STATISTICAL LABORATORY

ESTABLISHED 1933

ANNUAL REPORT

July 1, 1971 to June 30, 1972

IOWA STATE UNIVERSITY

Ames, Iowa

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, 1971, through June 30, 1972. It reports on the research, consulting, teaching and operational work of the staff of the university statistical center.

Since this is the last report which will be submitted to you over my name, it seems appropriate at this time to express appreciation to the administration for its support. I'm pleased to report that during the past two decades the statistical center has maintained its eminence and grown in stature.

The Statistical Laboratory, a research and service institute under the president's office, took early leadership as the first statistical institution of its kind. It has served as a model for dozens of similar institutes around the world, and is particularly recognized for its strength in the development of high level statistical theory and methodology and its research services.

The teaching Department of Statistics in the College of Sciences and Humanities consistently ranks at the top in the number of graduate degrees granted in statistics. The undergraduate program has been firmly established. At both graduate and undergraduate levels thousands of nonmajors are introduced to statistics through our vital service courses.

The statistics department of the Agriculture and Home Economics Experiment Station continues the services established by George Snedecor to aid research in these areas.

The statistics participants in the Sciences and Humanities Research Institute and the Engineering Research Institute have been established to extend the work in agriculture to the social and physical sciences, expanding the on-campus consulting and cooperative research activities of the statistical staff, in many cases by joint appointments in these substantive fields.

The staff members of the Statistical Laboratory work in cooperation with many institutions and departments of Iowa State University. This is the 22nd annual report I have made to review these activities and record the activities carried on solely by the Statistical Laboratory. I'm especially pleased that the foundations which have been laid will permit the statistical center to continue with vigor.

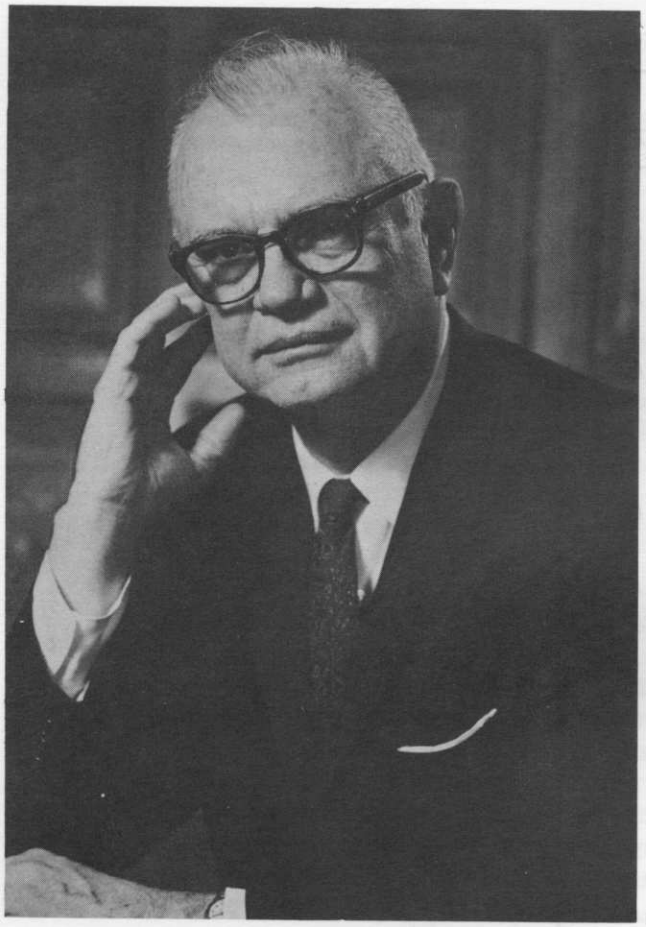
Respectfully submitted on behalf
of the Statistical Laboratory staff,

T.A. Bancroft

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

THE STATISTICAL LABORATORY

ANNUAL
REPORT
1971-1972



On June 30 the first person to hold the title of Head of the Department of Statistics and the second director of the Statistical Laboratory relinquished his administrative responsibilities as dictated by University policy. T. A. Bancroft became director of ISU's statistical center August 1, 1950, replacing Dr. Raymond Jessen who had served three years as acting head and director. Dr. Bancroft's association with ISU began nine years earlier when he enrolled in September 1941 as a graduate student in mathematics, earning a doctorate in mathematical statistics in 1943. Under his leadership the statistical center has grown physically and expanded influentially. It seems appropriate to record some of the developments in the past 22 years.

When Dr. Bancroft became director of the Statistical Laboratory, the faculty included five professors, three associate professors, four assistant professors and ten instructors or associates—numbers which have increased about 100 percent. The five graduate assistant positions in 1950 have been expanded five fold.

However quantity never has been substituted for quality. As an astute administrator, Dr. Bancroft has assured excellence by building a staff of experienced statisticians in methods and theory, while at the same time attracting promising young staff members and helping them develop. When outstanding statisticians were not available on a permanent basis, they were offered visiting short term posts so their expertise would be available to the statistical center. This program not only has brought experienced statisticians to the Statistical Laboratory, but has provided contacts with universities around the world.

The Laboratory has grown physically as well as numerically. With various renovations and a three story addition completed in 1961, the old Service Building now is devoted almost entirely to housing the statistical center. It has been renamed Snedecor Hall as a result of Dr. Bancroft's efforts. The computing hardware which Dr. Bancroft originally administered grew until it was reorganized in 1962 as the University Computation Center. It now is housed in its own building.

Although this growth has been impressive, the development within the statistical center is Dr. Bancroft's true legacy. Under his guidance the undergraduate curriculum was consciously developed with specialized courses for students in the B.S. degree program. The M.S. and Ph.D. programs were expanded with careful attention to quality which continues to attract students from all over the world. The Department of Statistics consistently ranks at the top in the number of graduate students granted degrees. Perhaps more important to the university, the department's service courses were expanded to the undergraduate level and increased at the graduate level. Today thousands of non-majors annually receive an introduction to statistics which enables them to interpret research reports and better

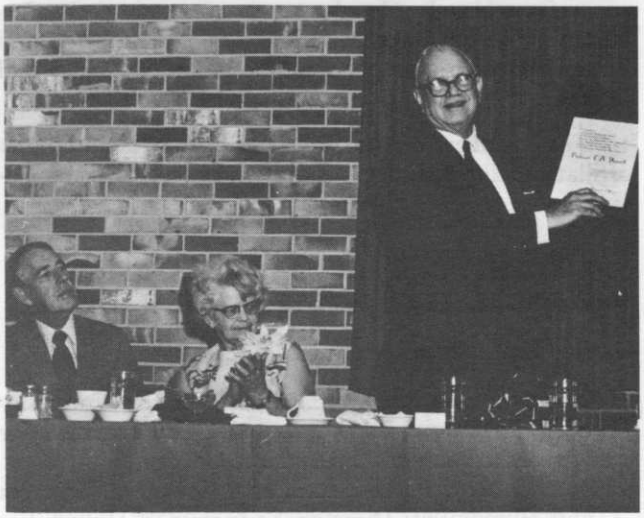
plan and carry out their own research. A joint Ph.D. program was established to encourage students to combine statistics with other substantive areas.

Dr. Bancroft has promoted joint appointments on the faculty level as well. He expanded the on-campus consulting and cooperative research program which had been so well established in agriculture. Today this cooperative program between statistics and a substantive area is made effective by joint appointments with the Computation Center, economics, genetics, industrial engineering, mathematics, political science, psychology, and sociology and anthropology. Cooperative agreements have been established with the Engineering Experiment Station and the Sciences and Humanities Research Institute which complement the early agreement with the Agriculture and Home Economics Experiment Station.

Through Dr. Bancroft's personal efforts, and his encouragement of other faculty members, numerous grants and contracts have been awarded to the Statistical Laboratory. These funds made possible greatly expanded research activities. These contracts have included agreements with the Army Chemical Corps, Atomic Energy Commission, Census Bureau, National Institutes of Health, National Science Foundation, U.S. Department of Agriculture, U.S. Office of Education and the Wright Air Development Center. Dr. Bancroft's personal research on inference theory and procedures has resulted in a number of publications and speeches at professional meetings.

His many committee assignments and elected offices indicate Dr. Bancroft's long-time leadership in his profession. He has served as president of both the American Statistical Association and the Biometric Society, ENAR. He has been named a Fellow of ASA and of the American Association for the Advancement of Science. During his administration he traveled to Columbia, England, Egypt, India, Iran, Iraq, Italy, Mexico, Syria and Yugoslavia to present papers or serve as a statistical advisor, spreading the fame of ISU's statistical center. He has served as a consultant to numerous U.S. and foreign universities to help establish statistical facilities. Many international visitors have come to see the Statistical Laboratory and foreign technicians and statisticians have received special training to help them help their countries through the Point IV and Mutual Security Agency Technical Assistance programs, ICA and FAO, and six years of summer Survey Institutes.

Throughout his association with the Statistical Laboratory and the Department of Statistics, Dr. Bancroft has worked tenaciously to assure that the administration recognizes the needs of the statistical center and appreciates its contributions. He inherited a solidly founded organization and built on that foundation. The strength of his leadership has resulted in the development of a center known for excellence throughout the world.



At a recognition dinner May 19 speakers included ISU President W. Robert Parks and (seated, left, top photo) Dr. Robert Hogg, chairman of the Statistics Department, University of Iowa. On behalf of the staff, Dr. Oscar Kempthorne (center photo) presented to Dr. Bancroft an engraved watch and a certificate (bottom photo) providing for life membership in the American Statistical Association.

Personnel

When the Statistical Laboratory was established in 1933 it was the first institute of its kind, organized on an interdisciplinary, university-wide basis, in the United States. It was established to promote and foster the appropriate and efficient use of statistical methods in university research—and to conduct research in statistical theory and methodology. Today the Statistical Laboratory, an institute under the president's office, is only one part of a complete statistical center. Other components are: the Department of Statistics in the College of Sciences and Humanities; the Statistics Department of the Agriculture and Home Economics Experiment Station; and the statistics participants in the Sciences and Humanities Research Institute and the Engineering Research Institute.

The various components of the statistical center share personnel, which means that a staff member's salary may be budgeted from several sources, depending on the emphasis of his work. In addition, a number of cooperative agreements with federal agencies provide research funds for both staff and graduate students.

The director of the Statistical Laboratory reports to the president of the university through the vice president for research. He also serves as head of the Department of Statistics and Statistics Department, and in these capacities reports to the respective dean and director.

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

THE STATISTICAL LABORATORY STAFF FOR THE FISCAL YEAR 1971-72

Under the administrative direction of

W. Robert Parks, Ph.D. .....President of the University
Daniel J. Zaffarano, 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 Agriculture and Home Economics Experiment Station, through January 18
Marvin Anderson, Ph.D. .....Acting Dean, College of Agriculture, beginning January 19
Theodore A. Bancroft, Ph.D. .....Director, Statistical Laboratory; Head, Department of Statistics; Head, Statistics Department, Iowa Agriculture and Home Economics Experiment Station

Professors

T. A. Bancroft
C. Philip Cox
David Cox
Herbert T. David—joint appointment with Department of Industrial Engineering
Wayne A. Fuller—faculty status in economics as well as statistics
Donald K. Hotchkiss
David V. Huntsberger
Oscar Kempthorne—Distinguished Professor, College of Sciences and Humanities
J. K. Sengupta—faculty status in statistics as well as economics
George W. Snedecor—Professor Emeritus—in absentia
Norman V. Strand
B. V. Sukhatme
James Walsh—joint appointment with Department of Psychology
Leroy Wolins—joint appointment with Department of Psychology
George Zyskind

Professor of Mathematics

James L. Cornette—summer 1972

Associate Professors

Barry Arnold—joint appointment with Department of Mathematics
Richard Groeneveld
Chien-Pai Han
Roy Hickman
C. C. Mosier—joint appointment with Computation Center
Edward Pollak—joint appointment with Department of Genetics
Richard D. Warren—joint appointment with Department of Sociology and Anthropology

Assistant Professors

Harold Baker
Terry Dickinson—joint appointment with Department of Psychology, spring quarter
Jon Geadelmann
Richard Heiberger—beginning winter quarter
Paul Hinz
Dean Isaacson—joint appointment with Department of Mathematics
William Kennedy
Glen Meeden
Richard Mensing
Vincent Sposito—joint appointment with Computation Center

Shashikala Sukhatme
John Sullivan—joint appointment with Department of Political Science

Postdoctoral Associate

A. B. Chia—beginning spring quarter

Instructors and Associates

George Battese
Bruce Bowerman
Mary Ann Chamberlain—summer 1971
G. L. Ghai
Joseph Grimes—summer 1971
Louis Jensen—summer and fall 1971
John Lin
Ting Kwong Lin—beginning spring quarter
Jeff Meeker
Gayle Meltesen
Esmat Nouri—summer 1971
David Pyne
Carl Roux—winter quarter
J. Richard Schmid
Wendell Smith
Basil Springer—summer 1971
Richard Stein
James Veale—winter quarter
William Warde

Graduate Assistants

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

Michael Althaus
C. Asok
Leah Bimblich
Cheryl Bowerman
Ted Emigh
Jeff Goebel
Linda Gorman
M. A. Hidiroglou
Pat Howard
Elizabeth Huang
Her Tzai Huang
J. D. Jobson
Kazimierz Karpinski
Geung Ho Kim
Jan Lommele
Ricardo Longoria
Robert Mason
James Mellon
Roger Mrachek
Martin O'Connell
A. Shawki Salem
Lonnie Vance
James Whipple
Kirk Wolter
Richard Zeller

NIH Trainees

Pamela Doctor
Lonnie Vance
James Whipple

NDEA Fellows

Richard K. Dorsch
Joan Keller
Rebecca Zeller

NSF Fellow

Thomas Keefe

Supported Graduate Students

Carlos Acuña, Latin American Scholarship Program
Lal Chand, USAID
Mohamed El-Sabbagh, (joint statistics-industrial engineering), Department of Industrial Engineering
Alix Garcia, Venezuela Government
Joseph Grimes, Department of Mathematics
Devendra Hajela, Fullbright-Hays Grant
Clifford Lee, Department of Mathematics
Omar Martinez, Centro de Investigaciones Agronomicas, Venezuela
Nimmagadda Murthy, AID India
Winston Richards, Ford Foundation
Julio Cesar Robles, AID, Peru
Gary Sime, Department of Mathematics
Preecha Sakarindr, Rockefeller Foundation, Thailand
Malte Sund, Volkswagen Foundation
Jose Villaseñor, Ford Foundation, Mexico
George Wang (joint statistics-economics), Department of Economics

Unsupported Graduate Students

Claude Angers
Ray Bailey
Kuo Ping Cheng
Cynthia Clark
Modesto Freites
Thomas Kodey
Ona Antonio Landicho
Dennis Pierson
Phantipar Sakrindr
Dennis Tsai
Wai Wo Wong
Shyr-Ching Wung
Tetsuo Yamada

Statistical Data Processing Service

Bud J. Meador, Supervisor
Charlotte Bentley
Ruth Lammey—beginning spring quarter
Mary Wilson—beginning spring quarter

Survey Section

Sandi Partlow, Secretary—through summer 1971
Sylvia McNulty, Secretary—beginning fall quarter
Marjorie Mason, Office Manager
Hazel Cook, Survey Supervisor
Evelyn Green, Survey Supervisor
Anna B. Woodrow, Survey Supervisor
Duane Lande, Programmer
Statistical Clerks:
Ava Klopf
Margaret Nichols
Florence Osam

General Office Staff

Margaret G. Kirwin, Administrative Assistant
Kathleen Ringgenberg, Accountant
Susan Alice Brown, Technical Writer-Editor
Avonelle Jacobson, Supervisor, Teaching Section
Kristie Whitaker, Secretary, Statistical Numerical Analysis and Data Processing Section

Iveta Zeliadt, Secretary, Experimental Design-Genetic Statistics Section
Sharon Bown, Secretary—beginning summer 1972
Norma Elwick, Secretary

Cheryl Huss, Secretary—through summer 1971
Hilda Merritt, Secretary—through summer 1971
Donna Millang, Secretary—through spring quarter
Peggy Nelson, Secretary—beginning fall quarter
Nancy Starr, Secretary—fall and winter quarters
Barbara Williams, Secretary—beginning spring quarter

Consulting and Cooperative Research

Activities of staff members involved with statistical consulting and cooperative research can be classified into three categories: direct consulting on the design and analysis of experiments, a continuing search for better tools to accomplish the data analyses required, and the development of new techniques and the adaptation and application of existing techniques to the research problem presented. By keeping current with the rapid advances in statistical methodology, consulting statisticians are able to help research workers examine their objectives to ensure that proposed investigations will answer the questions posed.

