Thomas in his doctoral thesis, "Asymptotic Value Distributions for Certain 2xn Games and n-Stage Games of Perfect Information." An abstract of the thesis appears in the publications section of this report.

It is expected that further research will proceed in the following directions:

1. For the perfect information games, considering moment convergence for payoff distributions other than the uniform.

2. For the matrix games, extending from 2xn to mxn games and deriving explicit limit forms for more general distributions.

3. For both types, replacing the conditions of mutual independence of the payoffs by a weaker condition such as exchangeability, and considering the joint asymptotic distribution of the values of several games of identical structure with correlated corresponding payoffs.

4. Investigating the similarities between the probability-generating function approach to branching process problems, and the present treatment of perfect-information games.

The grant will also provide funds for the continuing research of Patricia S. Conn and Richard Mensing in two areas previously supported by NSF Project GP-1801: the application of a planar reflection principle to random walk in the plane, and the asymptotic behavior of unabsorbed paths of random walks between absorbing barriers.

In the first of these areas, it is hoped to apply planar reflection to the computation of absorption probabilities, for various types of boundaries, of certain multi-dimensional Gaussian processes; such computations provide asymptotic null distributions of a class of non-parametric k-sample statistics.

In the second area, work is progressing in the area of non-stationary random walks continuous in space. Of special interest here is the asymptotic behavior of a normal random walk within parallel curved boundaries.

Research in Population Genetics

This research, supported by the National Science Foundation, Grant 18093, and the Agricultural Experiment Station, Project 1505, continued under the direction of Dr. Oscar Kempthorne with Dr. Edward Pollak as co-leader.

Dr. Pollak studied inbreeding and random genetic drift in a subdivided population containing two alleles. It was assumed that there were two subpopulations, between which there was a small amount of migration per generation. The results showed that if there is a very low rate of migration per generation, then it would take a very long time to have a high probability that one or the other of the alleles has been eliminated from the population.

Inbreeding in subdivided populations is being investigated further. An attempt will be made to extend the theory to dioecious species.

Research was also completed under this project on some effects of selection by culling which resulted in a paper by Dr. Pollak, "Some Consequences of Selection by Culling when there Is Superiority of Heterozygotes." An abstract appears in the publications section of this report.

Analysis of Variance Procedures and Related Topics

A new two-year Aerospace Research Laboratories contract has been approved, with Dr. Oscar Kempthorne and Dr. George Zyskind continuing as directors. A serious intent of the research, which is expected to generalize and relate closely with research done on previous ARL contracts, will be the further unification of least squares and the randomization and structure theory of experiments.

A technical report, Research on Analysis of Variance and Data Interpretation, summarizes work done on the current contract, AF 33(615)1737. It includes a section on variance components and mixed model problems, based mainly on the doctoral work of Rodney P. Basson as reported in last year's Annual Report, and a section on combination of information from distinct uncorrelated sources, based primarily on work done for Frank Martin's M.S. thesis. A thesis abstract appears in the publications section of this report and a paper on the general subject will appear in the October Annals of Mathematical Statistics.

A section on size and power of tests is based on the doctoral work of T. E. Doerfler. Doerfler's thesis also is abstracted in the publications section, and a separate report has been submitted to the Aerospace Laboratories.

In another section of the report, E. J. Carney has described work done on the high speed computation of generalized polykays and hence of variances and covariances of estimates of variance components. This work implements numerically and extends theoretically some of the previously obtained general results of Eugene Dayhoff.

Algorithms have been developed which allow one to obtain necessary formulas for variances and covariances of estimated variance components for arbitrary balanced population structures. A general method of obtaining all needed identities in a straightforward way has been developed and implemented in a computer program, so that generalized symmetric means are computable in terms of quantities, called D's or "derived" terms, in a minimum number of operations. Further programs have been developed which interpret the D's and compute their numerical values.

The report also contains a brief summary of Dr. Kempthorne's Fisher Memorial Lecture, abstracted in the publications section, which was presented at the Philadelphia statistical meetings. In Philadelphia Dr. Zyskind was discussant in a session devoted to developments of general formulations which have taken place under various ARL contracts with the Statistical Laboratory. Former personnel Robert White and Eugene Dayhoff were speakers on the program.

In other aspects of the current project, Dr. Kempthorne and Leon Jordan have been examining the role of sampling in determining a functional relationship between two variables. It is thought that this will have

implications to experimental design for the study of the dependence of a yield variable on experimentally controlled "process" variables.

Martin has recently been giving attention to the assessment of the efficiency of estimators constructed by simple weighting for cases where the corresponding parametric functions *are not* best combinable by simple weighting.

Dr. Zyskind has prepared a manuscript, "On Canonical Forms, Non-Negative Covariance Matrices and Best and Simple Least Squares Estimators in Linear Models." It considers the general linear model $y = X\beta + e$ with $E(e) = 0$ and with variance $E(ee') = \sigma^2 V$, where σ^2 is positive and unknown, and V is a known (to whatever extent needed) nxn non-negative symmetric matrix. One example of a situation which may be viewed as having a singular covariance matrix is that in which the parameters are subject to specified linear constraints. Further, an important class of situations in which the model covariance matrix is naturally singular is that arising in randomized experiments under additivity, when all errors are induced by the random assignment of treatments to subsets of the experimental material. Conditions are first considered under which all the simple least squares linear estimators are also best, then a general characterization of the best linear estimators is given, and then conditions for the equality of subsets of best and simple least squares estimators are obtained. One result is that in general the function w'y is best linear unbiased for its expectation, E(w'y), if and only if the vector Vw belongs to $\mathcal{C}(X)$, the column space of the design matrix X.

Design of Experiments and Analysis of Data

Dr. Oscar Kempthorne continues as director of Agricultural Experiment Station Project 890.

A description of the concept of identity of genes by descent and the use of this concept in understanding some of the dynamics of Mendelian populations was given at the Berkeley symposium on Probability and Statistics. The concept was applied to the probability status of an individual in a finite population, to the progress of a finite haploid population with random viability, and to a simplfied problem of a population existing in two niches with migration. The extension of the concept to consideration of triples, quadruples and n-ples of genes was described. The progress of a finite monoecious population with regard to the likeness among sets of 3 genes, sets of 4 genes, and so on was developed. The same aspects were examined for a finite haploid population with random viability.

Initial study of goodness of fit was made. The classical goodness of fit test, the chi-square test developed by Pearson, is appropriate, according to mathematical tests, if the expected cell frequencies are greater than five. Some writers may give a lower limit such as two. Also, the question of how the cells are to be formed is not discussed effectively. The procedure which has been investigated partially is that with N observations, the fitted distribution should be divided into N parts each with a probability content equal to $\frac{1}{N}$. The ordinary classical chi-square criterion is then computed and evaluated by the theoretical chi-square distribution with degrees of freedom equal to N minus the number of parameters fitted. The general conclusion is that the classical chi-square goodness of fit procedure can be applied with the number of cells of the order of the number of observations, thus giving expected values in each cell of unity, and that this procedure appears to be reasonably sensitive.

Design of Surveys and Analysis of Data

Dr. Wayne Fuller and Dr. J. Sedransk continued as directors of Agricultural Experiment Station Project 1005.

Research was continued on the planning of analytical surveys when a fixed factor analysis of variance model is considered appropriate. Research on the analysis of production response studies was conducted and procedures applicable for experiments with repeated determination on the same units was further developed.

Some preliminary work was carried out on the estimation of ratios in conjunction with the regression estimation procedures. Plans are to continue work on this and on production function analysis.

Statistical and Economic Analysis for Long-Term (Rotational) Agronomic Experiments

Dr. Foster Cady and Dr. Wayne Fuller continued as leaders of Agricultural Experiment Station Project 1578, with Dr. John Pesek and Dr. William Shrader as leaders in the Department of Agronomy.

The hypothesis that all differences in corn yields in different rotations are due to differences in the amount of nitrogen supplied to the corn was investigated for two long term rotation experiments, Carrington-Clyde and Clarion-Webster. In each experiment a range of nitrogen rates was applied to corn grain in a number of different cropping systems.

In each experiment it was found that the corn in all rotations could be fitted on one nitrogen response curve and that no other effect on corn was demonstrated. This model has resulted in a meaningful reduction of the data. For example, the seven years of experimental results (168 observations) of the Carrington-Clyde soil can be adequately described with a model containing ten parameters, five of which are subject to random year-to-year variation.

Other crops will be included as the analysis of rotation experiments continues, and economic analysis of the results is planned. It is hoped that estimates of the variances of yields which incorporate random year effects can be developed.

Sampling in Soil Surveys

During the year the Survey Group, with Professor Norman Strand as project leader and Mrs. Marjorie

Mason as supervisor, has continued to participate in a cooperative agreement with the Soil Conservation Service, administered under Agricultural Experiment Station Project 1312.

The Soil Conservation Service has begun to update the inventory of land samples drawn to determine conservation needs, resulting in necessary revising and updating of cards and tape stored by the university. Data continues to be transferred from cards to tape to permit processing by electronic machines.

Work on operational phases continued, including coding and punching of soil measurement data as made by SCS field personnel in states not having previously submitted such data. Diagnostic runs of soil, slope, erosion and land capability were made by the IBM 7074, so that these codes could be put on a statewide system. Watershed, land resource and acres checks were made for states treated in 1965, to permit putting these codes on a national system.

Preparation of summary tables of the expanded soil survey sample area data was continued for an interagency coordinated survey of river basins. Work was completed on tabulations for states or parts of states in the Missouri River Basin, for the state of Ohio by watershed and land capability unit groupings, for states or parts of states in the Upper Mississippi River Basin and for the state of Michigan for special watershed work.

Review of data for 13 northeastern states was begun, and special sets of tabulations were started for states or parts of states in the Columbia River Basin, for use by economists in ERS-USDA.

Evaluating the 1964 Census of Agriculture

Work continued on the research project with the Bureau of the Census on the evaluation of the 1964 Census of Agriculture. Charles Graham provided technical assistance at the government's location in Jeffersonville, Indiana, during July and August, and has continued this work in Ames.

Harold Baker assisted in the planning and preparations for the reconciliation phase of the study which was completed during the winter. Baker and Mrs. Marjorie Mason supervised the field work in Iowa, Nebraska and Kansas, and in the South Atlantic and East South Central areas of the United States.

The Survey Group, under Baker's supervision, is processing the data for analysis. Graham will write his master's thesis on some aspect of the study.

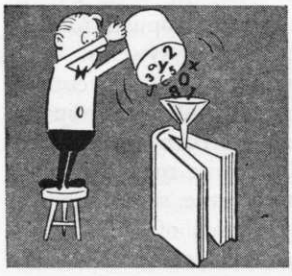
Agricultural Estimates

The Survey Group is continuing a research project with the Research and Development Branch, Statistical Reporting Service, United States Department of Agriculture, on the prediction and objective estimation of pasture and hay yields. Principal personnel on the project are Professor Norman Strand, Dr. Wayne Fuller, Harold Baker and Paul Rackow.

Previously developed cage procedures were used to estimate pasture production on a sample of farms in central and eastern Iowa. On those farms with alfalfa, sample plots were clipped twice prior to harvest to estimate hay production.

Research is currently underway to develop means of preparing lists of farmers with various farm enterprises.