The Iowa Agriculture and Home Economics Experiment Station (IAHEES) supports statistical consulting services for many staff members and graduate students in substantive areas. The Experiment Station budget also provides some funds for statistics research and the development of new statistical methods.

This report is intended only to give an indication of the consulting done by Statistical Laboratory personnel. It is neither possible nor practical to report every consulting project, but this condensation will give an indication of the type of projects with which staff members assist. Some projects require only a few minutes of a consultant's time, while others require many hours over a period of many months. Two or more staff members often will be consulted, independently or jointly, on a single project. The project may involve individual students, faculty members or a group of researchers. The results may appear in a thesis or be presented as a paper at a meeting. Many will be published. Sometimes the consultant's contribution will result in his recognition as a paper's co-author.

IAHEES Project 1448, Consultation and Research in Mathematical and Statistical Genetics, has permitted project director Dr. Edward Pollak to work with personnel from animal science and genetics. Project 113, Statistical Services for Sampling Investigations, provides consultation and statistical survey services for all IAHEES departments. The project is directed by Dr. Roy Hickman. Arrangements with the Engineering Research Institute, similar to that with IAHEES, support some of the consulting done by Dr. H. T. David and Dr. Richard Mensing.

Statistical Services in the Animal Sciences and Plant Sciences, IAHEES Project 101, has supported the consulting services of Dr. D. F. Cox, Dr. Jon Geadelmann, Dr. Paul Hinz, Dr. D. K. Hotchkiss and five graduate students. Advanced students James Mellon, Roger Mrachek and William Warde have assisted with a number of projects.

Consulting work in agriculture often involves experiments where some form of a split plot is used. The classical analysis of split plots presents no real problems, but modifications are required if the structure is not a true split plot. The most common situation is where the experimental units are measured several times as in most experiments involving growth. Data seen encompass a full range of work, including such things as patterns of blood constituents in cows subject to milk fever, ovarian enzyme activity and its relationship to pituitary hormones in rats, the errors in the placement of seeds by mechanical corn planters, the availability of phosphorus to plants as influenced by the time and place of application, investigations of models to predict yields of corn and sorghum under various conditions of moisture stress, growth of white oak seedlings, disease resistance of turf grass, effects of controlled burning in relationship to quail populations in game management areas,

climatological influences on milk production, influence of management practices on weight gains in feed lot steers, causes of lameness in swine, uses of various protein sources in poultry foods and influences of blood group genes on traits of economic importance in poultry.

The consulting staff works closely with personnel in computer science and numerical analysis to bring the full range of modern computer capabilities into the data analysis work. The use of the OMNITAB system has continued and expanded the effectiveness and efficiency of the consulting work. Recently a new statistical analysis system was acquired from North Carolina State University which has features useful in the work here. During the year a computer program to do cluster analysis and draw the resulting dendrograms also has been adapted for use here. This routine has been used for clustering botanical data. A computer program was developed to plot contours and computer maxima in response surface analysis, and a routine has been developed to analyze replicated balanced lattice design.

The consulting statisticians have studied multivariate methods for use in situations where repeated measures are made on the experimental units. The work involves a review of existing practices and some computer simulations of actual data situations.

The multivariate technique, cluster analysis, has also been used to screen a large number of drugs used to control bloat in cattle. The animal science project was designed to find families of similar drugs among over 200 possibilities by measuring for four characteristics when each drug was used on a laboratory sample of stomach contents. Multivariate techniques also were used for the Iowa State Conservation Commission to map the bottom of a large lake in Iowa by measuring the abundance of four species of zooplankton at 15 stations around the lake. The techniques showed good agreement between known depths and flow characteristics and the relative proportions of the various species reflected particular ecological niches in the lake. Multivariate analysis of variance and canonical analysis were used for a forestry study of growth, plant nitrogen and plant protein of cottonwood in response to soil nitrogen.

A study of enzyme kinetics in parasitology has utilized modifications of the two-reciprocal plots first outlined by Lineweaver and Burk (1934). Laws of mass action may be examined using techniques in hyperbolic regression. An animal science reproductive physiology study indicates the spacing of embryos in the uterus of a pig influences their survival. The factors controlling the spacing were under study and measures of spacing, such as average squared distance between implants, were examined as possible criteria.

Two agronomy studies involved analysis of experiments on forage grasses using a partially-balanced incomplete block design with two replicates of the basic design, and examination, using several multiple regression techniques, of effects of various morphological, physiological and environmental factors on net carbon exchange and evapotranspiration of soybean leaf canopies. Another extensive agronomy study involved the use of single-replication experiments to determine the influence of soil type and rate, depth and time of potassium application on the amount of plant-available potassium in soil. Covariance procedures were applied to these data and recommendations were made for the design of future experiments.

A staff member in agronomy was interested in the consistency and reliability of judging panels. Several methods of analysis were developed, involving ranking of the judges by concordance. Emphasis was placed on detecting various types of voting aberrations on the part of judges. Statistical consequences of random judging were derived, to provide benchmarks for the analysis.

A chi-square test was recommended for testing whether the proportion of offspring with crossover types of chromosomes in a genetics study differed in the reciprocal crosses. Research on genetic recombination among treated and untreated *Drosophila* stocks required an explanation of formula in the literature for an approximate 95 percent confidence limit for the ratio of the proportions among the controlled and treated stocks. Measurements on two inheritable traits in an animal science experiment were assumed to be jointly distributed according to a bivariate normal distribution. A standard transformation was used to obtain the distribution of the difference in measurements on the two traits. Transformation of data and analysis of variance (unequal numbers) was used for a food and nutrition study of dietary iron intake. Probit analysis was interpreted for another study, and the fiducial interval calculated. The textbook method was slightly modified to develop a simpler program.

Consulting on some 50 projects in sociology primarily involved data collection, analysis and processing, including coding, scaling and measurement. Much of this research will result in theses, but it also involved special studies of aging, rural development, rural communities and civil defense. Statistical Package for the Social Sciences (SPSS) is now available at Iowa State. Seminars have been presented to explain SPSS to faculty members and graduate students, which may result in an increase of quantitative research. Analysis of variance and t-tests were used in a political science study to determine correspondents' perception of power in the state legislature, using press correspondents stationed in Des Moines to observe legislators.

Procedures were calculated for orthogonal comparisons in unequal subclass number split plot design, for research in psychology. Data were related to avoidance conditioning in rats with different cortical lesions. For another psychology project a design matrix was set up to analyze split-plot data with unequal numbers in the subclasses by means of regression. Projects in industrial administration resulted in the factor analysis of determinants of attitudes toward collective bargaining for junior college teachers, and advice on summated-rating procedures in multifactor semantic differential data on brand (consumer products) identification. An agricultural engineering investigation of agricultural shop safety required forming predictor scales from semantic differential data, and forming maximally reliable criterion measures.

Regression analysis was used for a number of engineering projects. A regression model was set up for studying the amount of runoff of water from melting snow as a function of temperature. In a chemical engineering study a model was set up to determine the rate of oxygen absorption in water as a function of length of input tubes, distance between tubes and flow rate of the gas. An equation was generated for prediction and a suggestion made for further analysis to compare factor effects. The interpretation of R^2 in a regression situation and estimation when both variables are subject to error were discussed with industrial engineers. For an electrical engineering study a regression model was set up to estimate parameters in an input-output analysis of electronic equipment.

Distribution assumptions related to the compound Poisson process were clarified for a physics project involving the counting of rays emitted from a bombarded nucleus when the counting instrument does not detect all emissions. Calibration of lab and field data was studied for a civil engineering investigation of asphalt concrete. A Weibull distribution was fitted to industrial engineering data generated in the simulation of a scheduling problem.

A graduate student in metallurgy posed a problem involving the estimation of two parameters, both entering two functional relations. Suitable transformations allowed interpretation of the problem as a type of nonlinear bioassay problem, with one parameter estimate equal to the translation required to make two functions parallel, the other being the resultant displacement of the two functions. A staff member in aeronautical engineering consulted on the analysis of error propagation in navigational satellite systems.

Considerable consulting is done, by mail or personal visits, with off-campus sources as time permits. Norman V. Strand was on leave fall quarter to accept a three-month assignment in Bangkok, Thailand, sponsored by the Statistical Reporting Service of the U. S. Department of Agriculture. He worked on an analysis of the agricultural statistics methods and procedures used by the Ministry of Agriculture in Thailand.

In May Wayne Fuller spent two weeks in Peru to consult with members of the Peruvian government conducting surveys of household consumption. He assisted in setting up a survey under the Iowa Peru Project. This is an ongoing project sponsored by the Agency for International Development.

Closer to home, Chien-Pai Han, Professor Strand, Roy Hickman and Jeff Meeker have been working with Mercy Hospital in Des Moines on a study of stroke patients. Three cluster analyses have been completed and dendograms are printed. Profile analysis now is being made for the clusters.

Survey Section

The Survey Section of the Statistical Laboratory provides both consulting and direct operational services on all aspects of sampling, surveys and census-type studies. Dr. Roy D. Hickman assumed leadership for the section this year when Professor Norman Strand reduced his work load to half time. Staff members may design surveys, draw samples, assist with questionnaire construction, train and supervise field workers, collect data by personal interview or mail questionnaires, code and edit data for IBM processing, analyze data and maintain liaison with programmers and the Computation Center on machine manipulation of data. The services available are adapted to the needs and resources of the individual researcher; any or all may be required on a particular project. The following partial listing of the activities of the section indicates the wide range of services provided and departments served.

Surveys were designed for three economics projects: grain storage by elevators in a seven-county area in central Iowa, grain storage and marketing by Iowa farmers, and swine production and marketing practices of Iowa farmers. In the latter sudy, staff members also assisted in questionnaire construction, carried out the field work, and directed the data processing.

A survey was designed for researchers in home economics for a study of clothing purchasing practices. Assistance was provided in carrying out the field work and in processing the data. Similar services were provided researchers in sociology on a study of attitudes toward proposed reservoir construction on the Raccoon River.

Samples were designed and drawn and advice on survey procedures provided for a study of educational needs of women for a Drake University sociologist, an investigation of attitudes toward health care by the Health Planning Council of Central Iowa, a pilot study of nutrition in young married adults for an Iowa State graduate student in home economics, and a study of home owners for an Ohio State University home economist.

Having previously designed a veterinary medicine survey of trichinosis in humans, survey section personnel processed the data this year and advised on the analysis.

Assistance was provided in preparing questionnaires for a forestry mail survey of home builders and a study of faculty attitudes toward curriculum requirements for the Sciences and Humanities Curriculum Committee. Staff members also consulted on sampling procedures with researchers in sociology on a study of civil defense directors and with students on studies of recreational use of the Upper Iowa River, attitudes of dormitory residents toward coed housing, and attitudes of alumni donors.

Staff members of the Survey Section consulted with members of a committee to investigate the feasibility of instituting a procedure to estimate health characteristics of farm and other domestic animals. This committee was commissioned by the National Research Council of the American Academy of Science. The duties of this committee were, more specifically, to examine the feasibility of establishing statistical approaches to measure disease incidences, epidemiology of diseases, death loss and sickness of farm animals sold for meat in the United States. The main objectives of the program, if adopted, would be to study the economic effects of disease, and to acquire information which would be helpful in eradicating or lessening incidence of animal diseases.

Data from a food and nutrition study of nutritional profile of women during aging were collected from 35 women, but different women were observed a different number of times over several years. Assuming a positive correlation between measurements on the same individual, a simple transformation of the data was conducted so that parameter estimation could proceed with use of an ordinary least-squares regression program.

Statistical Numerical Analysis and Data Processing Section

The Statistical Numerical Analysis and Data Processing Section of the Statistical Laboratory provides support in the area of computer applications of statistics to research workers who use statistics as a research tool. Dr. W. J. Kennedy supervises the section. Although most of the research is supported by university departments or grants and contracts, the section routinely provides complimentary work for worthwhile research projects for which no supportive funds are available. The value of this complimentary time averages over $1000 per month, and benefits departments in all colleges.

Two closely allied groups work together within this section. The Statistical Data Processing group serves the university by consulting with researchers on problems in statistical data processing and serving as a liaison with the Computation Center to see that data actually is processed through the computer. Bud J. Meador is group supervisor. The increased demand for services during the year required the appointment of two full-time programmers. This staff addition expands the group's support capability. Of the nearly 200 projects handled, 37% were from sciences and humanities, 27% from home economics, 22% from agriculture and 7% from education. Other projects were from veterinary medicine, engineering, administration and off-campus sources.

The second group within the Section, Statistical Numerical Analysis, includes personnel who conduct research, consult on computer applications of statistics, and develop general-purpose computer programs for statistical applications. This group provides the general programming support within the section, allowing the data processing group to avoid programming which is not immediately applicable to a data processing problem at hand. Assistant Professor Richard Heiberger joined the staff during the year.

Dr. Heiberger is studying the algorithms used in the factor analysis programs available in the Statistical Laboratory. He also is working with a staff member in Computer Science on the development of a batch-oriented interpreter for the APL computer language, a general-purpose language that easily can be applied to statistical problems.

During the year a multivariate general linear hypothesis program was developed by Dr. Kennedy and graduate student R. A. Stein. Named MALAMUTE, it includes most of the features of the original AARDVARK program but has additional capabilities, partic-

ularly in the area of non-orthogonal and multivariate analysis. The system structure is totally different from that of its predecessor, AARDVARK. This restructuring along with other innovations has produced a system which is significantly more efficient for use in analysis of variance applications.

Several programs for processing seed classification data from a data bank were developed for the Plant Introduction Unit. Dr. V. A. Sposito has been working on a new computer program to determine least squares parameters subject to side conditions. This is a joint project for statistics, economics and veterinary medicine personnel. Graduate student Jeff Meeker developed a grading program for chemistry to average-grade large, particularly introductory, enrollment courses. During the year he debugged several programs in OMNITAB and conducted OMNITAB use seminars.

While it is not possible to report all assistance provided during the year, a partial listing will give an indication of the variety of departments served and the activities of section staff members. Linear programming was used for two economics studies, systems analysis of international feed grain marketing and a water treatment study. Engineers were helped to solve a transportation model with a nonlinear cost function, using separable programming.

Data handling procedures were used for a veterinary medicine study of the effect of DDT on the learning ability of monkeys. Data retrieval techniques were employed in an investigation of slaughter house output for agricultural economics. Regression and analysis of variance in corn borer data helped entomologists determine corn borer habits and habitats. An education investigation of public school supervisor attitudes required frequency counting and chi-square analysis of contingency tables. Chi-square goodness of fit was used for a wildlife management study of deer migration.

The university has been recognized as a 1970 Census Summary Tape Processing Center by the Bureau of Census. It is one of 160 such centers in the United States and three in Iowa to help census users obtain data. The Center, which is co-directed by Dr. Kennedy and H. C. Chang of the Department of Economics, will reproduce summary tape copies for other users; provide programming and computing services for users who want to obtain hard-copy printouts; maintain general programs prepared by the Census Bureau and others, and offer applications to local users; provide an information exchange in Iowa; aggregate and do census statistical work; and develop special programs and make them available. The center operates on a cost reimbursable basis.

Current Research

Iowa State ranks twentieth among the leading university-administered research centers in the nation; research has been conducted at the university since the institution opened. Research in statistics has produced many fundamental techniques valuable to research workers here and elsewhere.

Statistical research by staff members is supported by a variety of sources. The Statistical Laboratory budget supports research projects which are of specific interest to regular university research programs. Other research is part of a continuing cooperative program with other campus research institutes and experiment stations. Grants and contracts with off-campus agencies provide for supervised research on statistical problems of common interest.

Research by Dr. Richard Groeneveld on asymptotically optimal group rank tests for location has resulted in a paper to be published next year in the Journal of the American Statistical Association. Dr. Groeneveld examines the asymptotic efficiency of a simple group rank test: testing that the location parameter of a symmetric distribution is zero against the alternative that it is positive. Asymptotic optimality is shown subject to a condition on the density function. Efficiencies in relation to the sample mean and the sign test are found in several cases.

Dr. B. V. Sukhatme continued investigation of the use of auxiliary data in design and analysis of survey data, research partially supported by the Statistical Reporting Service, U. S. Department of Agriculture.

A design used frequently in surveys is multi-stage sampling in which selection at each stage is carried out with equal probabilities and without replacement. Using information on one or more auxiliary variables, several ratio-type estimators have been proposed for two-stage double sampling designs and their bias and efficiency investigated. These results have been obtained by N. S. Murthy, working under Dr. Sukhatme's direction, and are reported in Murthy's M.S. thesis. An abstract appears in the publications section of this report. The results now are being extended to more than two stages.

An attempt has been made to investigate the validity of the techniques used in deriving series approximations to the bias and mean square error of ratio-type estimators. To find the bias and mean square of a ratio estimator, it is usually assumed that $|\bar{x}-\bar{X}| < \bar{X}$, which may not be satisfied by all the (N_n) possible samples. Koop suggested an alternative approach to overcome this difficulty. Koop's approach has been examined and it has been shown that the stated assumption is still necessary. These results have been obtained by Isidoro P. David, working under Dr. Sukhatme's direction, and are reported in Dr. David's Ph.D. thesis. An abstract appears in the publications section.

Dr. H. T. David and Dr. R. W. Mensing continued work on project HR-157, Evaluation of Gap Graded Asphalt Concrete Mixtures, directed by Dah-Yinn Lee of the Department of Civil Engineering. The aim of this project is to compare certain physical properties of asphalt concrete for various aggregate size distributions. Initially calibration curves were developed in order to relate experimental results obtained at the Iowa Highway Commission and Iowa State. Models used involve split-plot error structures for fractional factorial designs; some of the components of this error structure are estimated by half-normal plotting.

T. A. Bancroft and Chien-Pai Han have been working on power of analysis of variance test procedures for incompletely specified fixed models. In testing the main effects it is suspected that the interaction may be absent in the model. In order to detect the presence of interaction, a preliminary test can be used for testing the interaction equal to zero. If the test is significant, the residual mean square is used in the F test for testing the main effects; if the test is not significant, the interaction mean square and the residual mean square are pooled and the pooled estimate of error is used in the test of main effects. This testing procedure belongs to inference in incompletely specified models.

The power function of this testing procedure was obtained by Bancroft in 1953. Some numerical computations of power were obtained by Lemus in 1955 and Mead in 1968 for special selections of degrees of freedom and parameter values. Recent computation extends to more combinations of degrees of freedom which include the case of unequal and proportionate subclass frequencies in a two-way classification. It is found that the power gain in the latter case of the sometimes pool procedure over the never pool procedure is appreciable.

NIH Research

The termination in June of the graduate training program in biostatistics ends a 14-year cooperative program between the Statistical Laboratory and the National Institutes of Health. The establishment of this program in June of 1958 represented a departure from the pattern of previous work in biostatistics at Iowa State. Trainees supplemented their course work and supervised research with a period of experience with research staff at some medical or public health center. The uniqueness of the Iowa State program resulted from its balance between courses in both statistical theory and applications, special courses in biostatistics and this off-campus experience.

During the program certain students worked summers with the Mayo Clinic, the U. S. Public Health Service, the Biometry Branch of the National Cancer Institute, and the Department of Preventive Medicine and Environmental Health at the University of Iowa. In addition, several students enrolled in NIH-sponsored graduate summer sessions of statistics in the health sciences.

Throughout the 14 years the program provided graduate training opportunity for 26 different participants. Of these, seven trainees received both M.S. and Ph.D. degrees from Iowa State. Nine either have completed or are completing their doctoral program. Seven others have been awarded M.S. degrees. Of the three who left the program before earning degrees, one completed his doctorate at Harvard, a second continues graduate work in biostatistics at the University of California, Berkeley, and the third is employed as a research statistician.

In addition to its own trainees, the Iowa State program provided course work in statistics for NIH trainees from the medical school at Western Reserve University until that institution established a graduate program in biostatistics. Even then the doctoral candidates continued advanced course work at Iowa State.

The NIH-sponsored training program was established to stimulate the interest of statistics graduate students in biometry, medical statistics or public health careers, to raise the quality and level of competence of these students, and to contribute to biostatistics generally by including basic research in their programs.

The present employment situations of the program graduates indicate that these objectives have been achieved. One graduate is a mathematical research statistician with NIH, another is a consultant in medical research and a third is employed by the Commission on Professional and Hospital Activities. Two work for the Mayo Clinic, four teach in Departments of Preventive Medicine or Biometry and three others teach statistics. Nine are employed as statisticians, four of them with pharmaceutical firms. At the present time, three are completing their doctorates.

Collectively these trainees have made significant contributions to medical and biological research, especially in quantitative studies which require more advanced statistical methodology than that available in the more public-health-oriented departments of biostatistics.

During this final year only three trainees have been supported by the program. Pamela Doctor continued her programming work with the Statistical Numerical Analysis and Data Processing Section. She completed requirements for an M.S. in statistics which was awarded in May, and will continue research for her doctorate. Barry Arnold is her major professor.

Lonnie Vance will complete his doctorate in the fall under the supervision of Chien-Pai Han. In addition to his course work and doctoral thesis research, he has assisted with the teaching of undergraduate courses in statistics.

James Whipple accepted a job as a statistician with Merch, Sharpe and Dohme and expects to continue work on his doctoral research. C. P. Cox served as his major professor.

James Veale, formerly supported by the grant, received his doctorate in May.

Former trainee Tom Fears, who is employed by Continental Oil Company, has now completed requirements for his doctorate, which will be awarded in August.

Professors Cox and Han have conducted research this year on hypothesis testing for the correlation coefficients of special bivariate normal distributions. It is well known that, given a sample from a bivariate normal distribution, the usual F-test for the significance of a regression coefficient is zero. For the special bivariate normal distributions in which the ratio of the marginal variances $V(y)/V(x) = c^2$, a known constant, an exact test for H_T: $\rho = \rho_T$ against either a one- or two-sided alternative is obtained again using an F-distributed test statistic. The power advantage of the test is highest for large $|\rho|$ and small sample size, in which cases confidence intervals for ρ also are appreciably narrower than those calculated ignoring the constant $V(y)/V(x)$ ratio.

Research by Professor Cox on estimating relative potency from quadratic log-dose relations will be published as a note in Biometrics. Elston (1965) published a simple procedure for estimating relative potency in continuous log-dose response bioassays. An equivalent alternative analysis has been obtained which is simpler primarily because the four analyses of variance originally required can be replaced by just one analysis.

Research in Mathematical and Statistical Genetics

The National Institutes of Health and Agriculture Experiment Station Project 1669 jointly support research in mathematical and statistical genetics directed by Dr. Oscar Kempthorne and Dr. Edward Pollak. Several papers have been published during the year and abstracts appear in the publications section.

Further work has been done on the mathematical theory of selection for viability and fecundity in Mendelian populations with overlapping generations by Professors Pollak and Kempthorne. G. L. Ghai has continued his work on partial inbreeding, with the system of mixed random mating and selfing being examined in great detail. The results in this case are extended to several unlinked loci with multiple alleles. He also has examined some deterministic models of partial assortative mating. A description is given in his thesis abstract.

Professor Pollak has been working on the mathematical theory applicable to a situation in which a rare gene may be present in more than one type of individual, and each type having the rare gene can have descendents of any of the types with the gene. Assuming that the rare gene has some chance of ultimate survival, it is shown that the moments of the conditional time to extinction of a line, given ultimate extinction, are finite, regardless of the type of the ancestral individual.

C. Z. Roux worked on a general theory of selection for a single locus and nonoverlapping generations. This includes nonmultiplicative fecundity and selection differing in the two sexes. Louis Jensen obtained solutions for equations describing the growth of a sexually reproducing population if it is assumed that the ratio of females to males at birth is a constant and couples are formed only between individuals of the same age. Upper bounds have been derived in other cases.

Dr. A. B. Chia, on sabbatical leave from the University of Malaysia, has been developing formulae for effective and average numbers of genes in a finite population of size varying over time.

T. E. Emigh and Professor Kempthorne have been studying the statistical problems of determining the role of heredity and environment in phenotypic expression, with particular reference to the case of IQ in humans.

E. M. Nouri continued his Ph.D. work on the theory of truncation selection. J. L. Cornette worked on the nature of functional iteration equations that arise in mathematical genetics and in upper truncation selection for a quantitative attribute.

Design of Experiments and Analysis of the Data

Dr. Oscar Kempthorne continues as director of Project 890, supported by the Agriculture Experiment Station. During the year random sampling of a lattice of factorial combinations has been studied, including the use of a random fractional plan. The nature of Bayesian statistical analysis of data has been explored, and it is concluded that its role is tightly restricted to the making of terminal decisions. It has grave defects for the reporting of experimental conclusions. Attention has been given to the foundations of the theory of random sampling.

Research conducted under this project has resulted in a book by Dr. Kempthorne and Leroy Folks which was published this year by Iowa State University Press. An abstract appears in the publications section of this report.

Research to Formulate Improved Techniques for Estimating Farm and Related Characteristics by Sample Surveys

Dr. Roy Hickman assumed responsibility for administering research supported by Agriculture Experiment Station Project 1753.

Soil, slope, erosion and land capability runs for editing original data entries were completed for all states for the soil and water conservation inventory. Using these diagnostic runs, original data has been updated for 28 states. Soil names for each soil code for 45 states have been assigned and added to the data set. Work was begun on planning and organization of interpretative analysis of soil data, and data processing test programs for these analyses are being written.

Work has been completed on a comparison between point sampling and the more time consuming cut and weigh or planimeter method of measuring areas using photographs. By sampling a set of 36 points within a 160-acre unit, it is possible to estimate acreages for soil, slope, erosion and land capability at considerably less cost with only a relatively small increase in sampling error.

From past work it has been determined that estimates are quite accurate for soils which have a relatively small acreage when only a small area sample is taken. Areas in any given classification which are relatively large with respect to totals are, of course, extended with greater precision. To learn more about increase in precision made possible by increasing sampling rates, additional sample units were drawn in Woodbury County, Iowa, and estimates of totals and variances were computed. The main interest was centered on minor areas. An empirical check is made possible by checking sample estimates against the complete measurement of soils.

A computer program has been prepared and is being tested to use information from secondary sources to determine cell totals using known relationships between row and column totals in a two-way table which cross-classifies land uses and land capability units.

The state of Missouri was completed and the states of Nebraska and Arkansas begun for the revision of the Master Sample of Agriculture. This project is to update the area sampling materials by restratifying areas and forming count units suitable for drawing samples of agricultural interests.

The final report is being prepared for the response error study in selected Iowa counties. Analysis was completed of data from a sample of farm operators with regard to interviewer effects on errors of observation.

Work continues on the use of auxiliary data in survey design and analysis. The purpose of this research is to investigate the uses of auxiliary information to increase efficiency in estimation. Depending on the availability of auxiliary data at different stages of sampling, several ratio-type estimators have been proposed and their bias and efficiency investigated.

Analysis of Data and Design of Surveys

Data transformations that reduce correlated errors with certain common covariance structures to uncorrelated variables, were investigated with the support of Agriculture Experiment Station Project 1806. Dr. Wayne Fuller continues as project director.

Estimators for the errors-in-variable model when estimates of the covariance matrix of the errors are

available have been examined for three cases: 1) errors in the equation are present, 2) there are no errors in the equation, 3) there are no errors in the equation and the errors of measurement are of smaller order than the unobserved true variables. Subcases can be identified if the covariance matrices have specified properties. For example, the covariance matrices may be diagonal or block diagonal. Estimators with finite moments were developed and the approximate mean square error of these estimators was shown to be smaller than those of the common estimators.

Methods of classifying survey respondents who make conflicting reports are under investigation.

Research in Mathematical Statistics and Probability

Co-investigators Dr. Barry Arnold, Dr. H. T. David, Dr. Dean Isaacson, Dr. Glen Meeden and Dr. Richard Mensing conducted research in mathematical statistics and probability. Dr. David served as project coordinator.