Publications and Professional Activities



Most of the research conducted by Statistical Laboratory staff members is reported in papers presented at professional meetings and in articles published in professional journals. In addition, the staff members take an active role in the operation of the professional societies of which they are members.

RECORD OF PUBLISHED RESEARCH

Articles published by staff members and graduate students during the past fiscal year are recorded on the following pages. When the research was conducted at Iowa State, but the author has since accepted a new position, his current location is listed in parenthesis after his name.

Some of these publications are included in the Statistical Laboratory's Reprint Series and copies are available upon request. These are indicated by an asterisk (*).

***Bancroft, T. A.:** "Inference for Incompletely Specified Models in the Physical Sciences." The 35th Session of the International Statistical Institute, Belgrade, 1965. Reprint Series, Statistical Laboratory, Iowa State University.

In making use of that part of modern statistics of great use in scientific investigations, one is often concerned with the specification of an appropriate statistical-mathematical model whose mathematical form is known, but whose parameters although definite in number have unknown values.

The scientific investigation; for example, an experiment or a survey, yields sample values to be used in estimating the values of the population parameters or in testing certain hypotheses concerning the population parameter values. In applying the usual inference theory, there is often some uncertainty regarding the appropriate statistical model specifications. In such cases of uncertainty, the research worker has often

adopted some objective rule of procedure which makes use of the data in hand to effect a preliminary test of significance, as an aid in determining an appropriate statistical-mathematical model specification for subsequent inferences.

It should be noted that this procedure assumes that a single sample is available for investigating both the appropriateness of the statistical model and for making the subsequent inferences. In making use of such procedures it is necessary that account be taken of the effect of the preliminary test of significance on the final inferences of primary interest.

A number of papers have been written in recent years on special problems involving the use of preliminary tests of significance in the manner described above. The author has attempted to summarize the common features of the procedures used in these special methodological investigations by introducing the concept of *incompletely specified models*. Using this concept the author has attempted to initiate the formulation of a general statistical inference theory for incompletely specified models.

In the present paper the author presents and illustrates certain analysis of variance procedures for incompletely specified models in physical sciences. In particular, an attempt is made to use the present methodology available for inference for incompletely specified models to handle a complex analysis of variance given in *Statistical Analysis in Chemistry and the Chemical Industry* by B. M. Bennett and N. L. Franklin. It was found that the procedures given by Bennett and Franklin and those given by the author differed considerably and led on one occasion to different inferences.

The remaining three sections of the paper are devoted to an account of some recently developed theory and methodology of inference for incompletely specified models in: least squares or regression analysis, life testing, and testing outlying observations. All of these new statistical procedures and results should be useful in many investigations in the physical sciences. Only brief accounts could be given; however, the reader is provided with references to papers containing more detailed explanations.

D. W. Staniforth, W. G. Lovely and **F. B. Cady:** "Sampling Procedures for Estimates of Weed Yields in Corn Plots." Weeds, 13:4, 357-360. October, 1965. Journal Paper No. J-5051, Iowa Agricultural and Home Economics Experiment Station, Ames, Projects 1520 and 1521.

Mature yellow foxtail infestations, growing in rows of corn, were harvested in 3-foot segments from paired 30-foot rows of corn. Basic analyses of variance were calculated so that the variances of the plot sizes involving multiples of 3 feet could be determined and compared.

Precision indices were calculated for harvesting various fractions of the plot area. Loss of precision did not exceed 25 percent when only 40 percent of the total area was harvested in random samples of 1-row x 3 feet, or in multiples of this basic unit. Practical implications of the findings are related to estimates of weed yields in crop-weed ecology studies and herbicide evaluation tests.

Daniel B. Stone, Joseph D. Brown and **C. Philip Cox:** "Effect of Tolbutamide and Phenformin on Lipolysis in Adipose Tissue in Vitro." American Journal of Physiology, 210:1, 26-30. January 1966.

This paper reports on a study of the effects of tolbutamide and phenformin on the release of glycerol and free fatty acids from rat epididymal adipose tissue incubated in Krebs-Ringer phosphate or bicarbonate medium containing neither glucose nor lipolytic hormones. Fasted rats were used.

Following variance stabilization by a logarithmic transformation, standard analysis of variance procedures were carried out. The results showed that tolbutamide induced a significant decrease in the net release of glycerol and free fatty acids from adipose tissue. No such effects were observed with phenformin.

***C. Philip Cox** and **Donna J. Ruhl:** "Simplified Computation of Confidence Intervals for Relative Potencies Using Fieller's Theorem." Journal of Pharmaceutical Sciences, 55:4, 368-371. April 1966. Reprint Series No. 174, Statistical Laboratory, Iowa State University.

Confidence intervals for relative potencies in bioassays are usually calculated by using Fieller's theorem, but the procedures presented in standard texts are computationally cumbersome.

It is shown that Fieller's formula can be expressed in an alternative form which takes advantage of calculated quantities from the analysis of variance (ANOV) and thus simplifies computations. Slope ratio assays and parallel line assays are discussed, and two examples illustrate the use of the proposed alternatives.

***C. Philip Cox** and **Thomas D. Roseberry** (C-E-I-R, Dugway Proving Ground, Dugway, Utah): "A Large Sample Sequential Test, Using Concomitant Information, for Discrimination between Two Composite Hypotheses." Journal of the American Statistical Association, 61:314, 357-367. June 1966. Reprint Series No. 181, Statistical Laboratory, Iowa State University.

In Wald-type sequential test procedures for discriminating between two composite hypotheses subjects are paired and receive one of two treatments at random. Decisions based on the cumulated mean within-pair difference may often be delayed because experimental subjects rarely arrive in well matched pairs.

A possibly ameliorating recourse in such situations is the use of suitable concomitant information and, to this end, a simple asymptotically valid test procedure is described for discriminating between the test and alternative hypotheses

$$H_T : \mu = \mu_T; \quad H_A : \mu = \mu_A$$

where μ is the difference between the population means of variates which measure the effects of treatments.

The analysis is based on the treatment 1 minus treatment 2 response differences $y = y_1 - y_2$ and the corresponding concomitant observation difference $x = x_1 - x_2$, where x and y are assumed to be distributed bivariate normally. It is shown that

$$\frac{n(\mu_A - \mu_T)}{\hat{\sigma}^2}(\bar{y} - \hat{\beta}\bar{x} - \frac{\mu_A + \mu_T}{2})$$

serves as an appropriate test statistic, $\hat{\sigma}^2$ and $\hat{\beta}$ being estimates of $\sigma^2_{y|x}$ and of the regression coefficient of $E(y \mid x)$ on x respectively.

Monte Carlo experiments on the performance of the sequential covariance test procedures are described. To avoid premature decisions at stages for which the large sample theory is not appropriate, an empirical censoring scheme was introduced, whereby early decisions were ignored. Determination of exact censoring levels was not critically essential for moderately large a.s.n.

Subject to the censoring the experiments showed that, although strict validity is theoretically achieved only for infinite a.s.n., definite covariance economy can be obtained in practically relevant situations with error rates close to those specified. It was found that observed mean sample numbers agreed closely with theoretical values predicted by the Wald formula, the indication being that a.s.n. are reduced by the factor $(1 - \rho^2)$ from comparable values obtained ignoring the covariate.

The relation between this ρ, the correlation coefficient between the x and y within-pair differences, and correlations between individual components, x_1, y_1, x_2, y_2, of the differences is derived and it is shown that ρ may be expected to be large when the correlation coefficient between x_i and y_i is large.

*C. E. Cress (Rutgers University, New Brunswick, N.J.): "Heterosis of the Hybrid Related to Gene Frequency Differences Between Two Populations." Genetics, 53:2, 269-274. February 1966. Reprint Series No. 173, Statistical Laboratory, Iowa State University.

Genetic diversity of two populations as measured by gene frequency differences was related to heterotic performance of the hybrid, where the measure of heterosis was deviation from the midparent.

Heterosis (M_H) was found to be non-negative in the case of two alleles, if negative dominance was excluded. With more than two alleles per locus, negative contributions to M_H are to be expected at certain loci, and the net effect may result in a hybrid genotypic value equal to or below the midparent. This can occur even when the dominance relationships of all pairs of alleles are positive.

Some implications of these results are given.

Eugene Dayhoff (Texas A and M University, College Station): "Generalized Polykays, an Extension of Simple Polykays and Bipolykays." Annals of Mathematical Statistics, 37:1, 226-241. February 1966.

In an earlier paper (1964), the author presented a generalization of the second degree bipolykays of Hooke (1956), defined for arbitrary balanced population structures, and showed the equivalence of these generalized polykays and the Σ functions defined by Zyskind (1962).

In this paper is presented a more general formalization of generalized symmetric means and polykays of arbitrary degree and some sampling properties of these. Utilizing the fact that the second degree generalized polykays are equivalent to the Σ's, which are defined in terms of components of variation, an application to obtaining the variances of estimates components of variation is also presented.

*E. L. Fuller, Jr. (University of Rhode Island, Kingston) and W. J. Hemmerle (University of Rhode Island, Kingston): "Robustness of the Maximum-Likelihood Estimation Procedure in Factor Analysis." Psychometrika, 31:2, 225-266. June 1966. Reprint Series No. 182, Statistical Laboratory, Iowa State University.

In order to determine the robustness of the maximum-likelihood estimation procedure, random variates from six distributions were generated independently on a high speed computer and then used to represent the common and specific factors in a factor analysis model in which the coefficients of these factors had been specified. Using Lawley's approximate χ^2 statistic in evaluating the estimates obtained, the estimation procedure is found to be insensitive to changes in the distributions considered.

*J. L. Gill (Michigan State University, East Lansing): "A Monte Carlo Evaluation of Predicted Selection Response." Australian Journal of Biological Sciences, 18, 999-1007. 1965. Journal Paper No. J-5073, Iowa Agricultural and Home Economics Experiment Station, Ames, Project 1508. Reprint Series No. 169, Statistical Laboratory, Iowa State University.

This study utilizes a computer program that simulates the effects of selection, linkage, and environmental variation on the genetic progress of finite populations. The results, with respect to selection advance and the inbreeding that occurs in small populations, have been discussed previously (Gill 1965).

In this paper, the correspondence of Monte Carlo results to the hypothetical progress predicted according to a mathematical formulation given by Griffing (1960) is evaluated.

The predicted contribution to change in the mean attributed to additive-by-additive genetic variance, in most cases, was far too large over several generations of selection, or for even shorter periods in the smallest populations. Random genetic drift and selection appeared to have considerable influence in changing the genetic parameters quickly.

The effects of restricted population size and selection

on changes in value of genetic parameters and the effects peculiar to a particular mode of gene action combined to obscure the prediction problem, so that Griffing's theoretical expression was accurate for more than a very few generations only when a fortuitous combination of several factors occurred. However, the magnitude of the discrepancies noted between predicted means and those observed in Monte Carlo populations is probably larger than it would be in a practical situation because of restrictions in the mechanics of simulation.

*J. L. Gill (Michigan State University, East Lansing): "Selection and Linkage in Simulated Genetic Populations." Australian Journal of Biological Sciences, 18, 1171-1187. 1965. Journal Paper No. J-5067, Iowa Agricultural and Home Economics Experiment Station, Ames, Project 1508. Reprint Series No. 172, Statistical Laboratory, Iowa State University.