Dr. Arnold continued investigation of examples of improved estimation which utilize available overestimates. Many of these can be recast in the framework or preliminary test procedures. In general, preliminary test procedures are sometimes better and sometimes worse than standard procedures. It is perhaps noteworthy that many of the preliminary test estimates which lead to uniform improvement over the usual estimates are associated with available over- (or under-) estimates. Dr. Arnold also has been concerned with waiting time distributions in certain elementary combinatorial problems. Such results might find application in discrete queueing problems and in some learning models.

Dr. Isaacson continued work in the area of martingale theory, resulting in two publications. One is abstracted in the publications section. The second, which will appear in the Proceedings of the American Mathematics Society, gives conditions for when a martingale generates a right continuous family of σ-fields. It also gives necessary and sufficient conditions for expressing a certain type of martingale as an integral with respect to Brownian motion and having the integrand non-zero, a.e. dtxdP.

Dr. Meeden has been interested in the problem of choosing a prior distribution over the parameter space when the Bayesian statistician has vague or incomplete knowledge about the parameter. Describing this vagueness of belief by assuming that the prior belongs to some class of possible probability distributions, he then attempts to find a decision function which is "good" against this whole class. He is particularly interested in testing problems and when the uniform prior can be used in these situations involving incomplete knowledge about the parameter.

Dr. Mensing is continuing research on probability models for near-saturated queues. Dr. David continued work on small sample and asymptotic distribution problems in passive stochastic programming.

Use of Preliminary Test(s) of Significance in Designing Surveys and Analysis of Survey Data

This research project in the field of design and analysis of sample surveys, supported by the U. S. Office of Education, continued with Dr. B. V. Sukhatme as the principal investigator. This research is mainly concerned with the extension and development of the theory and methodology of sampling involving the use of preliminary test(s) of significance to problems in the designing of sample surveys and analysis of survey data.

Work continued on the problem of allocation in stratified sampling based on preliminary test of significance. Sukhatme and Tang (see an abstract in the publications section) proposed an allocation called sometimes proportional allocation based on preliminary test of significance. They discussed its efficiency with respect to proportional allocation and modified Neyman allocation for the case of two strata when $\sigma_1 \leq \sigma_2$. The efficiency of sometimes proportional allocation depends upon the level of significance of the preliminary test. A table now has been prepared recommending optimum levels of significance of the preliminary test for different strata weights. The corresponding results for the case $\sigma_1 \neq \sigma_2$ also have been worked out. Some further results concerning the efficiency of sometimes proportional allocation for the case of three strata also have been obtained. Investigation concerning the optimum choice of the level of significance of the preliminary test for this case is in progress.

Linear Models and Analysis of Variance Research Procedures

The broad areas of research supported by this National Science Foundation grant concern the development and integration of linear model theory, the design and analysis of experiments, and the general problems of data analysis and of inference from experimental and observational data. Dr. Oscar Kempthorne and Dr. George Zyskind are the principal investigators. Research for Ph.D. theses by Richard Chamberlain, Leon Jordan Filho and John James Kinney was completed under this grant. Abstracts appear in the publications section of this report.

Some progress has been made on linear model theory and the grip on the role which conditional inverses play in this topic, particularly with respect to oblique projections and various parametric constraints. Dr. Zyskind has been investigating observational covariance structures arising directly as a result of the physical act of randomization in experiments. Some work on constrained randomization also has been pursued. General type normal equations appropriate to arbitrary non-negative covariance structures have further been investigated, and the relationship of these with oblique projection operators and classes of conditional inverses studied.

A related study to develop a largely rank free approach to matrix algebra and in particular to conditional inverses and projection operators is being pursued by graduate student Dick Stein under Dr. Zyskind's direction. A study is made of the general linear model $y = X\beta + e$ when singularities in the covariance matrix V are allowed in an arbitrary manner relative to the design matrix X. New equations for best linear unbiased estimation of $X\beta$, called BLUE($X\beta$), are developed and related to projection operators. Under multivariate normal distribution of data, BLUE($X\beta$) is found to remain consistent for certain types of sequences of observations for singular V of finite Euclidean norm. Linear transformations are studied in light of preserving BLUE($X\beta$). Simple least squares estimation of $X\beta$, called SLSE($X\beta$), is related to BLUE($X\beta$) by means of the minimum ratio of variances of all estimable parametric functionals. This minimum ratio, called efficiency, is expressed in terms of eigenvalues of V and the directional cosines of the corresponding eigenvectors relative to the column span of the design matrix.

Graduate student William Warde has been working under the guidance of Professor Kempthorne on the estimation of parameters in linear models, when the parameters are subject to linear inequality constraints. The case of linear regression with the slope parameter restricted by a linear inequality has been investigated. A comparison of the least squares and several Bayesian estimators has been made from the viewpoint of bias, mean square error and closeness. It is found that no one of the several estimators examined is uniformly best. A Monte Carlo comparison of several proposed interval estimators for constrained estimators currently is in progress.

Dr. Basil Springer of the University of West Indies was a visiting senior investigator during the summer, working in the area of multiple comparisons. A preliminary report by Drs. Springer and Kempthorne introduces simultaneous statistical inference and then discusses critically the existing multiple comparison procedures. On the basis of this critical discussion several areas are suggested for further development. Some of these are concerned with the tidying up of inference using these procedures and others are concerned with looking at new procedures in the light of the type of questions to be answered.

USDC, Bureau of the Census Research Project

During the year research on the multiple frame, respondent classification, errors in variables and nonlinear estimation topics has been supported by the continuing cooperative program between the Statistical Laboratory and the U. S. Bureau of the Census. Dr. Wayne Fuller is project director.

Estimates for the several domains associated with sampling from three frames have been investigated. It has been proven that a two-step procedure will yield estimators for the domain sizes that have a bias of $0(\frac{1}{n})$, where the estimators are $0(n)$.

Attempts have been made to include information from a second (auxiliary) variable to obtain an improved estimate for a characteristic on which two responses have been obtained. While it is clear that the auxiliary variable contains information, the method of using this information in the case of unknown response error is less clear.

Considerable work has been completed on the problem of classifying a respondent into one of two classes given that he gives two conflicting responses. It appears possible to use a third variable to estimate the most reliable of the two responses and then use this response as the classifier.

The possibility of using the errors in variables results in the analysis of response errors for 0-1 variables was investigated. It appears that the model may be used to answer certain questions. However, the fact that the variance of the response errors is a function of the true value means that certain of the variance formulas calculated for the classical errors in variables model are not directly applicable.

The problem involved in constructing a two-stage estimator for an unknown parameter in a model with unknown covariance structure was studied. Estimators for the covariance function are first constructed from the simple least squared estimators. These covariance estimators are then used in deriving approximate generalized least squares estimators, which are more efficient (asymptotically), than the simple least squares estimators.

Publications and Professional Activities

Publications appearing during the year reflect the research activities of Statistical Laboratory staff members. Frequently they are the result of papers presented at professional meetings. Staff members take an active role in professional activities and assist with the publication of the journals. A record of these activities for the past fiscal year follows.

Editorial collaborators for the Journal of the American Statistical Association included Barry Arnold, T. A. Bancroft, Richard Chamberlain, C. P. Cox, H. T. David, Wayne Fuller, Richard Groeneveld, Chien-Pai Han, Oscar Kempthorne, W. J. Kennedy, Basil Springer, Vincent Sposito, B. V. Sukhatme and George Zyskind.

Dr. Arnold and Edward Pollak refereed for the Journal of Applied Probability. Dr. Bancroft and Dr. Kempthorne served on the editorial advisory board of the Journal of Statistical Computation and Simulation, and Dr. Kennedy served as a referee. Dr. Kempthorne was an associate editor of Biometrics and Professor Cox, Dr. Fuller, Dr. Pollak and Dr. Zyskind served as referees for the publication. Dr. Zyskind and Dr. David refereed for the Annals of Mathematical Statistics and Dr. Zyskind also for Technometrics. Dr. Sposito and Dr. David were referees for the Journal of Operations Research. J. K. Sengupta was named a member of the editorial board of Stochastics, a new journal which deals with the theory and applications of stochastic processes to problems of filtering, modeling and identification. R. D. Warren is serving on the review panel for Sociological Quarterly. Dr. Fuller refereed for the American Journal of Agricultural Economics and the International Economic Review.

During the year the Iowa State University Press published a festschrift in honor of George W. Snedecor. Edited by T. A. Bancroft, assisted by Susan Alice Brown, it included contributions from statisticians all over the world; an abstract appears in this section. The Press also announced the publication of the Spanish translation of the sixth edition of *Statistical Methods* by George W. Snedecor and William G. Cochran.

RECORD OF PUBLISHED RESEARCH

This is a record of articles published by staff members and graduate students during the past fiscal year. 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 (*).

*T. A. Bancroft: "On Establishing a University-Wide Statistical Consulting and Cooperative Research Service." The American Statistician, 25:5, 21-24. December 1971. Reprint Series No. 284, Statistical Laboratory, Iowa State University.

In this paper it is pointed out that as a consequence of the dual nature of statistics (a mathematical science and a part of scientific methodology), university statisticians have the opportunity of providing a statistical consulting and cooperative research service in addition to the academic teaching and research programs of a usual university department.

The author discusses the levels of complexity of statistical consulting needs, the nature and administration of statistical consulting and cooperative research, methods of financing and reporting, interaction with the computing center and staff promotion and tenure policies.

T. A. Bancroft (editor): *Statistical Papers in Honor of George W. Snedecor.* 328 pp., Iowa State University Press, Ames. 1972.

This volume is presented as a tribute to George Waddel Snedecor, founder and first director of the Statistical Laboratory. Friends, former students and former colleagues of Professor Snedecor were invited to contribute. They selected topics which include binomial sequential design, choice test by panels, distribution of primes, forecasting by counts and measurements, graphic displays, history and future of statistics, inference and data analysis and inference procedures, mixed analysis of variance model, observational studies, recursive rules, selection of predictor variables, sensitivity, statistical appraisal in nutrition, systematically selected samples, a test of fit, transformations and transversals in Latin squares.

Contributors are Richard L. Anderson, David M. Allen, Foster B. Cady, T. A. Bancroft, C. I. Bliss, J. D. Borwanker, H. T. David, Charles D. Ingwell, George W. Brown, William G. Cochran, Walter T. Federer, John Gurland, Ram C. Dahiya, H. O. Hartley, William K. Vaughn, Raymond J. Jessen, Oscar Kempthorne,

M. G. Kendall, Jay L. Lush, M. Ray Mickey, Frederick Mosteller, P. V. Sukhatme, Gerhard Tintner, Gopal Kadekodi, Sture Thompson, John W. Tukey and Frank Yates.

T. A. Bancroft: "Some Recent Advances in Inference Procedures Using Preliminary Tests of Significance." Pp. 19-30 in *Statistical Papers in Honor of George W. Snedecor,* edited by T. A. Bancroft, Iowa State University Press, Ames. 1972. Journal Paper No. J-6804, Iowa Agriculture and Home Economics Experiment Station, Ames, Project 169.

In the application of statistical methodology the experimenter often is uncertain of some one or more of the assumptions required to validate a desired inference. The desired inference may be either a test of a hypothesis, the estimation of a parameter, or a prediction.

Although inference procedures incorporating preliminary tests of significance have been used intuitively for some time by research workers and applied statisticians, only in recent years and for a limited number of uses have attempts been made to evaluate their properties. In this paper the author discusses the use of such procedures and surveys recent advances in general theory and methodology. An example is given of inference for the incompletely specified fixed linear model.

***T. A. Bancroft:** "On Teaching of Service Courses in Statistics." The American Statistician, 26:2, 14-16. April 1972. Reprint Series No. 294, Statistical Laboratory, Iowa State University.

The author draws on his experience in developing a service course teaching program at Iowa State to discuss the nature of service courses in statistics and the choices of a departmental home for these courses. He presents a suggested model for a well-rounded department of statistics, combined with a university-wide consulting and cooperative research service.

G. E. Battese, W. A. Fuller and W. D. Shrader: "Analysis of Crop-Rotation Experiments, with Application to the Iowa Carrington-Clyde Rotation Fertility Experiments." Research Bulletin 574, 20 pp., Iowa Agriculture and Home Economics Experiment Station, Ames. May 1972.

A model is presented by which several crop rotations are compared and optimal fertilization and rotation practices determined. The model is developed with specific applicability to the rotation-fertility experiments at the Carrington-Clyde experimental farm near Independence, Iowa.

The substitutability of legume meadow and chemical nitrogen fertilizer and the effect of carryover of applied nitrogen from crop to crop are incorporated into the analysis. The split-plot nature of the rotation-fertility trials is noted, and a transformation of the yield data is employed to create nearly uncorrelated observations. Response functions are estimated for each crop in each rotation. Optimal fertilizer rates and rotations are determined on the basis of average annual return. Variance of return arising from yield variability over years also is estimated.

Continuous corn yielded the largest net income for the prices considered in the study. The net income per acre decreased with the introduction of oats and an increasing number of years of meadow. However, variability of annual return was largest with continuous corn and decreased as the number of years of meadow in the rotations increased.

***C. Philip Cox:** "Interval Estimation for X-Predictions from Linear Y-on-X Regression Lines Through the Origin." Journal of the American Statistical Association, 66:336, 749-751. December 1971. Reprint Series No. 287, Statistical Laboratory, Iowa State University.

When an interval estimate is required for the x-value, estimated from a calibration line corresponding to a test value $\bar{y}_T$, it is shown how the individual y_T -observations can be used to improve the interval estimation in the three cases where the residual variance is constant, proportional to x or to x^2.

L. L. Anderson, J. B. Peters, R. M. Melampy and **D. F. Cox:** "Changes in Adenohypophysial Cells and Levels of Somatotrophin and Prolactin at Different Reproductive Stages in the Pig." Journal of Reproduction and Fertility, 28, 55-65. 1972. Journal Paper No. J-6749, Iowa Agriculture and Home Economics Experiment Station, Ames, Projects 1325 and 1712.

Percentages of cell types in the adenohypophysis were compared with the content of STH and prolactin at different reproductive stages in the pig. Acidophils, which represent STH and prolactin activities, accounted for 53.5 percent of the cell population; 13.1 percent was represented by chromophobes, which are undifferentiated, inactive or depleted cells.

There were no significant correlations in the percentages of STH cells and the concentration or content of STH during pregnancy and lactation. Prolactin levels remained relatively constant during pregnancy and after hysterectomy, but declined during lactation. Exogenous oestrogen caused a consistently higher trend in prolactin activity in hysterectomized animals.

Larry P. Pedigo, C. L. Lentz, Jay D. Stone and **D. F. Cox:** "Green Cloverworm Populations in Iowa Soybean with Special Reference to Sampling Procedure." Journal of Economic Entomology, 65:2, 414-421. April 1972. Journal Paper No. J-6907, Iowa

Agriculture and Home Economics Experiment Station, Ames, Project 1718.