This study utilizes a computer program that simulates selection, linkage and environmental variation in finite populations. The intensity or magnitude of those factors is related to the genetic progress of small simulated populations under nine genetic models, and the results are discussed in relation to existing theory.

Populations with complete dominance, complementary factors, or duplicate factors were temporarily hindered in progress from selection by random drift, due to small population size, but the paucity of undesirable fixations indicates that the effect on total potential response should be negligible or small if selection is as intense as 1/6.

Selection was effective in advancing the genetic mean of small populations under the models of gene action in which the genotype of highest merit is homozygous, but was weaker than random genetic drift when heterozygous genotypes were optimum. Little evidence was obtained to support Robertson's hypothesis that less intense selection may be optimum for reaching long-time selection goals.

Differences in the amounts of simulated environmental variation between populations were important in affecting genetic progress only when the mean was changing rapidly because of intense selection. Genetic merit, gene frequency, and fixation essentially were unaffected by different levels of linkage, except in the first few generations of some populations. Linkage disequilibrium appears to bias estimates of components of genotypic variance for many generations in populations selected for intermediates.

W. J. Hemmerle (University of Rhode Island, Kingston): "Obtaining Maximum-Likelihood Estimates of Factor Loadings and Communalities Using an Easily Implemented Iterative Computer Procedure." Psychometrika, 30:3, 291-302. September 1965.

This paper considers the problem of computing estimates of factor loadings, specific variances, and communalities for a factor analytic model.

The equations for maximum-likelihood estimators are discussed. Iterative formulas are developed to solve the maximum-likelihood equations and a simple and efficient method of implementation on a digital computer is described.

Use of the iterative formulas and computing techniques for other estimators of factor loadings and communalities is also considered to provide a very general approach for this aspect of factor analysis.

Marjorie M. McKinley, Ivan L. Town, Young Sook Kim and **Donald K. Hotchkiss:** "Methods of Preparing Turkey for Quantity Food Service." Food Talks, Nutrition Services Section, California State Department of Mental Hygiene, 1-7. October 1965. Reprinted from Journal of Home Economics, 57:1. 1965. Journal Paper No. J-4785, Iowa Agricultural and Home Economics Experiment Station, Ames, Project 1338.

Three experiments designed to control the labor time and yield of cooked turkey meat were conducted as randomized complete block experiments. These studies were combined and comparisons among the various treatments were made using Duncan's multiple range test.

The results of this study were used to make recommendations to users of turkey in quantity food service.

*V. S. Huzurbazar (University of Poona, India): "Some Invariants of Some Discrete Distributions Admitting Sufficient Statistics for Parameters." Proceedings of the International Symposium: Classical and Contagious Discrete Distributions, Montreal, 1963. 231-240. Reprint Series No. 175, Statistical Laboratory, Iowa State University.

This paper contains a brief account of the invariants of Jeffreys (1946, 1961) and Huzurbazar (1960). Huzurbazar's method is applied to obtain some new invariants of some well-known discrete distributions where sufficient statistics exist, e.g. the Bernoulli, Binomial, Poisson and Multinomial distributions. Additional invariants are obtained by combination of the methods of Jeffreys and Huzurbazar.

Applications of invariants in the statements of prior probability of parameters in estimation are indicated, but the results obtained may also be regarded as a study of some interesting purely mathematical properties of the class of distributions admitting sufficient statistics for parameters.

J. C. Davies and **D. Jowett:** "Increases in the Incidence of *Atherigona indica infuscata* Emden Diptera (Anthomyiidae) on Sorghum Due to Spraying." Nature (London), 209, 104. January 1966.

Spraying with D.D.T. and Carbaryl A increased the incidence of *Atherigona indica infuscata* on two varieties of sorghum. Spraying with Fenitrothion gave results comparable with the control. Apparently spraying did not have any direct effect on the incidence of the pest, but D.D.T. and Carbaryl A reduced the population of parasites and predators upon *Atherigona,* which led to an increase in crop damage.

*B. K. Kale: "Approximations to the Maximum-Likelihood Estimator Using Grouped Data." Biometrika, 53: Parts 1 and 2, 282-285. June 1966. Reprint Series No. 180, Statistical Laboratory, Iowa State University.

The grouping of observations on a random variable (r.v.) X corresponds to a partition of real line into a finite number of disjoint intervals and every such grouping g defines a r.v. X_g which has a multinomial distribution.

Let G be the class of all such groupings. Under some regularity conditions on the density function $f(x,\Theta)$, $\Theta\epsilon\Omega$ of the r.v. X, Kale (Biometrika 51) proved that $I(\Theta_0, \Theta) = \text{lub}_{g\epsilon G}\{I_g(\Theta_0, \Theta)\}$ where $I(\Theta_0, \Theta)$ and $I_g(\Theta_0, \Theta)$ denote the amount of discriminatory information (Kullback) supplied by the r.v. X and X_g respectively.

Using this result, is is proved that there exists a sequence of groupings $\{g_K\}\epsilon$ G such that (1) $\lim_{K\to\infty} I_{g_K}(\Theta_0) = I(\Theta_0)$ and (2) for each K and any $\delta > 0$, the infrimum of $I_g(\Theta_0, \Theta)$ over $|\Theta_0-\Theta| > \delta$ is strictly positive whenever the infrimum of $I(\Theta_0, \Theta)$ over $|\Theta_0-\Theta| > \delta$ is bounded away from zero. This implies that the sequence of multinomial distributions $\{X_{g_K}\}$ satisfy the regularity conditions of Rao (Sankhya 18) and determines a sequence of maximum likelihood estimators (mle) $\{\hat{\Theta}_{g_K}\}$ of Θ which converges in distribution, (for large samples at least) to $\hat{\Theta}$ the mle of Θ based on observations of X.

*Oscar Kempthorne: "Development of the Design of Experiments over the Past Ten Years." Proceedings of the Tenth Conference on the Design of Experiments in Army Research Development and Testing, ARO-D Report 65-3, 19-46. Reprint Series No. 170, Statistical Laboratory, Iowa State University.

The main aspects of experimentation on which progress has been made are (a) the analysis of experiments, (b) the theory of incomplete block designs, and (c) the investigation of multifactorial situations. Apart from a few brief comments, this review paper discusses the last of these.

The present knowledge with regard to fractional replication of qualitative factorial systems is outlined. The general conclusion is that there is a totally adequate array of main effect plans but that there are obscurities with regard to plans for estimating 2-factor interactions.

For the case of continuous factors, results on the problem of optimum seeking are reviewed; the Box-Wilson procedures, the Partan algorithms, and methods of stochastic approximation. The work of Box and his co-workers on "response surface exploration" is discussed. The work on direct mathematical attack on optimality of polynomial fitting designs is reviewed. The various criteria of optimality are stated and some of the results obtained by Hoel, Kiefer and Wolfowitz given.

It is concluded that further work is necessary, in that optimality with regard to one criterion often leads to marked non-optimality with regard to other criteria. Attention to reasonable sub-optimality with regard to several criteria is therefore relevant to practical experimentation.

*Oscar Kempthorne: "Some Aspects of Experimental Inference." Journal of the American Statistical Association, 61:313, 11-34. March 1966. Reprint Series No. 178, Statistical Laboratory, Iowa State University.

This paper is the text of the Fisher Memorial Lecture for 1965 presented to the joint statistical societies. It is concerned with relating Fisher's ideas on inference for nonexperimental and experimental situations. In the former the basic ideas appear to be tests of significance, examination of the likelihood function and fiducial probability, while in the latter Fisher put forward randomization or permutation tests and seemed, at least in many contexts, to take the view that this test was the main inferential tool, which could be approximated by normal law tests.

The ideas of significance tests and likelihood are discussed. The use of the continuous likelihood function (the product of probability densities of the observations) for models involving underlying continuous distributions is discussed, and an example presented in some detail which indicates that this procedure may be quite misleading, particularly if local behavior of the likelihood function is used for inferential purposes.

Little is added to the obscurity about fiducial inference, except to point out that from the viewpoint that no continuous random variable is observable without some definite grouping error, every observation is discontinuous and it therefore appears that in a real sense, using Fisher's own statement, fiducial inference is impossible. It is suggested that fiducial densities cannot exist from the given data in that continuous observations are impossible.

In connection with fiducial inference, some Monte Carlo results on the Behrens-Fisher test are presented to show that apparently the Fisher significance level is distributed essentially in the way that one hopes for, that is, as a random variable uniformly distributed between O and 1.

For the case of randomized experiments, the writings of Fisher are evaluated. Quotations are given to indicate that Fisher felt that the validity of normal law t and F tests for "any particular body of data may be verified arithmetically" by the randomization test procedure. The contradiction inherent in requiring unbiased estimation of error, which is a property of randomization repetitions, and then using normal law models is discussed.

Finally, a summary is given of some comparisons of the Fisher randomization test, the Wilcoxon paired design test, the sign test and the normal law F test for small experiments.

*Edward Pollak: "Some Consequences of Selection by Culling when there Is Superiority of Heterozygotes." Genetics, 53:5, 977-988. May 1966. Journal Paper No. J-5200, Iowa Agricultural and Home Economics Experiment Station, Ames, Project 1505. Reprint Series No. 176, Statistical Laboratory, Iowa State University.

An analysis was made of a situation in which two alleles at one locus affect the expression of a character. Heterozygotes are assumed to have a higher genotypic value than both homozygotes. Selection occurs in each generation by the culling of individuals having the lowest genotypic values. The proportions culled could differ in the two sexes. Stable equilibrium frequencies were derived.

It was shown that it is possible for selection to cause a decline in the mean genotypic value of the population. It was also shown that it is possible for the population mean to decline when selection is relaxed.

Edward Pollak: "On the Survival of a Gene in a Subdivided Population." Journal of Applied Probability, 3:1, 142-155. June 1966.

This paper considers an infinite population divided into K partially isolated subpopulations, between which there can be migration. Generations are non-overlapping and one locus with two alleles, A and $\overline{A}$, is studied.

If there are initially only a few genes of type A, and individuals carrying them are assumed to reproduce independently of each other, it is possible, by using the theory of multitype branching processes, to calculate the probability that A survives.

There is then a discussion concerning a population which always has a large number, N_i, of genes in subpopulation i, $i = 1, \ldots, K$. It is assumed that all genes act independently of whatever other gene is present at the same locus in the adult. As in the previous problem, there is assumed to be migration of gametes after selection.

Probabilities that A survives, given any initial set of frequencies, are calculated. These are functionally related to probabilities involved in the infinite population problem.

*J. Sedransk: "Analytical Surveys with Cluster Sampling." Journal of the Royal Statistical Society, Series B, 27:2, 264-278. 1965. Reprint Series No. 168, Statistical Laboratory, Iowa State University.

This paper concerns the designing of certain analytical surveys (utilizing cluster sampling). The general concepts and problems peculiar to this type of study are discussed.

The question of the relevant population for inference purposes is treated, and this is reflected in the model considered. Illustrations are given to clarify the situations where this type of model may be applicable.

In general, the objective in planning such a survey is to select the sample so that maximum precision for the comparisons to be made is obtained for a specified total cost. Sample size allocations are carried out for several specifications of survey goals—these specifications being related to the type of comparisons to be made.

*J. Sedransk: "A Double Sampling Scheme for Analytical Surveys." Journal of the American Statistical Association, 60:312, 985-1004. December 1965. Reprint Series No. 171, Statistical Laboratory, Iowa State University.

The concept of analytical sample surveys is discussed in general, and a double sampling scheme is proposed for certain situations. Emphasis is placed on the presentation of a method which can be used to solve a certain class of problems.

It is assumed that the subgroups of the population which are to be compared form a one-way classification, and are not identifiable in advance of drawing a simple random sample from the population. With double sampling, a large sample is selected, and the group to which each element belongs is identified. Then a subsample is selected within each of the groups according to a sampling rule specified in advance.

It is desired to find those values of the preliminary and main sample sizes which will maximize some precision statement subject to a given budget. Approximate procedures to secure quick and reliable solutions are given. The validity of the approximations is also investigated.

*J. Sedransk: "An Application of Sequential Sampling to Analytical Surveys." Biometrika, 53: Parts 1 and 2, 85-97. June 1966. Reprint Series No. 179, Statistical Laboratory, Iowa State University.

The nature of an analytical sample survey is discussed in general, and a sequential sampling scheme is proposed for certain situations. It is assumed that the subgroups of the population which are to be compared form a one-way classification, and are not identifiable in advance of drawing a simple random sample from the population.

With sequential sampling, one continues to sample (randomly) from the general population until the variance constraints are satisfied. It is required that, for each pair of group means, the variance of the difference between them be no larger than a specified constant. Knowledge of the probability (P_n) that the constraints are met by the time n observations have been taken can be used to answer questions about the possible cost of the contemplated sampling scheme.

For the case of two groups, exact and approximate expressions for P_n are derived under the assumption of known, but unequal, subgroup variances. Some numerical examples are given to illustrate how the P_n depend on the subgroup variances, and the value of the probability that an element belongs to subgroup 1. Two approximations for the expected number of observations needed to satisfy the constraint are evaluated using these examples.

A direct method to find n so that $P_n = \alpha$ is also given. A procedure for the case of unknown (but equal)

subgroup variances is suggested, and some of its consequences are worked out.

A parallel development is carried out for the case of three groups. The exact expression for P_n is complex, and attention is directed towards approximations for this probability. Procedures to check these approximations are suggested, and the results of an extensive numerical investigation of their efficacy are presented. Both approximations perform very well, and should be useful if more than three groups are to be compared. Finally, a procedure for the case of unknown variances is given.

*L. E. Everson, **C. S. Shih** and **F. B. Cady:** "A Comparison of the Uniform Blowing and Hand Methods for the Purity Analysis of Poa Pratensis Seed." Proceedings of the International Seed Testing Association, 30:3, 493-511. 1965. Journal Paper No. J-5024, Iowa Agricultural and Home Economics Experiment Station, Ames, Project 1083. Reprint Series No. 177, Statistical Laboratory, Iowa State University.

This study had two main objectives: (1) to determine the variation of test results among International Seed Testing Association (ISTA) member laboratories for the uniform blowing procedure (using their present blower equipment) compared with the results for the hand method, and (2) to evaluate the performance of the Hearson blower compared with other blowers used in this study.

Eleven ISTA seed laboratories participated in this study. Six Poa pratensis seed samples of different bushel weights and origins were tested to determine the pure seed and germination percentages.

Two statistical procedures were used to analyze the test results. Analysis of variance was used to determine whether the participating laboratories obtained uniform test results. Tolerance intervals were calculated to compare the variation of test results observed in the experiment with the variation allowed by the Rules.

Variation among ISTA laboratory test results (both purity analysis and germination) was excessive when the hand method was used. Purity analysis test results among ISTA laboratories were satisfactory when the uniform blowing method was used. Variation among laboratories was relatively small and strict application of the tolerances in the Rules may be observed if the uniform blowing method is adopted.

Test results obtained with the Hearson blower were not significantly different from the results obtained with the other blowers used in this study.

June L. Hearn, Don C. Charles and **Leroy Wolins:** "Antecedents of Measured Personality Variables." Journal of Genetic Psychology, 107, 99-110. September 1965.

The purpose of this study was to investigate the relationship between answers to questions about past experiences and personality test scores. A total of 161 male subjects responded to the two kinds of questions.

It was concluded that reported behavior early in life is related to scores on the Edwards Personal Preference Schedule. The kind of personality a person has depends on: 1) the kind of behavior reinforced early in life, 2) parents' personality, and 3) socio-economic and educational level of parents.

Letter

C. Philip Cox. The American Statistican, 20:3, 49. June 1966.

Query Answer

"Missing Values in Factorial Experiments." George Zyskind. Technometrics, 7:4, 649-650. November 1965.

ABSTRACTS OF THESES

Geoffrey S. Boehm: "Computer Simulation of an Individual's Responses to Objective Personality Test Items." M.S. thesis. Iowa State University Library. May 1966.

A model of the objective personality test item response process is constructed by means of computer simulation. Both item parameters and subject parameters are combined in a linear and additive relationship which deterministically simulates true-false type item responses to three specific personality trait scales.

Errors in prediction (differences between simulated and actual responses) differ for items in particular trait scales for males and females having particular characteristics. The final simulation model is numerically determined such that errors are minimized for a sample of 100 subjects.

The model as constructed from the sample of 100 is cross-validated on an additional sample of 88. Using as criteria two item parameters which have been used previously to predict item responses, the constructed model does significantly better than either of the criteria, especially for certain categories of subjects and items.

Since this simulation represents a "first attempt," many possible changes in the general model, parameters, and tests might be made for future improvement of the model.

Robert Smith Cochran: "Theory and Application of Multiple Frame Surveys." Ph.D. thesis. Iowa State University Library. July 1965.

In many sampling situations it is not possible to designate a unique reference frame for some reason. It then becomes necessary to supplement the original frame with an additional frame or frames in order to obtain full coverage of the population, and the investigator must design a survey based upon a multiplicity of sampling frames.

In other situations, it is possible to designate one frame that will give complete coverage, but it may be possible to use another frame to cover a subset of the original frame. Here, again, it may be advantageous to the investigator to consider his problem as being one of multiple frame sampling.

Historically most uses of multiple frames have been concerned with:

(1) a "master" frame with 100 percent coverage, and
(2) a "cheap" frame not possessing 100 percent coverage.

Usually a sample design has been designated for both frames, but whenever a unit sampled from the "master" frame was encountered which belonged to the "cheap" frame it was discarded.

The approach to be presented and evaluated in this thesis uses a weighting system that allows all items obtained in the sampling from all frames to be included in the various estimators.

After the sampling from a frame has been completed it is necessary to separate the sampled units into groups for the purpose of estimating group means and totals as well as overall means and totals. If the number of items in the population belonging to each group is not known, the groups are referred to as "domains of study" or just "domains."

In the multiple frame sampling scheme to be presented in this thesis, the concepts of post stratification and of domain estimation will play a major role.

The "groups" referred to above arise as follows: if there are two sampling frames, there are three possible post strata or domains. If the sample unit belongs to frame A only, it is in post-stratum or domain a. If the unit belongs to frame B only, it is in post-stratum or domain b. If the unit belongs to both frames, it is in post-stratum or domain ab.

The primary function of this thesis is to use the weighting procedure mentioned above to develop estimators of population totals, the variances of these estimators, and estimates of the variance of the estimates. The multiple frame estimators are then compared with possible competitors by considering the relationship between the variances of the estimates.

It is shown that when using optimum (minimum variance for fixed cost) weights and sample allocations the multiple frame estimators have variances no larger than corresponding single frame estimators. Whenever there exists the possibility of using a screening procedure with a resulting cost savings due to screening, situations are given in which the multiple frame estimators are not the most efficient.

Thomas Eugene Doerfler: "Size and Power of Some Tests Under Experimental Randomization." Ph.D. thesis. Iowa State University Library. July 1965.

In this study the consequences of experimental randomization in comparative experiments are examined. Only the paired design is considered in which a small number of pairs is available in the sample.

If two treatments are applied at random to pairs of experimental units within each of N blocks, there are 2^N conceptual experiments that could have been observed. On the basis of the results of the actual plan selected, the null hypothesis of no treatment difference can be tested against shift alternatives by utilizing various statistics proposed in the literature.

The testing procedures examined in this study are the normal theory F test, the Fisher randomization test, the Wilcoxon paired test and the sign test. The relative and absolute performance of these test criteria are studied with respect to the population of repetitions induced by the physical act of randomization. The evaluation of significance and the frequency with which significance is achieved are considered for specific test sizes.

General power integrals are derived for the Fisher randomization and Wilcoxon tests for experiments of three and four pairs. Various interesting relationships and characteristics of the non-parametric techniques are also indicated. The results of extensive numerical investigations are presented for experiments involving up to ten pairs.

The size and power of the test procedures are evaluated over the population of randomizations for sets of differences of basal yields randomly generated from a range of mathematical populations. Treatment differences are imposed on the data and hence a numerical indication of the small sample test behavior under various shift alternatives is obtained.

For experiments involving no more than eight matched pairs, size and power are computed over the totality of 2^N experiments comprising the population of interest. For $N \geqq$ ten, several sampling schemes are proposed to investigate the behavior of Fisher's randomization test.

The distribution of the size of the F test and the variability of the power of the tests are also examined in some detail.

Frank Burke Martin: "On Simple Linear Combinability of Information from Independent Sources." M.S. thesis. Iowa State University Library. November 1965.

This thesis presents a theory of combinability of information by simple weighting of estimates from independent sources in the case of the general linear model.

Within the set of all linear parametric functions, $\lambda'\beta$, estimable from either or both of two uncorrelated sets of data, $y_1 = X_1\beta + e_1$ and $y_2\beta + e_2$ with known non-singular variances, a general characterization is presented of those $\lambda'\beta$'s for which the best linear unbiased estimator (b.l.u.e.) is obtainable from one source of information alone or by simple weighting of its respective b.l.u.e.'s from each of the two sources. It is shown that if the intersection of the row spaces of X_1 and X_2 has rank r then there are exactly r independent $\lambda'\beta$'s, estimable from each of the two sources, for which the b.l.u.e. is obtainable by simple weighting. Some related statements are made for $k > 2$ uncorrelated sources of information.

In the case of incomplete block designs, the reduced intrablock normal equations and the interblock normal equations may be regarded as originating from two uncorrelated sources of information on the treatment parameter vector τ. It is shown that an estimable treatment contrast, $\gamma'\tau$, is best estimated from one source alone or by simple weighting of its b.l.u.e.'s from the respective

sources if and only if γ is an eigenvector of $\Lambda = (\lambda_{ij})$ where λ_{ij} is the number of times treatments i and j occur together in a block. For symmetric factorial or quasifactorial designs, it is shown that any effect or interaction degree of freedom contrast is an eigenvector of Λ, and hence, is best estimated by simple weighting of its interblock and intrablock estimates.

John Edward Schlater: "Analysis of Variance and Covariance Computations on a Digital Computer for Balanced Complete Structures Based on Algebraic Model Specifications." M.S. thesis. Iowa State University Library. August 1965.

Any practical statistical computing system must employ special techniques to handle analysis of variance and covariance computations for balanced-complete structures. Computer storage and time considerations make a regression approach very inefficient. Problems in which there are unequal cell frequencies in the subclasses fall into the bailiwick of a balanced-complete algorithm if an analysis is performed on the cell means.