Larval populations of Plathypena scabra (F.) were sampled in Iowa soybeans during the summers of 1968-70. Intensive (small plots) and extensive (broad area) sampling programs allowed comparison of fumigation-cage, shake, sweep-net, vacuum-net, and pitfall collection techniques.

In the intensive program sweep-net samples demonstrated great fidelity to cage samples ($r = 0.92$), but pitfall samples did not ($r = 0.69$). None of the sampling techniques used in the intensive program showed larval age-class bias. Shake samples would require more study for proper evaluation.

Although sweep-net and vacuum-net samples were highly correlated ($r = 0.94$) in the extensive program, the vacuum-net technique was less precise, more expensive and showed age-class bias.

J. D. Borwanker, **H. T. David** and **Charles D. Ingwell** (Western Electric Company, Chicago): "Binomial Sequential Design of Experiments." Pp. 45-57 in *Statistical Papers in Honor of George W. Snedecor,* edited by T. A. Bancroft, Iowa State University Press, Ames. 1972.

The authors consider how to select sequentially, under a certain general class of loss functions, one of two available binomial sources of information, differing both in reliability and sampling cost. Sampling cost need not be asymptotically unbounded for members of this class. The main result is that the Bayes strategies have the usual characterization. It is not known whether the class can be adapted naturally to the general theory of Haggstrom (1966). This paper addresses itself to certain questions in the area of additive loss, specifically the inadmissibility of one of the two sources, OC and ASN computations, and characterization and computation of the Bayes procedures.

Chien-Pai Han: "Dependence of Random Variables." The American Statistician, 25:4, 35. October 1971.

Pierce and Dykstra (1969) have given an example to show that the joint density of a set of n (≥ 3) random variables is not normal and dependent, yet any proper subset is jointly normally distributed and mutually independent. In this note it is shown that this example belongs to a class of random variables whose common univariate marginal density satisfies a certain condition. The condition is derived and two examples are given.

C. Phillip Baumel, W. H. Thompson and **Roy D. Hickman:** "Impact of Transportation Equipment Shortages and Substandard Transportation Service in 1969 on Iowa Country Elevators." Special Report 68, 18 pp., Iowa Agriculture and Home Economics Experiment Station, Ames. December 1971.

Data were collected by mail questionnaires from a sample of elevators to determine the impact of equipment shortages on Iowa country elevators in 1969, when shortages reached serious proportions. The sample elevators were analyzed by geographic location in the state, storage capacity, location from the interstate highway system, and location on railroad lines heavy enough to carry covered-hopper cars.

From the analysis of the responses, it is estimated that 61 percent, or 536, of the total 874 elevators in the state incurred costs from either delay or failure to obtain grain transportation equipment in 1969.

G. Fix and **R. Heiberger:** "An Algorithm for the Ill-Conditioned Generalized Eigenvalue Problem." SIAM Journal of Numerical Analysis, 9:1, 78-88. March 1972.

The spectrum of $Ax - \lambda Bx = 0$ consists of stable and unstable eigenvalues, which undergo, respectively, small and large changes in response to small changes in A and B. The algorithm isolates and accurately computes the eigenspace associated with the stable eigenvalues.

***William G. Hill** (Institute of Animal Genetics, Edinburgh): "Probability of Fixation of Genes in Populations of Variable Size." Theoretical Population Biology, 3:1, 27-40. March 1972. Journal Paper No. J-6601, Iowa Agriculture and Home Economics Experiment Station, Ames, Project 1669. Reprint Series No. 292, Statistical Laboratory, Iowa State University.

A method is derived for computing mean gene frequencies and absorption probabilities in populations of variable size, where the probabilities of transition between the alternative population sizes can be specified. A haploid model is adopted, with two alleles at a single locus undergoing weak selection. The results are approximate, involving the first terms in a matrix series, in which the dimensions of the matrices are the number of alternative sizes the population can take, rather than the total number of population size and gene frequency states in the full model.

A diffusion-equation approximation also is considered, which leads to a very simple formula, which is valid when population sizes and selective values are large but have small coefficients of variation, and when a stationary distribution of population sizes is reached quickly. A model of selective values assuming a normal distribution of fitness is used to illustrate the results.

R. M. Wangen, W. W. Marion and **D. K. Hotchkiss:** "Influence of Age on Total Lipids and Phospholipids of Turkey Muscle." Journal of Food Science, 36, 560-562. 1971. Journal Paper No. J-6722, Iowa

Agriculture and Home Economics Experiment Station, Ames, Project 1696.

The objective of this investigation was to study quantitatively the individual phospholipids in turkey breast and thigh as the animal advanced toward market age. Of equal interest was the fundamental question of the relationship of lipid composition and the rapid rate of oxidative deterioration of turkey.

Proximate analysis data was collected at seven age levels to compare percentages of moisture and lipid in breast and thigh muscle. Further research is needed to determine how muscle lipid composition and subsequent flavor stability in the turkey are affected by the nutrition and physiology of the turkey and the current processing procedures.

*Dean Isaacson: "Continuous Martingales with Discontinuous Margin Distributions." Annals of Mathematical Statistics, 42:6, 2139-2142. December 1971. Reprint Series No. 286, Statistical Laboratory, Iowa State University.

In this paper the author constructs a continuous, nowhere constant, square integrable martingale such that $P\{M(1/2)^k = 0\} \geq 7/8$ for $k \geq 3$. This construction is used to show that in general,

$\lim_{t \to o} \int_o^t \Phi(s)dM(s, \omega)/M(t, \omega) \neq \Phi(0)$ where $\Phi(s)$

is nonrandom and right continuous, $M(t,\omega)$ is a continuous, nowhere constant, square integrable martingale, and the limit is a limit in probability.

Dean Isaacson: "Uniform Integrability of Square Integrable Martingales." Annals of Mathematical Statistics, 43:2, 688-689. April 1972.

Let (M_t, F_t), $t \geq 0$, be a continuous square integrable martingale and let A_t be the natural increasing process in the Doob decomposition of M_t^2. Extending a result of Burgess Davis, it is shown that there exist constants C_1 and C_2 such that

$$C_1 E[\sqrt{A_t}] \leq E[\sup_{s \leq t} |M_s|] \leq C_2 E[\sqrt{A_t}]$$

for all $t > 0$. Now if $A_\infty = \lim_{t \to \infty} A_t$, moment conditions on A_∞ are found which relate to uniform integrability of M_t. In particular, $E[\sqrt{A_\infty}] < \infty$ implies M_t is uniformly integrable which implies $E[A_\infty^{1/\delta}] < \infty$ for all $\delta > 4$.

D. Jowett (University of Wisconsin, Green Bay), R. E. Ford and J. C. Tu: "Statistical Analysis of Some Dilution Assays of Maize Dwarf Mosaic Virus." Phytopathology 62:3, 366-368. March 1972. Journal Paper No. J-6216, Iowa Agriculture and Home Economics Experiment Station, Ames, Projects 101 and 1628.

An established statistical model, based upon the assumption that the number of effective virus particles in an aliquant of infective sap follows a Poisson distribution, is applied to previously published dilution assays of maize dwarf mosaic virus. The model gives good results for the number of virus particles when sap from infected plants is diluted with sap from healthy plants, but not after dilution with water or phosphate buffer unless data from higher concentrations are omitted.

Oscar Kempthorne: "Probability, Statistics and the Knowledge Business." Pp. 470-499 in *Foundations of Statistical Inference,* edited by V. P. Godambe and D. A. Sprott, Holt, Rinehart and Winston of Canada, Limited, Toronto and Montreal. 1971. (Proceedings of the Symposium on the Foundations of Statistical Inference held at the Department of Statistics, University of Waterloo, Ontario, Canada, from March 31 to April 9, 1970.)

The author comments on the disunity and basic disagreements he sees in the statistics profession. He defines five aspects of statistics and discusses probability as a basis for condensation of data, probability as related to an unknown outcome, theories of inference, accept-reject rules, other approaches, data mapping rules to measure strength of evidence and their relevance to data analysis and interpretation. He closes with the view that probability inference in the sense of probabilities of hypotheses is a will-of-the-wisp, in contrast to statistical inference which is used very widely and effectively.

Oscar Kempthorne and Leroy Folks: *Probability, Statistics and Data Analysis.* 555 pp., Iowa State University Press, Ames. 1971.

This introductory text on probability ideas and their role in the interpretation of observational data takes a simplified approach to probability, data handling and the development of innovative ideas on data examination. Requiring only a knowledge of basic calculus and Riemann integration for understanding, it is especially suited for the senior, the first-year graduate student and the researcher.

The authors employ the unusual approach of presenting ideas on the theory of distributions, averages, moments, and the like, as devices for the partial description of real populations, rather than as attributes of probability structures. This very useful mode of thinking about data situations enables the reader to visualize what would be appropriate if he had an indefinitely large amount of data.

Also of special interest is the treatment of statistical inference, a term which Kempthorne and Folks use in a much broader sense than is traditional in statistics. Their discussion of inference, comprising a substantial part of the book, distinguishes between the formation of opinion and decision-making. Final chapters discuss

some applications of the ideas to study of the relationships between variables and data from structured populations.

*Oscar Kempthorne: "The Statistical Treatment of Data with Genetic Structure." Pp. 163-182 in *Cranio-Facial Growth in Man,* edited by Moyers and Krogman, Pergamon Press. 1971. Reprint Series No. 278, Statistical Laboratory, Iowa State University.

In this paper the author indicates some of the general ideas of data manipulation, summarization and condensation which are applicable to data on craniofacial growth. Since the rediscovery of Mendelism, plant and animal breeders have been interested in the assessment of quantitative data which have genetic structure. However a very large portion of present methodology traces back to R. A. Fisher, who was concerned with the question of whether so-called continous variation could be "explained" in terms of genetic and environmental causation. The author discusses the nature and utility of this methodology and compares it with the statistical methodology of categorical or qualitative data, with some reference to the study of craniofacial growth. He discusses also the logical problems of disentangling the roles of heredity and environment.

Oscar Kempthorne: "Theories of Inference and Data Analysis." Pp. 167-191 in *Statistical Papers in Honor of George W. Snedecor,* edited by T. A. Bancroft, Iowa State University Press, Ames. 1972. Journal Paper No. J-6810, Iowa Agriculture and Home Economics Experiment Station, Ames, Project 890.

The development of mathematics has proceeded in a more or less steady fashion for the past 3,000 years. This paper is concerned with another development of human intellectual processes of much more recent origin. The relation of mathematical systems to the real world is not at all necessary and obvious, as can be seen vividly in the mathematical treatment of the infinite. A big question is how correspondence can be established between the world of mathematics and the real world.

In this paper the author traces the recognition of error, the development of learning in the presence of variability, and the role of statistical methods in this development. He points out that for the past 15 years or so the field of statistics has undergone deep controversies. Some workers appear to take the view that statistical methods is utter nonsense and that the people who follow these methods are stupid or have been misled by their proponents. The author recognizes the many deep underlying questions that have not been resolved, and believes there are aspects common to most presentations of statistical methods that may reasonably be questioned. However, he points out that the future of statistical methods lies in the appreciation of the investigator-data interaction process and the implementation of this process by means of the modern computer.

The purpose of this paper is to discuss the history of ideas and to comment on present-day controversies.

*W. J. Kennedy and T. A. Bancroft: "Model Building for Prediction in Regression Based Upon Repeated Significance Tests." Annals of Mathematical Statistics, 42:4, 1273-1284. August 1971. Reprint Series No. 280, Statistical Laboratory, Iowa State University.

Research reported in this paper is concerned with two model building procedures: Forward Selection and Sequential Deletion. These are considered for use in model building when the experimenter believes that the usual error assumptions are appropriate in his full regression model, however he feels that many of the independent variates will be of no real value in a predictor of the predictand y.

The objectives of this study are: 1) to provide a means for examining, with respect to bias and mean square error of predictand, the consequences of using the two model building procedures; 2) to give a summary of the results obtained in a numerical study of the efficiency of the two procedures relative to one another and to the procedure wherein all independent variates are retained; 3) to recommend, based upon the results of the numerical study, significance levels for use in model building in various circumstances.

*Glen Meeden: "Some Admissible Empirical Bayes Procedures." Annals of Mathematical Statistics, 43:1, 96-101. February 1972. Reprint Series No. 289, Statistical Laboratory, Iowa State University.

In this paper the author considers some empirical Bayes procedures which have been discussed by H. Robbins, E. Samuel and M. V. Johns. These procedures are shown to be inadmissible relative to a class of priors. By using some of the results of Rolph (1968), admissible procedures are found for two examples.

*Ahmed Zogo Memon (West Pakistan Agricultural University, Lyallpur) and Masashi Okamoto: "Asymptotic Expansion of the Distribution of the Z Statistic in Discriminant Analysis." Journal of Multivariate Analysis, 1:3, 294-307. September 1971. Reprint Series No. 282, Statistical Laboratory, Iowa State University.

This paper deals with the classification statistic Z due to John (1960), which is a competitor to the Anderson statistic W in discriminant analysis with two multivariate normal populations. An asymptotic expansion of the distribution of Z as well as the associated probability of misclassification with respect to the three numbers of degrees of freedom is given. Some coeffi-

cients in the expansion for the latter are computed numerically and compared with those for W, which Okamoto gave before.

*Edward Pollak and Oscar Kempthorne: "Malthusian Parameters in Genetic Populations, Part II. Random Mating Populations in Infinite Habitats." Theoretical Population Biology 2:4, 357-390. December 1971. Journal Paper No. J-6745, Iowa Agriculture and Home Economics Experiment Station, Ames, Project 1669. Reprint Series No. 285, Statistical Laboratory, Iowa State University.

In this paper the authors develop ideas presented in a previous paper on the dynamics of haploid genetic populations in an infinite habitat. A brief review of necessary ideas and a discussion of a concept of value for haploid populations are given. A general model for a diploid population, which incorporates life tables, mating of individuals, and fecundities is presented and general recursive relationships for frequencies of genetic types developed. Because of its intractability, special cases are then considered in which there is equal fecundity of all matings in the population of matings that occurs.

It is found that in some cases the numbers of the various types increase asymptotically at geometric rates, so that each type may be said to have a Malthusian parameter. It is then found that a version of Fisher's Fundamental Theorem holds, in that the asymptotic rate of increase of the average Malthusian parameter is equal to the genotypic variance in this parameter. Additionally, the Malthusian parameters are found to be additive. It does not seem possible, however, to extend the concept of value to diploid mating populations.

*Edward Pollak: "On Survival Probabilities and Extinction Times for Some Branching Processes." Journal of Applied Probability, 8, 633-654. 1971. Journal Paper No. J-6666, Iowa Agriculture and Home Economics Experiment Station, Ames, Project 1669. Reprint Series No. 291, Iowa State University.

In this paper the author considers branching processes for which the first three moments of the distribution of offspring exist. Let $f(t)$ and z be, respectively, the generating function of the distribution of offspring and the smallest positive root of the equation $f(t) = t$. Then if $M = f'(z)$ and $f_n(t)$ is equal to the generating function of the distribution of n th generation descendants of a single individual, it is known that, quite generally, $(z - f_n(O))/M^n$ tends toward a constant as n increases.

A method is derived for obtaining upper and lower bounds for this constant, which gives an exact solution when there is a geometric distribution of offspring and good bounds when there are Poisson or negative binomial offspring distributions. With some further calculations, one can also obtain finite upper and lower bounds for the mean time to extinction of a line descended from an individual, given there is extinction. These bounds apply even if z is less than 1. Numerical values are given for the Poisson and negative binomial cases.

*N. Sedransk (University of Wisconsin, Madison) and Masashi Okamoto: "Estimation of the Probabilities of Misclassification for a Linear Discriminant Function in the Univariate Normal Case." Annals of the Institute of Statistical Mathematics, 23:3, 419-435. 1971. Reprint Series No. 290, Statistical Laboratory, Iowa State University.

The probability of misclassification inherent in the use of a linear discriminant function is not necessarily known to the experimenter using such a function. Various estimators calculated from the sample used to generate the sample discriminant function have been proposed.

The purpose of this paper is to evaluate and to compare several of these estimators using unconditional mean square error as the criterion. Discussion is restricted to the case where each of the distributions is univariate normal with common variance.

Jati K. Sengupta and Gerhard Tintner: "A Review of Stochastic Linear Programming." Review of the International Statistical Institute, 39:2, 197-223. 1971.

The authors discuss several operationally important methods for the solution of stochastic linear programming problems in the framework of the general theory of chance-constrained linear programming. The methods of programming under risk include discussions and critical appraisal of a number of areas concerning, for example, the sensitivity of the parameters, the distribution of optimal profits, the reliability of the system of chance-constrained linear programming and the use of nonparametric methods in stochastic programming.

Jati K. Sengupta and Gene Gruver: "Chance-Constrained Linear Programming Under Truncation and Varying Sample Sizes." Swedish Journal of Economics, 184-203. 1971.

The effects of truncation and varying sample sizes on optimal profits are investigated for linear programming problems, where either the coefficients of the objective function or the elements of the resource vector are assumed to be normally distributed and chance-constrained. An economic application to a crop-mix problem is considered for illustrating the various implications of the problem.

Jati K. Sengupta: "A System Reliability Approach to Linear Programming." Unternehmensforschung 15, 112-129. 1971.

A system reliability approach to linear programming is developed for the case when the restrictions are chance-constrained. Methods of characterizing a system reliability measure for a linear programming system, its implications under alternative probability distribution assumptions and its uses for specifying policies with an improved system reliability routine are analytically discussed.

Jati K. Sengupta: "Foundations of a Dynamic Theory of Economic Growth." Kyklos, XXIV:3, 546-556. 1971.

In this paper the author discusses *Theory of Economic Growth* by Michio Morishima, which he considers a fundamental contribution. The specific conditions required for a series of short run equilibria starting from a historically given capital-labor endowment to approach the state of long-run persistent growth equilibrium are discussed, in the framework of neoclassical and Keynesian economies. The author analyses the detailed bases of working of a multi-sector, multi-process general equilibrium model of growth dynamics, which is derived in large measure by extending the celebrated Von Neumann model in several realistic directions, most of which are Morishima's own contributions. He discusses the relationships existing between the different variants of the "turnpike theorems", e.g., the production turnpike and the consumption turnpike, and examines the cases where oscillations and cyclic exceptions may persist.

Gerhard Tintner and **Jati K. Sengupta:** *Stochastic Economics: Stochastic Processes, Control and Programming.* 315 pp., Academic Press, New York. 1972.

This book presents a balanced treatment of several operational aspects of economics from a stochastic point of view. Its unifying theme is the integration of stochastic methods with specification of the deterministic parts —particularly when decision rules and economic policies are to be evaluated.

The book stresses those operational aspects of the stochastic framework that are applicable to economic and other empirical models. Because it emphasizes methods rather than theory, it is flexible enough to be used in any field dealing with methods for applying stochastic processes, control and programming. Specifically, it includes several results and concepts arising from the authors' own research, and reports original results in the areas of 1) the specification and estimation of stochastic process models in economic growth, 2) the theory of stochastic control applicable to resource allocation problems in economics, and 3) the use of several operational methods of probablistic programming.

This book will be of value to mathematical economists, econometricians, management scientists, and economic statisticians. Areas of particular interest to the economist include implications of alternative decision rules under different stochastic schemes, and various methods of analyzing the risk elements and the stability implications of deterministic models under alternative stochastic generating schemes. Topics of interest to the mathematician and the operations researcher include empirical and computational problems of applications in the treatment of evolutionary times series, the use of nonparametric methods in stochastic process models in economic growth, and the problems of specification in economic models.

***Vince A. Sposito** and **H. T. David:** "Saddle-Point Optimality Criteria of Nonlinear Programming Problems Over Cones Without Differentiability." SIAM Journal of Applied Mathematics, 20:4, 698-702. 1971. Reprint Series No. 279, Statistical Laboratory, Iowa State University.

The authors consider Kuhn-Tucker duality without differentiability conditions for the types of domains recently treated in the literature in which the two orthants of the classical Kuhn-Tucker theory are replaced by a convex cone L and a set C that is typically, but not necessarily, convex. A natural modification of the Slater condition, in addition to the convexity of a certain auxiliary set, yields sufficiency of the constrained optimization problem for the associated saddle-point problem. No conditions are required for the converse.

***B. V. Sukhatme** and **Victor K. T. Tang** (Humboldt State College, Arcata, California): "Allocation in Stratified Sampling Based on Preliminary Test of Significance." Proceedings of the Social Statistics Section, American Statistical Association, 1970. Reprint Series No. 272, Statistical Laboratory, Iowa State University.

A two-phase sampling procedure based on preliminary test of significance has been proposed to allocate sample sizes to the different strata. This paper considers in detail the procedure and investigates its efficiency with respect to the current procedures not based on preliminary test of significance.

G. R. Seth, **B. V. Sukhatme** and A. H. Manwani: "Sample Surveys on Mango and Guava in Uttar Pradesh." I.C.A.R. Report, New Delhi.

The report describes Indian surveys carried out with special reference to 1) design of the survey, 2) type of data collected, 3) organization of field work, 4) analysis of the data collected, and 5) feasibility of carrying out large-scale surveys on such crops.

***M. S. Avadhani** and **B. V. Sukhatme:** "Estimation in Sampling on Two Successive Occasions." Statistica Neerlandica, 26:2, 1972. Reprint Series No. 293, Statistical Laboratory, Iowa State University.

For estimating the mean of a finite population on the second of two successive occasions from a simple random sample, the authors have proposed elsewhere an estimate which utilizes the data obtained from the sample on the first occasion as ancillary information. In this paper it is shown that this estimate is more efficient than the one similar to that of Pathak and Rao in all situations where the well-known ratio estimate in simple random sampling is no less efficient than the usual regression estimate or the Rao-Hartley-Cochran estimate in sampling with varying probabilities and without replacement.

Kirk E. Farnsworth, Edwin C. Lewis and **James A. Walsh:** "Counseling Outcome Criteria and the Question of Dimensionality." Journal of Clinical Psychology, XXVII:1, 143-145. 1971.

The inability to demonstrate a conclusively positive effect of helping relationships has resulted from, among other methodological problems, inadequate criterion development. An appropriate way to develop relevant criteria is to ask counselors what criteria to use and how to apply them to the general run of clients.

In this study responses were obtained from 107 counselors to a 108-item inventory of client changes designed with relevant criterion issues as a guideline. Following a reduction to 51 items, a principal components factor analysis and varimax rotation extracted six factors.

While the criteria were found to be multidimensional, it was suggested that development of a multiple criterion measure should await replication of the present study, with certain modifications.

Ezra Stotland, Stanley E. Sherman and Kelly G. Shaver, in collaboration with R. Crawford, J. Buss, R. Dunn, P. Johnsen, M. Murray, **J. Walsh** and K. Weigel: *Empathy and Birth Order: Some Experimental Explorations.* 198 pp., University of Nebraska Press, Lincoln. 1971.

This first systematic, large-scale experimental investigation of empathy focuses on birth order as a primary determinant of which interpersonal and motivational conditions will lead a person to empathize with the emotions of another. Empathy is defined as a state of emotional arousal and is measured both physiologically and subjectively. A person's ordinal position is employed as an index of his social schemas—cognitive structures about people in certain situations—the schemas in turn partly determine when he will empathize. The studies' results have important implications for many areas of psychology and sociology and offer valuable leads for further investigation.

George Beal, **Richard Warren** and David Duncan: "Life Experiences May Foretell Managerial Success." News for Farmer Cooperatives, 38:4, 3-6. July 1971. Journal Paper No. J-6908, Iowa Agriculture and Home Economics Experiment Station, Ames, Project 1626.

The primary focus of this report is on the relationship of interview responses given by 98 co-op managers to their performance and to the economic success of their cooperatives.

Findings are discussed in four sections: childhood and teenage experiences, job experiences, general perceptions, and self-concept and related behavioral traits. Relationships between life-history factors and two measures of success are presented.

Management performance, the first measure of success, was measured by responses of managers to a series of questions about how they performed their jobs. Responses were scored by a panel of judges at Iowa State University. The second measure of success was determined by combining the ratios of net savings to fixed assets and to sales.

George Beal, **Richard Warren** and David Duncan: "Training, Knowledge, Experience—How They Relate to Managerial Success." News for Farmer Cooperatives, 38:6, 3-6, September 1971.

This is the second of a series of reports on the results of interviews with 98 co-op managers. Findings reported in this article are discussed in five sections: education and training, knowledge, experience, the interrelation of these areas, and causal relationships.

The findings discussed in the first three sections involve direct relationships between a number of predictor variables and measures of managerial success. As is indicated in the causal relationships, variables that have no apparent direct relationship to managerial success frequently affect success indirectly.

Richard Warren and George M. Beal: "How Attitudes Affect Managerial Success." News for Farmer Cooperatives, 38:8, 3-5. November 1971.

Findings reported in this article, the third of a series resulting from interviews with 98 co-op managers, concern the relationship of attitudes and perceptions to managerial performance, cooperative success, experience and training. Only a few of the attitude scales were directly related to both managerial performance and economic success measures. However, a number of attitudes were related to education, training and knowledge which are all reasonably good predictors of managerial performance.

Charles L. Mulford, Gerald E. Klonglan and **Richard D. Warren:** "Socialization, Communication and Role Performance." The Sociological Quarterly, 13, 74-80. Winter 1972. Journal Paper No. J-6889, Iowa Agriculture and Home Economics Experiment Station, Ames, Project 1754.

This paper reports on a research project designed to test the hypothesis of Etzioni (1961) involving socialization, communication and role performance. The data indicate both socialization and communication are significantly associated with role performance. Communication continues to affect role performance to a significant degree regardless of the degree of initial socialization experienced. These data do not support Etzioni's hypothesis.

Gerald E. Klonglan, **Richard D. Warren** and Judy M. Winkelpleck: "Study on Cigarette Smoking." Iowa PTA Bulletin, 72:1, 2. January 1972.

Gerald E. Klonglan, **Richard D. Warren** and Judy M. Winkelpleck: "Cigarette Smoking and the Role of Dentists." Iowa Dental Journal, 58:1, 43-44. February 1972.

Gerald E. Klonglan, **Richard D. Warren** and Judy M. Winkelpleck: "Cigarette Smoking and Physician-Patient Interaction." Journal of the Iowa Medical Society, 62:3, 133-135. March 1972.

These three papers report on a recently completed Iowa State University study on the smoking behavior, knowledge and attitudes of individuals, and on the participation and effectiveness of organizations in programs directed at reducing cigarette smoking. The research project provided data for organizations which seek to develop intervention programs designed to reduce or stop cigarette smoking. These papers report attitudes toward the Congress of Parents and Teachers, the Iowa Dental Association and the Iowa Medical Society as discovered by responses to questions about the two statistics is the subject of this paper. Only the simplest cases are considered so that the more basic inferential problems may be examined.

A procedure is developed and illustrated which uses efficient computational procedures and modern computer software and hardware together with generally known statistical theory. For rather moderate expenditure of time and money an experimenter or data analyst can obtain precise and detailed information, both graphical and numerical, about the test he is using or contemplating. The specific examples studied have illustrated the power and flexibility of the procedure devised and have shown that there are definite and regular differences between the behavior of the two tests when N is small, and that neither dominates the other.

Letters

Barry C. Arnold. Zero Correlation and Independence. The American Statistician, 25:4, 53. October 1971.

C. P. Cox. Regression through the Origin. The American Statistician, 25:3, 56. 1971.

C. P. Cox. Notation for Nested Models. The American Statistician, 26:1, 48. February 1972.

Book Reviews

James A. Walsh: Review of *Statistics: Probability, Inference and Decision, Volumes I and II* by Hays and Winkler. Educational and Psychological Measurement, 31, 310-312. 1971.

Richard D. Warren: Review of *The Application of Psychophysical Scaling Techniques to Measurement of Political Variables* by Allen Mayhew Shinn, Jr. American Sociological Review, 36:6, 1139-1140. December 1971.

ABSTRACTS OF THESES

a, domain b, and domain ab respectively. It is assumed that the frame sizes, N_A and N_B, are known. It is further assumed that simple random sample sizes of n_A and n_B are selected from frames A and B respectively.

Estimators are developed for two cases: domain sizes, N_a, N_{ab}, and N_b, known and unknown. When the domain sizes are known, it is shown that the estimator $\hat{Y}_d = N_a\bar{y}_a + N_{ab}\bar{y}_{ab} + N_b\bar{y}_b$ (where $\bar{y}_a$ is the mean of sample elements in domain a, $\bar{y}_{ab}$ is the mean of the distinct units in the sample in domain ab and $\bar{y}_b$ is the mean of sample elements in domain b) is the most efficient of the estimators considered when costs are ignored. Since $\hat{Y}_d$ is a function of the distinct elements included in the sample, its use requires the identification of duplicated elements. Therefore the cost structures that would lead one to choose an alternative estimator are investigated.

Estimators of N_{ab} are developed for the case of unknown domain sizes. Estimators of N_{ab} with bias of smaller order and smaller mean square error than those estimators appearing in the literature are presented. Estimators of N_{ab} are developed for the two cases: duplicated elements identified and duplicated elements not identified. The estimators of N_{ab} are then utilized in estimators of the total, Y. These estimators of the total are shown to be more efficient than previously suggested estimators.

The allocation of the sample to domains to minimize the variance of the suggested estimators of Y subject to a cost constraint is investigated.