Hemmerle (1963) developed an algebraic statistical language to serve as a basis for analyzing statistical statements and specifications to determine computations to be performed by an analysis of variance algorithm which he implemented.

This language is utilized in the algorithms which have been developed in this thesis to handle fully the balanced-complete case within the limitations of established theory and practice. In this context, the work is divided into three parts:

1) An algorithm is presented which removes the alphabetic restrictions for writing the statistical model. It has the ability to compute the degrees of freedom, sum of squares, means and residuals for any source of variation of a balanced-complete structure.

The facility to pool model terms to form additional sources of variation has been included for the sake of generality. The method employed to compute the sum of squares for a given source forms the residuals corresponding to this source by taking a linear combination of a subset of the arrays of means which are created from the input variables.

2) A computing procedure is described for analysis of covariance problems. This algorithm computes an analysis of covariance table as defined by the statistical model and adjusted mean and adjusted residuals when specified.

3) To handle models with random effects or mixed effects as well as fixed effects models, an algorithm has been developed to calculate variance components and F values for tests of significance. Designation of random effects or factors is included in the symbolic description for the problem.

The concepts and methodology presented have all been implemented on the IBM7074 currently in use at Iowa State University. An effort was made to produce a system which is as machine independent as possible.

Chang Sheng Shih: "Interval Estimation for the Exponential Model and the Analysis of Rotation Experiments." Ph.D. thesis. Iowa State University Library. May 1966.

Under the assumption that the parameter Θ is uniformly distributed over the interval (O, K), and that the least squares estimate, $\hat{\Theta}$, given Θ is $N(\Theta, 1)$, it is shown that a gain in the efficiency in interval estimation in terms of expected length of confidence intervals can be achieved by constructing confidence intervals based on interpolation tests. The interpolation tests are two-sided tests such that the two rejection regions are of unequal size, with the limiting test being one-sided.

The parameter space of the non-linear parameter ρ of the exponential model $y = a + \beta\rho^x$ is the interval (0,1). Let r be a linear ratio estimator of ρ. It is shown that Fieller's theorem can be modified to give real, finite confidence intervals for ρ based on r, belonging to the interval (0,1) only.

Two graphical methods are suggested for the determination of such confidence intervals. For a particular region of the sample space, these procedures can be modified by using interpolation tests to give shorter average confidence intervals. Modification of the technique required when the parameter space is (0,K) for $K \neq 1$ is also discussed.

One class of long-term experiments in agriculture is the class of rotation experiments for the study of the effects of various systems of crop rotation. A characteristic of rotation experiments is that the treatment effect tends to level off in the long run. By hypothesizing a growth process for rotation effects, the exponential model becomes a part of the statistical model for rotation effects.

Another statistical model investigated and estimated assumes that all rotation effects can be described by a common growth curve. Analysis based on these models is relatively simple computationally and offers meaningful and interpretable results.

A design criterion for estimating the asymptotic value of the exponential model for known ρ is also discussed.

Jarilaos Stavrou: "An Agriculturally Oriented Modification of a Response Surface Design." M.S. thesis. Iowa State University Library. November 1965.

It is often desired to investigate a functional relationship $\eta = f(x_1, x_2, \ldots, x_k)$ between a response η and the levels of k quantitative factors $x_1, x_2, \ldots, x_k$. In agriculture and other biological fields, these investigations are sometimes done using the composite designs of Box and associates. However these designs were not developed primarily for the agricultural and biological fields and modifications are sometimes desirable.

This thesis considers the problem of adding a check plot (a treatment combination with actual zero levels of the k factors) to a three-dimensional, second order,

composite design, maintaining at the same time much of the orthogonality and the precision of the estimates which is characteristic of this group of designs. The check plot is equivalent to having a point at the origin of the set of coordinate axes, which is usually at some distance from the center of the design.

Second order designs were constructed from irregular first order designs (designs that estimate the linear effects with different precisions) by use of the simplex method of Box and Behnken. Other modified second order designs were also developed. In general, it was found that in order to include the check plot, it was necessary to have rather diverse precisions for the estimates of the different effects.

Also, a brief discussion is given of the transformations used to translate and rotate the designs into their proper positions inside the factor space.

David Reginald Thomas: "Asymptotic Value Distributions for Certain 2xn Games and n-Stage Games of Perfect Information." Ph.D. thesis. Iowa State University Library. August 1965.

The study is concerned with the distribution of the value of a game with random payoffs. Two types of games are considered: certain games of perfect information with independent and identically distributed terminal payoffs, and matrix games with independent and identically distributed matrix elements.

Consider a two-person zero-sum perfect information game, with Player I and Player II alternatively choosing one of several alternatives. In the special games of this type considered, Player I and Player II each choose n times; moreover, it is assumed that there are always p and q alternatives available respectively to Players I and II.

There will be $(pq)^n$ terminal payoffs (to Player I) $x(i_1, i_2, \ldots, i_{2n})$, where the indices $i_1, i_3, \ldots, i_{2n-1}$, each with range $(1, 2, \ldots, p)$, indicate the successive alternatives chosen by Player I, and the indices $(i_2, i_4, \ldots, i_{2n})$, each with range $(1, 2, \ldots, q)$, indicate the successive alternatives chosen by Player II. The value of the game $v(\{x(i_1, i_2, \ldots, i_{2n})\})$ equals

$$\max_{i_1} \min_{i_2} \max_{i_3} \min_{i_4} \ldots \max_{i_{2n-1}} \min_{i_{2n}} [x(i_1, i_2, \ldots, i_{2n})].$$

Now replace the $(pq)^n$ numbers $x(i_1, i_2, \ldots, i_{2n})$ by independent random variables $X(i_1, i_2, \ldots, i_{2n})$, each with distribution function F, and define $V_n \equiv v(\{X(i_1, i_2, \ldots, i_{2n})\})$.

The asymptotic behavior of the random value V_n is investigated for general distributions F. A functional equation is exhibited which the asymptotic distributions for V_n necessarily must satisfy; this functional equation leads to a characterization of the set $\mathcal{L}$ of all possible asymptotic value distributions. A certain subset of $\mathcal{L}$ is shown to attract a large number of payoff distributions F, and the asymptotic value distributions in this subset are shown to possess all moments. It is also shown that an element L of this subset of $\mathcal{L}$ attracts all of the common payoff distributions possessing densities, e.g., uniform, beta, gamma, normal, exponential, etc. Moment convergence is also established in a very special case.

For the other general game situation considered, let $\| x_{ij} \|$, $i = 1,2,\ldots,m$; $j = 1,2,\ldots,n$ be the payoff matrix of a zero-sum two-person game, and let $v(\|x_{ij}\|)$ be its (possibly mixed) value. Consider the random value $V_{m,n} = v(\|X_{ij}\|)$, where X_{ij} are mn mutually independent random variables, each distributed according to the probability density f. It is shown that the conditional distribution of $V_{m,n}$, given that it is pure, is that of the n^{th} largest of $m + n - 1$ mutually independent random variables, each distributed according to f. For uniform f, a method is given for determining the conditional distribution of $V_{2,n}$, given that it is mixed. An asymptotic distribution L is shown to attract all densities f that are zero for $t < t_0$, and are continuous to the right and discontinuous to the left at t_0.

Janet Joyce Zrubek: "Quadratic Programming with Reference to Large Scale Economic Models." M.S. thesis. Iowa State University Library. May 1966.

This study is concerned with convex programming. A particular case of convex programming is quadratic programming. The general problem may be stated:

$$\max_x \left[f(x) = p'x - \frac{1}{2} x' Cx \right]$$

subject to $Ax \leqq b$, $x \geqq 0$.

The theoretical aspects of the problem, based on the classical method of Lagrangian multiplier optimization, are described. A discussion of the relationship of quadratic programming to linear programming indicate that utilization of linear programming techniques will result in efficient optimization of quadratic models.

The quadratic algorithm of C. Van de Panne and Andrew Whinston was programmed on the IBM 360 system. The program employs the product form of the inverse and the revised simplex algorithm. This program is capable of handling problems consisting of a maximum of one thousand rows.

The quadratic program will be added to the resource library of the Numerical Analysis and Programming Section of the Statistical Laboratory to be used for future consulting purposes. It should be a valuable research tool, particularly for research in optimization of economic models.

PAPERS AND SPEECHES

Papers presented at scientific and professional meetings reflect the research and activities of the Statistical Laboratory staff. Many of these papers will appear later in publications. Abstracts of papers often are published, and in such cases references are given.

Om P. Aggarwal: "Bayes and Minimax Procedures for Estimating Mean of a Population with Two-Stage Sampling," at the annual meeting of the American Statistical Association, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11. Abstract 10 in Annals of Mathematical Statistics, 36:5, 1596, October 1965.

Om P. Aggarwal: "Ratio and Regression Estimators as Mini-

max Procedures for Estimating the Mean of a Population," a contributed paper by title, at joint meetings of the Biometric Society (ENAR), Institute of Mathematical Statistics (Eastern Region), and American Statistical Association (Biometrics Section and Section on Physical and Engineering Sciences), at Brookhaven National Laboratory, Upton, L.I., New York, April 27-29. Abstract 7 in Annals of Mathematical Statistics, 37:3, 759, June 1966.

Om P. Aggarwal: "Agricultural Census in Peru: 1963," at a Forestry Seminar, Ames, May 20.

T. A. Bancroft: "Inference for Incompletely Specified Models in the Physical Sciences," at the 35th session of the International Statistical Institute in Belgrade, Yugoslavia, September 14-22.

T. A. Bancroft: "The Masters' Degree Course Program in Biostatistics," at the Western Reserve University School of Medicine, Cleveland, Ohio, June 10.

E. J. Carney: "The Lattice of Ordered Partitions and its Relation to Generalized Symmetric Means and Generalized Polykays," a contributed paper by title at joint meetings of the Biometric Society (ENAR), Institute of Mathematical Statistics (Eastern Region), and American Statistical Association (Biometrics Section and Section on Physical and Engineering Sciences), at Brookhaven National Laboratory, Upton, L. I., New York, April 27-29. Abstract 15 in Annals of Mathematical Statistics, 37:3, 761-762, June 1966.

C. Philip Cox and **T. D. Roseberry:** "Results on Sequential Tests for Discrimination between Two Hypotheses Using Concomitant Information," at the annual meeting of the American Statistical Association, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11. Abstract 1156 in Biometrics, 21:4, 1023, December 1965.

C. Philip Cox and **Paul Leaverton:** "Statistical Procedures for Quantitative Response Bioassay when the Condition of Similarity Does Not Obtain," at the Statistical Methods in Bioassay Session, American Association for the Advancement of Science meeting, in Berkeley, California, December 26-30.

H. T. David: "Probabilistic Solutions of Diffusion Problems," at a Chemical Engineering Seminar, Ames, October 21.

Earl Foster: "Quality of Experimental Hybrids," at a conference on Development of Hybrid Barley at the University of Minnesota, Minneapolis, January 20-21.

W. D. Shrader, **W. A. Fuller** and **F. B. Cady:** "Estimation of a Common Nitrogen Response Function for Corn in Different Crop Rotations," at the 57th annual meeting of the American Society of Agronomy in Columbus, Ohio, October 31-November 5.