Robert Wayne Centner: "Explicit Solutions for a Certain Class of Linear Programming Models." M.S. thesis. Iowa State University Library. August 1971.

The interval linear program IP (a, b, c, A): maximize (c, x), subject to $a \leq Ax \leq b$, recently has been solved explicitly in the feasible bounded case with A of full row rank by Ben-Israel and Charnes (1968). The explicit solution, explicit in the sense that $A^{-1}b$ is an explicit solution of $Ax = b$, has obvious theoretical (and possibly computational) advantages over the well-known iterative methods of linear programming.

In this thesis two linear programs are considered: (LP) maximize (c, x), subject to $Ax \leq b$; and its dual program (DLP) minimize (b, y), subject to $A^ty = c$, $y \geq 0$. Explicit solutions are obtained for both. In particular, three separate computational solution methods are provided for the cases A of full row rank, A full column rank and A of arbitrary rank. The explicit representations of optimal solutions require only a generalized inverse T, $T \in \{ T | A\,T\,A = A \}$ rather than the Moore-Penrose generalized inverse.

A consistent formalism is presented, leading from mathematical derivations to concrete applications. The explicit solution methods are applied to the m x n matrix games associate with two-person zero-sum game theory. The orthogonality condition $b \perp N(A^t)$ is violated when non-essential strategies are present; but the solution methods are ideally suited for the % matrix games containing only essential strategies.

When the transportation problem is investigated, it is found that the condition $b \perp N(A^t)$ determines a set of solvable problems. The tableau for a given arbitrary m-source, n-destination problem is independent of the particular supply, demand and cost requirements so that a "tables book" procedure for explicit solution of transportation problems is conceivable.

Richard Lavern Chamberlain: "The Non-Orthogonal Analysis of Variance." Ph.D. thesis. Iowa State University Library. February 1972.

The problem of analyzing arbitrary experimental arrangements using the linear model $y = X\beta + \epsilon$, where y is an n x 1 vector of observations, X is an n x p model matrix, β is a p x 1 vector of parameters, and ϵ is a vector random variable with mean zero and variance $\sigma^2 I$, is discussed in some detail.

Complex questions concerning linearly estimable functions are examined. The vector space generated by the columns of X, generally referred to as the estimation space, is partitioned into disjoint and sometimes orthogonal subspaces. These subspaces characterize the best linear unbiased estimates of linearly estimable functions. Distances in these subspaces are used to calculate sums of squares for an analysis of variance table. Information on the estimability of certain linear functions of the parameters determines the hypotheses to test.

The arbitrary experimental design with two factors is examined in detail; results are extended to experiments involving several factors. Some projection operators are defined and then used to construct the proper subspaces of the estimation.

Finally, some computational procedures suitable for programming on a high speed computer are described, including procedures for determining whether or not a predefined function of the parameters is estimable.

It is kept in mind that the experimenter is interested in a particular coordinate system. Though coordinate free approaches are elegant in many respects, they often fail to give results demanded by the experimenter.

Isidoro Pineda David: "Contributions to Ratio Method of Estimation." Ph.D. thesis. Iowa State University Library. August 1971.

In this thesis a different approach to the usual method of obtaining approximations to the bias and MSE of the ratio estimator $\bar{R}_n = \bar{y}_n/\bar{x}_n$ of the population ratio $\bar{R}_N = \bar{y}_N/\bar{x}_N$ is presented, justifying the use of the usual approximations to the bias and MSE of

$\bar{R}_n$. This approach is applied to other ratio-type estimators. Bounds to the error incurred in the use of such approximations are given.

In stratified sampling, an approximately unbiased combined ratio-type estimator analogous to Tin's modified estimator is given. A combined-type analogue of the Hartley-Ross unbiased ratio-type estimator is presented and its exact variance is derived. In all, eight different ratio-type estimators, four of the separate type and four of the combined type, are discussed and compared on the basis of their MSE's to terms of order n_1^{-2}. Some numerical comparisons using nine pairs of variables from the 1959 and 1964 censuses of agriculture for Iowa also are included. A surprising result is that in some instances, combined ratio-type estimators are more efficient than their separate counterparts. In general, it seems that the Lahiri-type unbiased ratio estimators are more efficient than the other ratio-type estimators considered.

Gauri Lall Ghai: "Analysis of Some Nonrandom Mating Models." Ph.D. thesis. Iowa State University Library. November 1971.

This research deals with the effect of nonrandom mating due to (a) partial inbreeding, and (b) partial assortative mating, on various statistical properties of a population. The mathematical theory is developed assuming that the population is large enough so that fluctuations due to sampling can be ignored, and that there are no fertility or viability differences.

Theoretical models have been developed for one autosomal locus for populations practicing a mixture of breeding systems. These include mixed random mating and (1) selfing, (2) full- and half-sib mating, (3) parent-offspring mating, (4) double first cousin mating, and (5) a general mixture of consanguineous mating systems. The system of mixed random mating and selfing is examined in great detail. The results in this case are extended to several unlinked loci with multiple alleles.

For each system of mating, the genotypic distributions at any given time and at equilibrium are determined in terms of the initial frequencies and the parameter of partial inbreeding. The effects of such systems on the genotypic mean and variance also are discussed. An important result is the considerable amount of heterozygosity at equilibrium that these systems can maintain in predominantly inbred populations. The level of heterozygosity depends upon the system of mixed mating, amount of inbreeding, and the initial heterozygosity. The relative effects of different systems of mixed mating on the maintenance of heterozygosity at equilibrium are discussed.

A few asymmetric models of assortative mating are analyzed for an autosomal trait controlled by a single locus, possibly with multiple alleles. The analysis is confined to the case in which preference for mating is exercised by the individuals of one sex only. It is assumed that males possess unlimited fertility. The dynamics of the population and its equilibrium distribution are discussed. The gene frequency usually changes with time and the equilibrium distribution depends only on the assortment parameters. Some results for a two-loci model with complete positive assortative mating also are presented. It is shown that, in general, an equilibrium population will have three homozygous genotypes instead of only two homozygous types, as is usually thought.

Leon Jordan Filho: "Bias and Mean Square Error in Experimental Designs." Ph.D. thesis. Iowa State University Library. August 1971.

In the first part of this thesis least squares polynomial fitting is considered, and the so-called minimax bias designs are obtained which minimize the maximum of the $(\text{bias})^2$ function over the interval of interest when a polynomial of degree s is fitted and the true underlying model has degree s+1. It is also shown that when the difference between the degree of the fitted model and the true polynomial is bigger than one, this problem has no solution independent of the parameters deleted from the model fitted.

Next min-average bias estimable designs were obtained. These designs minimize the average square bias and allow its estimation in situations when the experimenter decides to fit a polynomial of lower degree than the true model. It is also shown that the variance and $(\text{bias})^2$ functions of the designs optimal with respect to the average square bias criterion have bias and variance functions which assume very large values in the extreme portions of the interval. Optimal designs are obtained with respect to the average square bias weighted with a positive function with finite moments. For the case where the weight function is a beta, gamma, or normal density function, the optimal designs when a polynomial of degree s is fitted and the true underlying model has degree s+1, place the observations at the zeros of a Jacobi, Laguerre and Hermite polynomial of degree s+1 respectively. For the case of the Chebyshev weight equal allocation at the zeros of a Chebyshev polynomial of degree $n \geq [(s + t + 1)/2]$ is optimal when the polynomial fitted has degree s and the true underlying model has degree t, with $t > s$. It is shown that the class of optimal designs so weighted and the minimax bias designs are the same. Comparisons between these designs and designs available in the literature indicate that designs optimal with respect to bias are also efficient with respect to variance, but not vice versa. It is also concluded that of the designs studied, minimax bias designs are preferable in situations involving both bias and variance error.

The case where the independent variable is a linear function of qualitative factors is then considered for the case when well defined fractions of the treatment com-

binations are chosen at random with the purpose of estimating response at all the points in the factorial system. Random star designs for the estimation of main effects and random fractional replication designs are introduced and their bias and variance properties studied in detail. General forms for the average mean square error of these two classes of designs were obtained in a simple form involving the variance of observation and sums of squares of appropriate effects and interactions of the factorial system.

Joan Keller: "Comparison of Model Building Procedures with Measurement Error Present." M.S. thesis. Iowa State University Library. May 1972.

Three procedures of data manipulation with respect to model building and estimation are compared. The first procedure constructs and estimates the final model from the same set of data. The other two procedures each divide the given data into two distinct subsets, splitting the measures in one case and splitting the sample in the other. The respective models are built from the first subset and estimated from the second subset. An empirical analysis in terms of multiple linear regression is included, using sociological data.

Random measurement error is assumed to be present in the models; thus three methods of analysis are also examined. The first method, using least squares, ignores the presence of measurement error. The other two methods: correction for attenuation and the classical errors-in-variables approach, make corrections for this presence of error. Relative efficiency was chosen as the criterion for comparing the methods of analysis and the procedures of data manipulation. Empirical, as well as theoretical, results are included.

John James Kinney: "Multivariate and Generalized Polykays in Statistical Structures." Ph.D. thesis. Iowa State University Library. August 1971.

A new method, which utilizes the cumulant properties of polykays, is given for the expression of univariate polykays in terms of Fisher's univariate k statistics. The method is thought to be more efficient than that previously proposed by Wishart, and many heretofore unrecorded formulas are derived. New proofs of the properties of randomized sums are given and these serve to connect the properties, first shown by Tukey, with the other work which has been done on Fisher's k statistics.

In the multivariate case, a symbolic method is developed for deriving multivariate results from univariate ones. Expressions for multivariate k statistics through weight 5 in terms of multivariate sums are presented. In addition, bivariate bracket functions through weight 4 are expressed in terms of multivariate k statistics. Bivariate polykays through weight 8 are given in terms of bivariate k statistics.

Techniques developed for the polykays are applied to the determination of moment characteristics of statistics arising in considerations of normality. In particular the first four moments of two statistics arising when considering several samples chosen from homoscedastic normal populations with possibly different means are computed. In the bivariate normal case an unbiased estimate of the generalized variance and its variance are found.

The Σ quantities, which are equivalent to generalized polykays, and which have been characterized by Wilk and Zyskind, are shown to be related to the population structure with which they are connected by a series of matrix products for structures which are described as unitary. Non-unitary structures are defined and characterizations of them made in terms of matrix products.

Richard William Madsen: "Asymptotic Properties of Superpositions of Non-negative Kernels." Ph.D. thesis. Iowa State University Library. August 1971.

This thesis is a study of weakly and strongly ergodic behavior for stochastic and non-negative kernels. Different kinds of ergodic behavior are studied using, in many cases, the ergodic coefficient for stochastic kernels as defined by Dobrushin in 1956. The ergodic coefficient is useful in subsequent chapters because the non-negative kernels can be transformed into stochastic kernels. This technique allows the author to generalize some of the results on ergodic behavior of non-negative kernels that are contained in Patricia Conn's Ph.D. thesis (1969).

In the case of non-negative kernels the function $f_n(y)$ is defined to be $f_n(y) = f_0 M_1 \ldots M_n$, where $f_0(y) \geq 0$ and $\int f_0 d\mu < \infty$. The behavior of the sequence $\{f^*_n(y)\}$ is studied, which is the sequence $\{f_n(y)\}$ suitably normalized. Sufficient conditions are found for both weakly and strongly ergodic behavior. The behavior in both the L_1 sense and in the pointwise sense is studied. Some, but not all, of the sufficient conditions involve right or left eigenfunctions. Conditions on the right or left eigenfunctions can be used to show weakly or strongly ergodic behavior holds respectively. It is not too surprising that when the strongly ergodic behavior holds, the sequence $\{f^*_n(y)\}$ tends to the limit of the left eigenfunctions of the kernels $\{M_n(x, y)\}$.

Finally, applications are given to random walks with absorbing barriers and to generalized sequential probability ratio tests looked upon as random walks with possibly changing absorbing barriers. When one considers a stochastic matrix or stochastic kernel restricted to the non-absorbing states or regions, one has a matrix or a kernel of the type studied in previous chapters. The functions $\{f^*_n(y)\}$ can be thought of as the probability distribution over the non-absorbing states, assuming absorption has not yet taken place.

Roger Joseph Mrachek: "Some Statistical Aspects of Clustering Procedures." M.S. thesis. Iowa State University Library. February 1972.

The purpose of this thesis was to develop criteria for determining the presence or absence of structure in a data matrix. A stochastic model for clustering procedures and two approximate tests of structure have been proposed. One test is based on distributional assumptions and the other uses jackknife procedures.

It was observed that the grouping ability of a clustering procedure is adversely affected by noninformative variables. Thus the researcher should be selective in the variables that he measures or a cluster analysis might produce poor results.

Nimmagadda Sadasiva Murthy: "Ratio Estimates in Multi-Stage Sampling." M.S. thesis. Iowa State University Library. August 1971.

In this thesis several ratio-type estimates and almost unbiased ratio-type estimates of the population mean are considered, using one or more auxiliary variables in multi-stage double sampling design.

Using information on one auxiliary variable, the classical ratio-estimate of the population mean is corrected for its bias to the first order of approximation to obtain an almost unbiased estimate.

Using information on two auxiliary variables, two estimates: Olkin's type estimate and a new estimate denoted as "chain type estimate", are considered. The chain type estimate is used when information on the auxiliary variables is not uniformly available at all stages in a multi-stage design. Two almost unbiased estimates are obtained after correcting for the bias to the first order approximation in Olkin's type and chain type estimates. Further, the mean square error of the adjusted estimate is equal to the mean square error of the unadjusted estimate when the contribution of the terms of order greater than or equal to $1/n^2$ (where n is the size of the sample) is small.

The different estimates obtained are compared for efficiency among themselves and with the classical ratio-estimate, using no auxiliary variable.

James Raymond Veale: "Inference Procedures for Gamma Populations when Spurious Observations May Be Present." Ph.D. thesis. Iowa State University Library. May 1972.

Only recently have statisticians begun to study the effect of the utilization of procedures rejecting outliers and spurious observations on subsequent inferences concerning parameters of interest.

In this dissertation three models which incorporate spurious observations are considered: the "unidentified" model, the "identified" model, and the "generalized identified" model.

The hypothesis testing problem was focused upon in the unidentified case, and considered in the identified case. In both the identified case and the generalized identified case, various estimators of σ (expected life) are considered. The preliminary test (sometimes pool) estimators dominate (m. s. e.) in the identified case and perform quite well in the generalized identified case. In the identified case a test incorporating a preliminary (UMP unbiased) test of H_0: $k = 1$ is found (for $n = 2$) to be generally less powerful than the likelihood ratio test.

An important by-product of these results is an improved procedure (which incorporates repeated significance tests) for estimation of variance components in the analysis of variance for many commonly used experimental design models.

Milton Eugene Winger: "Aspects of Functional Iteration." Ph.D. thesis. Iowa State University Library. May 1972.