Takeshi Amemiya and **Wayne Fuller:** "A Comparative Study of Alternative Estimators in a Distributed-Lag Model," at meetings of the Econometrics Society in New York City, December 27-29.

Wayne Fuller: "Some Topics in the Analysis of Production Experiments," a seminar at North Carolina State University, Raleigh, March 17.

Wayne Fuller: "Estimation Employing Post Strata," at the central regional meeting of the Institute of Mathematical Statistics, Purdue University, Lafayette, Indiana, March 23-25.

D. V. Huntsberger, Carol B. Fuchs and **R. J. Mead:** "A Follow-up Study of Graduates with Degrees in Statistics from Iowa State University," at the annual meeting of the American Statistical Association, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11.

D. V. Huntsberger and **James R. Veale:** "A Weighted Estimator for a Mean when One Observation May Be Spurious," at the anual meeting of the American Statistical Association, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11. Abstract 1162 in Biometrics, 21:4, 1025, December 1965.

B. K. Kale: "A Test of Goodness of Fit Based on Discriminatory Information," at the annual meeting of the American Statistical Association, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11. Abstract 26 in Annals of Mathematical Statistics, 36:5, 1601, October 1965.

B. K. Kale and **T. A. Bancroft:** "Inference for Some Incompletely Specified Models," at joint meetings of the Biometric Society (ENAR), Institute of Mathematical Statistics (Eastern Region), and American Statistical Association (Biometrics Section and Section on Physical and Engineering Sciences), at Brookhaven National Laboratory, Upton, L. I., New York, April 27-29.

O. Kempthorne: "Some Aspects of Experimental Inference," the Fisher Memorial Lecture at the annual meeting of the American Statistical Association, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11.

O. Kempthorne: "Comparison of Some Tests of Significance for the Paired Design," presented while serving as a departmental scholar at Virginia Polytechnic Institute, Blacksburg, November 1.

O. Kempthorne: "The Classical Problem of Inference: Goodness of Fit," at the American Association for the Advancement of Science meeting, in Berkeley, California, December 26-30.

O. Kempthorne: "The Concept of Genes Being Identical by Descent," at the Fifth Berkeley Symposium on Mathematical Statistics and Probability, Berkeley, California, December 27-January 7.

O. Kempthorne: "The Basic Problem of Inference: Goodness of Fit," a seminar at New Mexico State University, Las Cruces, April 28.

O. Kempthorne: "Goodness of Fit," at the Twin Cities Chapter meeting of the American Statistical Association, St. Paul, Minnesota, May 12.

O. Kempthorne: "Identity of Genes by Descent," at a meeting of the Genetics Group, University of Minnesota, Minneapolis, May 12.

O. Kempthorne: "Fisher's Fundamental Theorem of Natural Selection," a seminar at the Summer Institute in Quantitative Genetics, Brown University, Providence, Rhode Island, June 15.

Akio Kudô: "Some Remarks on the Use of Multivariate Analysis in Biological Research," a seminar at the Oakridge National Laboratory, Oakridge, Tennessee, October 19.

Akio Kudô: "Some Multivariate Tests with Restricted Alternative Hypothesis," a seminar at the University of Georgia, Athens, October 22.

Akio Kudô and **Irving Hall:** "On Slippage Problems," at the central regional meeting of the Institute of Mathematical Statistics, Purdue University, Lafayette, Indiana, March 23-25.

Edward Pollak: "The Effects of Two Types of Migration on the Survival of a Gene in a Subdivided Population," at the annual meeting of the American Statistical Association, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11. Abstract 1172 in Biometrics, 21:4, 1028, December 1965.

Edward Pollak: "Random Genetic Drift in a Subdivided Population," at the central regional meeting of the Institute of Mathematical Statistics, Purdue University, Lafayette, Indiana, March 23-25.

J. Sedransk: "Stratified and Multi-Factor Analytical Studies," at the annual meeting of the American Statistical Association, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11. Abstract 1176 in Biometrics, 21:4, 1029, December 1965.

J. Sedransk: "Multi-Factor Analytical Surveys," at joint meetings of the Biometric Society (ENAR), Institute of Mathematical Statistics (Eastern Region), and American Statistical Association (Biometrics Section and Section on Physical and Engineering Sciences), at Brookhaven National Laboratory, Upton, L. I., New York, April 27-29.

David R. Thomas and **H. T. David:** "Game Value Distributions," at Purdue University, Lafayette, Indiana, October 26.

David R. Thomas and **H. T. David:** "Game Value Distributions," a seminar at the University of Minnesota, Minneapolis, March 4.

Edwin C. Lewis, **Leroy Wolins** and Julie Johnson Yelsma: "Patterns of Educational Attitudes Among College Women," at the annual meeting of the American Educational Research Association in Chicago, Illinois, February 17.

George Zyskind and **Frank Martin:** "On Simple Combination of Information from Uncorrelated Linear Sources," at the central regional meeting of the Institute of Mathematical Statistics, Purdue University, Lafayette, Indiana, March 23-25.

PARTICIPATION IN PROFESSIONAL ACTIVITIES

Dr. T. A. Bancroft continued as organizer and Dr. Om P. Aggarwal as one of the organizing secretaries for the International Symposium on "Biometry and Statistics in Food, Population and Health Research." During the ISI statistical meetings in Belgrade, Dr. Bancroft consulted with the Latin American statisticians in attendance and as a result a decision was reached to postpone this International Symposium of the Biometric Society, proposed for Mexico City for 1966, to a later date to be announced.

Dr. Bancroft continues as a member of the National Research Council, representing the Biometric Society (ENAR) in the Division of Biology and Agriculture of the National Academy of Sciences. He recommended at the annual meeting and received approval of the appointment of a biometrician or statistician as a member of the United States National Committee for the International Biological Program.

During the year Dr. Bancroft also attended, as a member, the annual meeting of the ASA Advisory Committee for Statistical Policies to the U. S. Bureau of the Budget. He concluded his term as a member of the ASA Board of Directors.

As a member of a special committee of the Institute of Mathematical Statistics, Dr. Bancroft has continued investigation of methods universities may use to initiate or develop statistical programs in teaching and research. In June he consulted with the staff of the Division of Biometry, Western Reserve University School of Medicine, Cleveland, Ohio, concerning the changes in the joint program between Iowa State University and Western Reserve in statistics.

For a number of years graduate students from Western Reserve have taken most of their statistical course work at the graduate level at Iowa State University. Beginning the fall of 1966, Western Reserve is planning to offer the course work for the M.S. degree in biostatistics at Western Reserve but will continue to send students beyond the M.S. degree level to ISU for courses in statistics leading to the Ph.D. In the past, as well as in the future, theses will be written at Western Reserve and the degrees granted by that institution.

Dr. Foster B. Cady served as secretary to the Biometric Section, American Statistical Association, and representative to the regional committee, Biometric Society (ENAR) at the annual meeting of the American Statistical Association, Biometric Society (ENAR) and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11. For the second time, Dr. Cady was re-elected secretary of the Biometric Section, ASA, extending his term of office to 1967.

Dr. Cady also served on the program committee for the Biometric Society (ENAR), for joint meetings of ENAR, the Eastern Region of the Institute of Mathematical Statistics and the Biometrics Section and Section on Physical and Engineering Sciences, American Statistical Association, at Brookhaven National Laboratory, Upton, L.I., New York, April 27-29.

Edward J. Carney is serving as program chairman for the central Iowa subsection of the Iowa City section of the American Society for Quality Control.

Professor C. Philip Cox was a representative to the Regional Advisory Board, Biometric Society (ENAR) at the annual meeting of the American Statistical Association, Biometric Society (ENAR) and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11.

For the second year Professor Cox was invited to lecture at Yale University at the Graduate Summer Session of Statistics in the Health Sciences. He taught Statistical Methods of Biological Assay at the 1965 session, June 28 through August 6, and at the 1966 session beginning June 27.

Dr. H. T. David served as chairman of the ASA and IMS session on "Sequential Search Procedures", at the annual meeting of the American Statistical Association, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11.

At the central regional meeting of the Institute of Mathematical Statistics, Purdue University, Lafayette, Indiana, March 23-25, Dr. David served on the program committee and chaired a session.

During the year Dr. David has served on two Iowa State standing committees: Annuities and Insurance, and Graduate Study. He is a member of the University Scholarship Standards committee and was appointed chairman of the Sciences and Humanities Scholarship Standards committee.

Dr. David served on the COPSS (Committee of Presidents of Statistical Societies) committee for the Visiting Lecturer Program sponsored by the National Science Foundation and the statistical societies.

Dr. D. K. Hotchkiss has been appointed faculty representative for Iowa State to the American Statistical Association. During his 3-year term which began in January, he will familiarize students and others regarding ASA's activities, publications etc., and serve as liaison with local chapters.

In late December Dr. Hotchkiss went to Southern Methodist University in Dallas, Texas, to meet with a subcommittee of the ASA membership committee to plan proposed undergraduate membership in the Association.

Dr. David Huntsberger served during the year as president and Dr. Carol Fuchs as secretary of the Iowa Chapter of the American Statistical Association. Newly elected vice-president to serve during the coming year is Dr. J. Sedransk.

Dr. Huntsberger is a member of the COPSS (Committee of Presidents of Statistical Societies) Career Brochure Committee.

Dr. Oscar Kempthorne was discussion leader for the Biometric Society (ENAR), ASA Biometrics Section and IMS Section on Physical and Engineering Sciences, session on "Statistical Methods for Data Analysis," at the annual meeting of the American Statistical Associa-

tion, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania September 8-11.

Dr. Kempthorne continues his two-year term as a council member of the Biometric Society, representing ENAR. He also is continuing as a member of the U.S. Committee for Planning the International Biological Program. During the year he served on the Editorial Board of Biometrics.

Dr. Kempthorne has been elected a member of the International Statistical Institute.

The American Statistical Association called on Dr. Kempthorne to serve as a member of the first Wilks Award committee. The award was established in memory of Samuel S. Wilks to honor a statistician who has contributed to the advancement of scientific or technical knowledge in Army statistics.

Donald J. Soults attended the Joint Users Meeting on IBM Mathematical Programming System 1360 in Houston, Texas, December 5-9. The program included discussions on linear and non-linear programming procedures, topical with respect to linear and quadratic systems now being written at Iowa State.

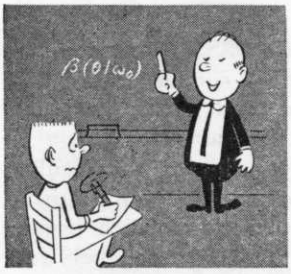
Dr. George Zyskind served as discussion leader for the ASA Section on Physical and Engineering Sciences, session on "Problems in the Analysis of the General Comparative Experiments," at the annual meeting of the American Statistical Association, Biometric Society (ENAR), and the Institute of Mathematical Statistics in Philadelphia, Pennsylvania, September 8-11.

Dr. Zyskind was elected a Fellow of the American Association for the Advancement of Science.

During the year Dr. Aggarwal, Dr. David and Dr. Zyskind served as referees for the Annals of Mathematical Statistics, and Dr. Kempthorne and Dr. Zyskind as referees for Biometrics. Editorial collaborators for the Journal of the American Statistical Association included Dr. Aggarwal, Dr. Bancroft, Dr. David, Dr. Kempthorne, Dr. Sedransk and Dr. Zyskind.

Newly elected members of Sigma Xi, honorary society of pure and applied research scientists, include a number of staff members, graduate students and graduates. Full members are: Robert S. Cochran, Charles Cress, E. E. Dayhoff, Wayne Fuller, J. Sedransk, Chang Sheng Shih, Norman Strand, Florence Tetreault, David Thomas and Richard Warren. Elected to associate membership are: Harold Baker, Edward Carney, Edmund Fuller Jr., Frank Martin, Richard Mensing, Martin Rosenzweig, John Schlater, Richard Swanson and James Veale.

Teaching



The Department of Statistics in the College of Sciences and Humanities 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 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 application and modern statistical theory.

A new graduate program in computer science, administered jointly by the departments of statistics, mathematics and electrical engineering, was instituted July 1 and has its first students. Both M.S. and Ph.D. programs are offered.

The department also offers minor and supporting work in statistics. When desired, a joint major program may be arranged between statistics and agriculture, biology, economics, engineering, genetics, mathematics or psychology.

Fall quarter enrollment in all courses in statistics was up 32 percent over the previous year. The highest enrollment in any quarter was recorded in the spring with a total of 1157 students studying statistics. The continued increase reflects both the growth of the department and the university, and the emphasis being placed on statistical training by other campus departments.

The departmental library facilities have been expanded with the development of a third floor reading room, a supplement to the first floor Statistical Laboratory reprint and reference library. The reading room contains a working collection of books on permanent loan from the main Iowa State University library, including high level reference books on all areas of statistics.

It is anticipated that facilities, faculty and course offerings will continue to increase to meet the demands of the expected continued increase in enrollment.

COURSE OFFERINGS IN STATISTICS

The courses offered by the Department of Statistics during the academic year 1965-66 were as follows:

Courses for Undergraduate Students Only

201,	Principles of Statistics	5	FWS*	Bruner, Burmeister, DeGracie, Fuchs
201A,		3	WS, SS_1	Foster, Hotchkiss
201B		3	FS	Mensing

* Because the fiscal year began July 1, 1965, and ended June 30, 1966, the courses taught in the second summer session of 1965 through the first summer session of 1966 are reported here. Symbols indicate the quarter each course was taught: SS_2—Second Summer Session, F—Fall, W—Winter, S—Spring, SS_1—First Summer Session.

327	Elementary Business Statistics	3	F	DeGracie, Mead
341,	Introduction to Theory of	3	F	Huntsberger
342,	Probability and	3	W	Huntsberger
343	Statistics	3	S	Huntsberger
380	Introduction to High Speed Computing	3	FWS	Jespersen, Kennedy

Courses for Graduate Minors and Undergraduates

401,	Statistical Methods for Research Workers	4	FW, SS_1	DeGracie, Fuchs, Hotchkiss, Jowett, Lund, Mensing, Thomas, Warren, Wolins
402		4	SS_2, WS	DeGracie, Fuchs, Jowett, Mensing, Thomas, Walsh, Warren, Wolins
411	Experimental Design for Research Workers	3	S, SS_1	Cady, Jowett
421	Survey Design for Research Workers	3	SS_2, S	Aggarwal, Fuller
431	Elementary Statistical Quality Control	3	S	Carney
446,	Statistical Theory for	3	F	Huntsberger
447,	Research Workers	3	W, SS_1	Hotchkiss, Pollak
448		3	SS_2, S	Hotchkiss, Huntsberger
480,	Processing of Statistical	2	F	Mosier
481,	Data	2	W	Mosier
482		2	S	Mosier
499	Special Problems	Arr.	SS_2, FWS, SS_1	Aggarwal, Cady, Kennedy, Soults

Courses Primarily for Graduate Students, Major and Minor

501	Intermediate Statistical Methods	3	F	Bancroft
505	Psychometrics	3	S	Wolins
506	Factor Analysis	3	F	Wolins
511,	Design of Experiments	3	W	Kempthorne
512		3	S	Kempthorne
521,	Design of Surveys	3	W	Sedransk
522		3	S	Sedransk
531	Industrial Statistics: Sampling Inspection	3	F	David
535	Biological Statistics	3	S	Cox
536,	Genetic Statistics	3	F	Pollak
537		3	W	Pollak
538	Elementary Econometric Statistics	3	F	Fuller
539	Operational Research Methods	3	W	Thomas
541,	Theory of Probability and	3	F	Arnold
542,	Statistics	3	W	Arnold
543		3	S	Arnold
544	Statistical Decision Theory	3	S	David
581	Scientific Applications of Digital Computers II	3	S	Carney
599	Special Topics	Arr.	SS_2, FWS, SS_1	
	A. Theory			Bancroft, Cox, David, Huntsberger, Kale, Pollak, Soults
	B. Methods			Bancroft, Cady, Cox, Kempthorne
	C. Design of Experiments			Kempthorne, Zyskind
	D. Design of Surveys			Aggarwal, Sedransk

Courses for Graduate Students, Major and Minor

601	Advanced Statistical Methods	3	F	Cox
608	Seminar on Statistical Methods	3	W	Cox
621	Advanced Design of Surveys	3	W	Aggarwal
622	Seminar on Design of Surveys	3	S	Aggarwal
638	Advanced Econometric Statistics	3	W	Ramasubban
641	General Theory of Linear Hypothesis	3	F	Zyskind
642	Probability and Distribution Theory	3	F	Kale
643	Theory of Estimation and Testing of Hypotheses	3	W	Kudô
646	Time Series	3	SS_2, S	Fuller, Ramasubban
647	Multivariate Analysis	3	S	Kudô
649	Recent Developments in Statistics and Probability	3	SS_2, S, SS_1	Kale, Kudô
699	Research	Arr.	SS_2, FWS, SS_1	Aggarwal, Bancroft, Cady, Carney, Cox, David, Fuller, Hotchkiss, Jowett, Kale, Kempthorne, Kudô, Sedransk, Zyskind

INSTITUTES AND SHORT COURSES

In addition to regular course offerings, special short term institutes are offered for campus and off-campus personnel.

Summer Institute on Survey Sampling Techniques

Nineteen students representing eleven foreign countries attended the second annual summer institute on survey sampling techniques for foreign students at the Statistical Laboratory July 19 through August 26.

This special summer program was pioneered in 1964 under an arrangement with the United States Bureau of the Census, which again cooperated in the project. Mrs. Anne Casey, Ernest Johnson and Mrs. Katherine Manno from the International Statistical Program, Bureau of the Census, came to Ames at intervals to assist with the institute.

The institute is planned to train participants who

will return to responsible positions in statistics in their own countries. The course was conducted by Dr. Om P. Aggarwal and Professor Norman V. Strand. Lectures and practical exercises were given by various sampling statisticians at the Laboratory and operational personnel of the Survey Group. The work included planning a survey, drawing a sample, writing a questionnaire, studying interviewing techniques, collecting, editing, code punching and verifying data and examining tabulated material.

Dr. Carl F. Kossack, director of the Laboratory for Computer Sciences, Southwest Center for Advanced Studies, Dallas, visited Ames to lecture at the institute.

Eight institute participants were sponsored by the Census Bureau's Agency for International Development, five by the United Nations and six by the United States Department of Agriculture, which cooperated in the project for the first time this year.

Participants represented Ecuador, Indonesia, Iran, Liberia, Nigeria, Pakistan, Sierra Leone, Thailand, Trinidad, Turkey and the United Arab Republic. Each participant who successfully completed the study program was presented with a certificate by Iowa State University.

Engineering and Management Institute

Again this year the Statistical Laboratory participated in presenting a Design for Quality Control Institute, sponsored by Engineering Extension and the Department of Industrial Engineering, with the cooperation of the State Department of Public Instruction. This was the sixth such cooperative institute.

Edward J. Carney was again chairman of the planning committee for the institute, which met May 19 and 20 in the Memorial Union. Dr. H. T. David also served on the committee.

The major emphasis of the institute was an overall look at quality control, its organization and relation to other functions. It was particularly designed for persons with responsibility for organizing and planning quality control, and for those wishing a wide perspective of the field.

Carney participated in an "Introductory Techniques" session, dealing with fundamentals, control chart and acceptance sampling. Dr. David, Dr. David R. Thomas and Richard Mensing presented the "Advanced Techniques" session, on analysis of variance and distributional problems arising in quality control.

GRADUATE STUDENTS

In addition to working with statistics majors, many Statistical Laboratory faculty members work closely with graduate students minoring in statistics. One indication of this work is the participation on graduate committees where the student has formally declared a minor in statistics at the Ph.D. level.

Professors who regularly serve on M.S. and Ph.D. committees in areas where the major is other than statistics include Dr. Bancroft, Dr. Cady, Dr. David, Dr. Fuller, Dr. Hotchkiss, Dr. Huntsberger, Dr. Kempthorne, Dr. Pollak and Dr. Wolins.

Twenty staff members now are members of the graduate faculty. Full members are: Dr. Aggarwal, Dr. Bancroft, Dr. Cady, Professor Cox, Dr. David, Dr. Fuller, Dr. Kempthorne, Dr. Wolins and Dr. Zyskind. Associate members are: Dr. Arnold, Dr. Fuchs, Dr. Hotchkiss, Dr. Huntsberger, Dr. Jowett, Dr. Pollak, Dr. Sedransk, Dr. Thomas and Dr. Warren. Dr. Kale and Dr. Kudô are honorary members of the graduate faculty.

Enrollment of graduate students majoring in statistics continues to increase, resulting in a 20 percent increase in the number of candidates for graduate degrees since last year's annual report:

Ph.D. Candidates

Munir Ahmed
Edward J. Carney
Leroy Edward Carver
Robert S. Cochran
Patricia Conn
James S. DeGracie
Thomas Doerfler
Audrey Duthie
James Gebert
Irving Hall
Clayton Haugse
John W. Hazard
John Johnson
Leon Jordan
William Kennedy
Richard Lund
Frank B. Martin
Donald McElhone
Ahmed Memon
Richard Mensing
John Meyer
Kenneth Mount
Syed T. M. Naqvi
Esmat Nouri
Paul Rackow
Martin Rosenzweig
Carl Z. Roux
Donna J. Ruhl
Ahmed Salem
Charles Sampson
Hans Schreuder
Justus Seeley
Chang Sheng Shih
V. B. Solomon
Donald Soults
David Thomas
Philip Van Veldhuizen
Ing-Tzer Wey
Franklin Wolf
Mia Mohammed Yusuf

M.S. Candidates

Joseph Abbey
Joseph Atkinson
James Blinn
Geoffrey Boehm
Gordon Booth
Carlos Brain
Nell Bruner
Leon Burmeister
K. T. deGraft-Johnson
Ralph Folsom
Richard Frauendorfer
Charles K. Graham
Omar Henriquez
James Immordino
Louis Jensen
Paul A. Johnson
Mark Malone
Frank B. Martin
Ronald Mead
Peter O'Brien
James Olin
Sue Rowe
John Schlater
Steven Selvin
Mary Ann Smith
Douglas Splitstone
Jarilaos Stavrou
It-Thi Sawunkatat
Nimnual Sriplung
Hermann Wiedenhofer
Janet Zrubek

Degrees Granted and Positions Taken

The April issue of the Annals of Mathematical Statistics ranks Iowa State fourth in the number of degrees granted in statistics during the 1965 calendar year. During that period Iowa State graduated 9 statistics majors while the University of California (Berkeley and UCLA) graduated 11 and Stanford and the University of Paris each graduated 10.

Titles and abstracts of theses written as partial fulfillment of the requirements for advanced degrees during the 1965-66 fiscal year appear in the publications section of this report. Students who were graduated during the year are:

Recipients of the Ph.D. Degree

Robert Smith Cochran (July 1965, under H. O. Hartley) returned to his position as assistant professor of statistics, University of Wyoming, Laramie.

Thomas E. Doerfler (July 1965, under Oscar Kempthorne) accepted a position with Booz-Allen Applied Research, Inc., Bethesda, Maryland, as a senior scientist.

David R. Thomas (August 1965, under H. T. David) remains at Iowa State where he joined the Statistical Laboratory as an assistant professor.

Chang Sheng Shih (May 1965, under Wayne Fuller) has taken a job with the Statistical Research Service, Central Experimental Farm, Ottawa, Canada.

Recipients of the M.S. Degree

John Schlater (August 1965, under W. J. Hemmerle) has joined the mathematics division of the United States Steel Research Center, Monroeville, Pennsylvania.

Frank B. Martin (November 1965, under George Zyskind) remains at Iowa State, working toward his doctorate in statistics.

Jarilaos Stavrou (November 1965, under F. B. Cady) remains at Iowa State, working toward a Ph.D. degree in economics.

Geoffrey Boehm (May 1966, under James Walsh) was commissioned at 2nd Lt. in the USAR and has been assigned by the Army to Dugway Proving Grounds, Dugway, Utah.

Janet Zrubek (May 1966, under T. A. Bancroft) is working at the Management Information Center of Union Carbide, in Port Lavaca, Texas.

The George W. Snedecor Award in Statistics

Frank B. Martin was named the 14th winner of the Snedecor Award, given annually in honor of Professor George W. Snedecor.

The award has been given since 1954 to the student selected by the graduate faculty in statistics as the department's most outstanding candidate for the Ph.D. degree. It consists of a year's membership in the Institute of Mathematical Statistics, a subscription to the Institute's Annals and a cash gift.

UNDERGRADUATES

There has been a sharp jump in the number of undergraduate statistics majors, as the department continues to grow in all areas. About 45 undergraduate majors have been enrolled each quarter, a 50 percent increase since last year. Six undergraduate statistics majors were recognized for academic excellence spring quarter when they were named to the Dean's List.

Dr. D. V. Huntsberger continues as undergraduate adviser. Five students have been graduated during the year:

Recipients of the B.S. Degree

Martha A. Stroud (November 1965)
Adele Berry (May 1966)
Roger Nielsen (May 1966)
Harvey Miller (May 1966)
Bonnie Roberts, joint mathematics-statistics (May 1966)

Iowa State University Stat Club

The undergraduate statistics majors who participated in the Stat Club had an eventful year, highlighted by winning first place in the physical sciences division of the College of Sciences and Humanities for their Veishea Statistics Open House display, for the second year in a row. Bonnie Roberts and Marla Warrick were co-chairmen of the exhibit.

Stat Club president Adele Berry reigned as Veishea Queen of Queens, after first being elected 1965 Homecoming Queen.

Dr. Carol Fuchs and Dr. D. K. Hotchkiss continued as faculty advisers. Club activities included sponsorship of a trip to Iowa City in April so students could attend the spring meeting of the Iowa Chapter of the American Statistical Association.

Other programs featured a tour of the home economics research facilities conducted by Drs. Frances Carlin and Lotte Arnrich, Department of Food and Nutrition; a discussion of how computers are used to match couples in an IBM mixer dance, by Todd Brown and Drs. Edwin Lewis and Leroy Wolins; a slide lecture by Dr. David Jowett on "Statistics Performed with African Tribes;" and Dr. Om P. Aggarwal discussing the "Agricultural Census in Peru."

The club has voted to establish an undergraduate scholarship from its treasury and is now in the process of contacting an industrial co-sponsor for it. In addition the membership automatically receives a subscription to the American Statistician paid for by club funds.

Newly elected officers for 1966-67 are: Sandra Thompson, president; Sharon Kay Burr, vice president; Carol Van Riper, secretary and Douglas Keyes, treasurer.

SEMINARS

Statistical Laboratory-Department of Statistics Series

Each year the Statistical Laboratory and the Department of Statistics sponsor weekly seminars which are offered on a non-credit basis and are open to students and faculty from other departments on the campus. Talks on current staff and graduate research projects and on more general developments in particular areas of statistics precede informal discussion.

The seminar committee was composed of C. Philip Cox, chairman; H. T. David and Edward Pollak. The 1965-66 program included the following topics and speakers:

Fall Quarter 1965

September	15	The Statistical Laboratory: 1965-66. D. V. Huntsberger
September	22	On Simple Linear Combinability of Information from Independent Sources. Frank Martin
September	29	Comparison of Tests for the Paired Design. Oscar Kempthorne
October	6	A Test of Goodness of Fit for a Continuous d.f. B. K. Kale
October	13	Relationship Algebra and the Analysis of Variance of a PBIBD. Junjiro Ogawa, Nihon University, Tokyo
October	20	Bayes and Minimax Procedures for Estimating Mean of a Population with Two-Stage Sampling. Om P. Aggarwal
October	27	The Estimation of Distributed Lags. Wayne Fuller
November	3	Goodness of Fit Procedures. Oscar Kempthorne
November	10	Use of Response Surface Designs in Field Experimentation. Foster Cady
November	17	Limit Theorems Arising in the Theory of Games. David Thomas

Winter Quarter 1966

December	1	Monte Carlo Experimentation for Certain Econometric Distributional Problems. David Richardson, Purdue University
December	8	On Conceptual Foundations of Survey Sampling. Dr. V. P. Godambe, Johns Hopkins University
December	15	Alternative Procedures for Analyzing Learning Data. Leroy Wolins
January	5	On Random Genetic Drift in Subdivided Populations. Edward Pollak
January	12	The Analysis and Interpretation of Some Class of Multivariate Linear Regression Model. Akio Kudô
January	19	On Canonical Forms and Singular Covariance Matrices in Linear Models. George Zyskind
January	26	Planning Multi-Factor, Comparative Analytical Studies. J. Sedransk
January	27	Program of the Inter-American Statistical Training Center at Santiago, Chile. Emilio Ellena, Inter-American Statistical Training Center
February	2	Serial Correlation Coefficients and Their Sampling Distributions. T. A. Ramasubban
February	9	Stimulus Sampling Theory for Continuous Time Prediction Processes. Barry Arnold
February	16	Estimation of the Exponential Model. Chang Sheng Shih

Spring Quarter 1966

March	7	Comparative Study of Various Tests of Normality. Martin Wilk, Bell Telephone Laboratories
March	9	Some Statistical Approaches to Agricultural Research in East Africa. David Jowett
March	21	Non-balanced Experimental Designs to Estimate Variance Components. R. L. Anderson, North Carolina State
March	30	The Lattice of Ordered Partitions and Computation of Generalized Polykays. Edward Carney
April	6	Some Applications of Statistics to Agronomic Problems in North Dakota. A. E. Foster
April	13	Inference for Some Incompletely Specified Models. B. K. Kale and T. A. Bancroft
April	20	Computational Aspects of Mathematical Programming. Donald Soults
April	27	On Slippage Problems. I. Hall and A. Kudô
May	4	A Dialysis System with One Absorbing and One Semi-Reflecting State. Marvin A. Kastenbaum, University of Wisconsin.
May	12	Multivariate Sequential Diagnostics. George F. Liska, University of Saskatchewan
May	18	The Sample Survey Section of the Statistical Laboratory. Harold Baker and Wayne Fuller
May	21	Some Sequential Procedures for a Slippage Problem. M. S. Srivastava, Princeton University

Quantitative Genetics Series

Seminars are held regularly on topics in quantitative genetics. Staff members and graduate students participating are from the departments of statistics, genetics, animal science, poultry science, agronomy and horticulture. Professors Kempthorne and Pollak were in charge of arranging the series. The following seminars were given:

September	28	Some Elementary Ideas and Uses of the Concept of Identity by Descent. Oscar Kempthorne
October	12	An Experiment in Crossbreeding with Dairy Cattle. Ben Bereskin
October	26	A Breeding Scheme to Develop a Population Segregating for Whole and Intact Sex Chromosomes in Chickens. Arne Nordskog
December	7	Use of Inbreeding Studies in Research on Quantitative Inheritance. W. J. Schull, University of Michigan
January	11	Inbreeding in Subdivided Populations. Edward Pollak
March	8	Experimental Fostering in Litter-Bearing Animals. D. F. Cox
April	26	Development of Single Cross Hybrids from Two-Eared Maize Populations. Arnel Hallauer
May	10	Cell Culture Studies in Swine Breeding. L. N. Hazel

FORD FOUNDATION MEXICAN PROJECT

Two professors from the Department of Statistics have left for Mexico where they will teach during the coming year as part of a $640,000 three-year cooperative project with the Mexican government and two Mexican educational institutions, supported by the Ford Foundation.

The funds are being used to develop a graduate program in agricultural economics and to further strengthen the graduate program in statistics. The program is being jointly administered by the Statistical Laboratory, which is working with the National School of Agriculture at Chapingo, and the Department of Economics and Sociology, which will work both with the Chapingo institution and the University of Nuevo Leon.

The Mexican statistical center at Chapingo was established about five years ago by Dr. Basilio Rojas, a Ph.D. graduate in statistics from Iowa State. Dr. T. A. Bancroft is coordinating a program to provide teachers, advisers and consultants in statistics to the statistical center. Ph.D. candidates in statistics from Mexico will do advanced work at Iowa State.

Dr. Henry Tucker, who will join the Statistical Laboratory staff temporarily July 1, and Dr. Foster Cady will be teaching in Chapingo during the year ahead. Dr. Cady will be working in the area of experimental statistics, applied especially to agriculture research in plant and animal sciences. Dr. Tucker will teach econometrics and survey sampling methods, and will help strengthen and make efficient use of the computer facilities in Chapingo.

Dr. Bancroft, Dr. Cady and Dr. Om P. Aggarwal have made trips to Mexico this year, to confer on project plans and consult with Mexican officials. It is expected that Dr. Aggarwal will spend several months in Chapingo in 1967 to teach design and analysis of surveys.

Dr. Bancroft and Dr. Cady visited with the staff of the Ford Foundation in Mexico and at the School of Agriculture at Chapingo in December relative to the preparation of graduate theses at the M.S. degree level of twelve students in the Statistics and Computing Center at Chapingo. Arrangements were made to bring Mr. Sigfrido Romero to Iowa State for the spring quarter to complete his thesis begun at Chapingo under the direction of former staff member Basilio Rojas. Similar arrangements were made for Mr. Alfonso F. Carrillo to come during the summer of 1966. Assistance to Mr. Romero in Ames was provided by Dr. Aggarwal, Dr. Bancroft and Ed Carney.

A publication of the Statistical Laboratory
Iowa State University
Susan Alice Brown, editor