Definitions, concepts and examples pertaining to iteration of real transformations having domain and range in R_n are presented, with some emphasis on R_1. Successive scaling of the functional argument to achieve convergence under iteration for a class of functions having a "repulsive" fixed point is used.

Iteration of probability generating functions in simple branching processes, after suitable scaling, yields a relation between probability generating functions and moment generating functions along with a continuous extension.

A real variable theorem is developed displaying certain results for the limit function when various conditions are imposed on the function being iterated. An application of the theorem involves the iterated maximin functions used in stochastic game theory. The limit function of iterates of the maximin function having properly scaled arguments is determined to have its first derivative at zero equal to unity.

Classical results with iteration of analytic functions of a complex variable are specialized to R_1 to provide an alternate approach to characterizing limit functions of iterates of certain probability-related functions.

Bound functions that are readily expressible in closed form under successive iteration are used to show almost sure convergence of the iterated median and iterated maximin. It is seen that they converge to the fixed points in (0, 1) of their respective distributions. The topic of non-stationary iteration is briefly examined.

To extend results to R_n, the concept of an approximate inverse is introduced and illustrated. This concept removes the restriction of scaling with inverse matrices of nonsingular differential matrices only.

It is shown that the successive powers of a certain matrix correspond to successive iterates of a multivariate linear fractional transformation.

Use of the differential matrix as a scaling device to obtain results in R_n analogous to those obtained in R_1 is exploited and several theorems related to this approach are given, imposing various restrictions on the matrices. Multitype branching processes are used as an example in this connection.

Bivariate bound maps are suggested as an R_2 analog of the bound functions employed in R_1.

PAPERS AND SPEECHES

This is a record of papers and speeches presented at scientific and professional meetings by Statistical Laboratory staff members. Many of these papers will be published. In cases where abstracts already have been published, references are given.

Seminars July 12-13 at Stanford University:

G. L. Ghai: "Quantitative Genetics Theory with Respect to Partial Inbreeding;"
Oscar Kempthorne: "Review of the Theory of Quantitative Genetics;" and
Edward Pollak: "Theory of Qualitative Truncation Selection."

Statistical Society Meetings August 22-26 at Colorado State University:

T. A. Bancroft: "Service Courses at Iowa State;" and
G. Nicholas Lauer II and **Chien-Pai Han:** "Power of Cochran's Test in Behrens-Fisher Problems," abstract 131-32, Annals of Mathematical Statistics, 42:6, 2167, December 1971.

Statistical Society Meetings April 26-28 at Iowa State University:

Barry C. Arnold: "Some Examples of Improved Estimates which Incorporate a Preliminary Test;"
C. Philip Cox and **Chien-Pai Han:** "Hypothesis Testing for the Correlation Coefficients of Particular Bivariate Normal Distributions;"
D. L. Isaacson: "On a Subclass of Square Integrable Martingales;"
Leon Jordan and **Oscar Kempthorne:** "Random Star Designs;"
Oscar Kempthorne: "Science, Statistics and Society;" and
G. D. Meeden: "Bayes Estimation of the Mixing Distribution, the Discrete Case."

T. A. Bancroft: "A Closer Examination of Rewards which a Statistician May Expect," and "The Two Faces of Statistics," at the NSF-sponsored 1971 Summer Institute in Statistics for Teachers of College Mathematics, July 14-15 at the University of Iowa;
"Some Recent Advances in Inference Procedures Using Preliminary Tests of Significance," a seminar in November at the University of Manitoba; and
"The Statistical Community and the Protection of Privacy," April 6 at Indiana University.

Susan Alice Brown: "Communications Accountability" March 18 during a regional meeting of the national professional society for women in journalism and communications at the University of Texas.

H. T. David (as a visiting lecturer in the NSF-funded program sponsored jointly by the principal U. S. statistical organizations): "What Is Statistics?" at Minot State College, January 26; Cornell College March 20 and Coe College March 21;
"Applications of Statistics in Engineering" at North Dakota State University January 27;
"What Is Game Theory?" at the University of North Dakota January 28, Cornell College March 20 and Knox College March 22;
"Mathematical Programming and Statistics" and "Sequential Decision Making" at Knox College March 23.

Wayne Fuller: "Simple Estimators for the Mean of Skewed Populations," a seminar October 28 at the University of Manitoba;
"Properties of Some Estimators for the Errors-in-Variables-Model," at a meeting of the Econometrics Society December 25-31 in New Orleans;
"Transformations for Correlated Error Models," a seminar April 14 at North Carolina State University; and
"Regression Estimation in Correlated Error Models," a seminar May 12 at CEINES, Santiago, Chile.

Jon Geadelmann: "Plant Genetics Research," a seminar for the Department of Agronomy and Plant Genetics at the University of Minnesota, September 30.
Richard Groeneveld: "Rural to Urban Transition in Iowa," at an NSF-sponsored short course on Operations Research March 9-10 in Chicago.
Richard Heiberger: "Extensions to ANOVA: Fitting Unequal Cell Variances," at a colloquium for the Department of Statistics, Harvard University, March 31.
Oscar Kempthorne: "Heredity and Environment" at a Data Analysis Seminar July 23-31 at Colorado State University; and
"Sampling a Multidimensional Lattice" and "Experimentation in the Social Sciences," seminars March 13-15 at the University of Michigan.

William Warde: "Simple Linear Regression with Inequality Constraints," a seminar March 10 at Oklahoma State University; and
"Simple Linear Regression with Inequality Constraints on the Parameters," a seminar April 18 at Rutgers.

Richard D. Warren: "Leisure Orientation Scale—Replication and Measurement Analysis (with Yoesting and Burkhead)", and
"Influence of Meaningful Subgroups on Attitude Scales and Programs Directed at Changing Smoking Behavior (with Winkelpleck)", at the annual meeting of the Rural Sociology Society August 26-29 in Denver.

George Zyskind: "Aims, Logic and Methods of Transformations," at the 15th annual Technical Conference, Chemical Division, American Society for Quality Control, October 13-16 in Charlotte, North Carolina;
"Error Structures, Randomization and Linear Model Theory," at a joint colloquium for the Université de Montreal and McGill University February 16-19; and
"Integrative Aspects of Linear Models and Randomization Theories," as an invited participant at a symposium on Mathematical Statistics February 27-March 4 in Oberwolfach, Germany.

PARTICIPATION IN PROFESSIONAL ACTIVITIES

At the statistical society meetings in August at Colorado State University, T. A. Bancroft attended Board meetings and presided at the presidential address as past-president of ASA. In November he served as a consultant to the University of Manitoba on the advisability of establishing a Ph.D. program in statistics. During December he participated in meetings in Washington, D. C. between government officials and statisticians on the reorganization of federal statistical activities. He has been reappointed to the ASA Advisory Committee on Statistical Policy to the Office of Management and Budget, which heard a report from the

President's Commission on Federal Statistics. Dr. Bancroft also serves as an expert for co-option/consultation for the appointment of teachers in the Department of Mathematics and Statistics, West Pakistan Agricultural University, Lyallpur.

Susan Alice Brown continues as national treasurer of the professional society for women in journalism and communications. She has been elected treasurer of the Iowa Home Economics Association and served on the Assembly of Delegates at the American Home Economics Association annual meeting June 26-30 in Detroit.

C. P. Cox served as chairman of a session of contributed papers at the statistical society meetings in August at Colorado State University, and as chairman of "Statistics in Environmental Research" during the April statistical society meetings in Ames. Also during the Ames meetings Dr. Bancroft was chairman of a session on "Inference Procedures Incorporating Preliminary Tests of Significance." H. T. David coordinated IMS meetings with ENAR. Paul Hinz and Richard Mensing were in charge of local arrangements for the meetings, which drew nearly 400 statisticians. C. P. Han was chairman of a session of contributed papers and D. K. Hotchkiss chaired a panel discussion: "Introducing Statistics in the Secondary School Classroom—Summer Institute Programs." David V. Huntsberger was a discussant and George Zyskind served on the IMS program committee and organized a joint session on "Linear Models and Experimental Designs."

Dr. David has been elected District 8 Representative to the ASA Council and serves on the advisory board of the ASA Section on Physical and Engineering Sciences. He is a participating lecturer in the Visiting Lecturer Program in Statistics and serves on two IMS committees: Nominations and Summer Research Institute. June 21-23 he chaired a session at the 3rd International Multivariate Analysis Symposium at Wright State University, Dayton, Ohio. He is a member of the executive committee of the ISU chapter of Sigma Xi. This spring Dr. David was elected to a three-year term on the Faculty Council. He continues to serve on ISU's Annuities and Insurance Committee. Dr. David was on leave fall quarter while he was affiliated with Johns Hopkins University as a visiting professor.

Richard Groeneveld attended an NSF-sponsored Chautauqua-Type Short Course C-110, Operations Research, in Chicago November 18-19 and March 9-10.

Dr. Han served as president of the Iowa Chapter, ASA. W. J. Kennedy has been elected vice president for 1972-73.

Roy Hickman was granted faculty improvement leave during the summer of 1971 to study current survey research methodology and sampling theory and investigations in non-sampling errors at the Survey Research Center, University of Michigan.

Dr. Hinz testified as an expert witness in the court challenge of the reapportionment plan adopted by the 1971 legislature.

Dr. Hotchkiss was elected to a two-year term on the executive committee of the ASA Section on Training of Statisticians. He has been named a member of the auditing committee of the ISU Employees Credit Union.

Oscar Kempthorne has been appointed to the 1972 committee for selecting the Samuel S. Wilks Memorial Medal winner. He continues as chairman of the R. A. Fisher Memorial Lecture committee.

Jeff Meeker served during the year as vice president of the Graduate Student Senate; he has been elected to the Graduate College Review Board for the coming year.

Dr. Mensing participated in the planning and lecturing for a quality control short course given at Iowa State May 11 and 12. Quality control personnel from industries throughout Iowa (food, metal, rubber, electronic instruments and other industries) attended.

Edward Pollak was elected to membership in the American Society of Naturalists by the society's executive committee.

V. A. Sposito was appointed secretary of IBM's SHARE Mixed Integer Programming Projects. He served as chairman of IBM's SHARE XXXVIII Mathematical Programming session on Recent Mathematical Programming Developments at IBM's World Trade Corporation in San Francisco March 8. April 13-15 he presented a short course for the Computation Center on "Solutions of Linear Programming Models via MPSX."

B. V. Sukhatme and Dr. Zyskind were elected Fellows of the American Statistical Association. Dr. Zyskind was a discussant for a linear model session during statistical society meetings in August at Colorado State University. He organized a session on Design and Analysis of Experiments for the ASA section on physical and engineering sciences.

Richard D. Warren, who has a joint appointment with the Department of Sociology and Anthropology, served as acting head of that department during July and August 1971. He was a discussion leader for a session at the annual meeting of the Rural Sociology Society in August in Denver.

Teaching

The Department of Statistics continues to offer the B.S., M.S. and Ph.D. degrees in statistics through the College of Sciences and Humanities, and the B.S. in biometry through the College of Agriculture. Course work emphasizes both modern statistical theory and the sound application of methods. Each student follows an individual program tailored to his particular interests and needs.

There has been a general renumbering of introductory courses this year to indicate their true level of emphasis. The orientation for undergraduates was given an official title and number, 100. The principles of statistics courses, 201, 201A and 201B became 101, Principles of Statistics, and 104 and 105, Introduction to Statistics. Business Administration Statistics, previously offered as 499X, is now 127. The special problems courses, previously numbered 499 and 599, are now 490 and 590.

Two industrial statistics courses were reorganized. Industrial Statistics: Sampling Inspection, 531, has been renamed Industrial Statistics: Process Control, and will be offered fall 1972 to alternate with 533, offered this year. 533, Industrial Statistics: Reliability, replaces 532, Industrial Statistics: Design of Experiments. Eleven students enrolled in 533 fall quarter to study probabilistic aspects of reliability models; inference for reliability parameters; design of multi-component systems and replacement and inspection policies.

Nonparametric Statistical Theory was offered for the first time under its new number, 546. Previously offered as 599, it is an introduction to nonparametric problems; one-sample, two-sample, and c-sample problems; order statistics and their applications; rank tests, tests for location and dispersion and their large sample properties; tests based on sample distribution functions and asymptotic relative efficiency of nonparametric tests. Theories of Inference, offered two years ago as 649, has been renumbered 661.

COURSE OFFERINGS IN STATISTICS

The courses offered by the Department of Statistics during the 1971-72 academic year were:

Courses for Undergraduate Students Only

100	Orientation in Statistics	R	F*	Hotchkiss
101	Principles of Statistics	5	FWS	B. Bowerman, Groeneveld, Hotchkiss, Huntsberger, Lin, Pyne, Schmid, S. Sukhatme Veale
104,	Introduction to Statistics	3	WS, SS_1	B. Bowerman, Hotchkiss, Huntsberger, Lin, O'Connell, Schmid, S. Sukhatme
105		3	FS	Groeneveld, Lin, Schmid, S. Sukhatme
127	Business Administration Statistics	5	FWS	C. Bowerman, Jobson, Zeller
327	Elementary Business Statistics	3	F	Groeneveld
341,	Introduction to Theory of Probability and Statistics	3	FW	B. Bowerman, Huntsberger
342,		3	WS	B. Bowerman, Huntsberger
343		3	S	Huntsberger
380	Statistical Applications of Digital Computers	3	FWS	Heiberger, Smith

Courses for Graduate Minors and Undergraduates

401,	Statistical Methods for Research Workers	4	FW, SS_1	C. P. Cox, D. Cox, Geadelmann, Groeneveld, Hickman, Hotchkiss, Meeden, Mensing, Sullivan, Walsh, Warren, Wolins
402		4	SS_2 WS	D. Cox, Geadelmann, Groeneveld, Hickman, Hotchkiss, Meeden, Mensing, Sullivan, Walsh, Warren, Wolins

*Because the fiscal year began July 1, 1971, and ended June 30, 1972, the courses taught in the second summer session of 1971 through the first summer session of 1972 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.

411	Experimental Design for Research Workers	3	S, SS_1	D. Cox, Dickinson, Geadelmann, Hinz
421	Survey Design for Research Workers	3	SS_2S	Baker, B. Sukhatme
431	Elementary Statistical Quality Control	3	S	Mensing
436	Genetic Statistics for Research Workers	3	S	Geadelmann
446,	Statistical Theory for	3	F	Hinz
447,	Research Workers	3	W, SS_1	Hinz, Mensing
448		3	SS_2S	Hinz, Huntsberger
481,	Processing of Statistical	2	W	Mosier
482	Data	2	S	Mosier
490	Special Problems	Arr.	WS	Sullivan, Wolins

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	Walsh
508	Sociometric Statistics	3	F	Warren
511,	Design of Experiments	3	W	Kempthorne
512		3	S	Zyskind
521,	Design of Surveys	3	W	Han
522		3	S	Han
533	Industrial Statistics: Reliability	3	F	Mensing
535	Biological Statistics	3	S	C. P. Cox
536,	Genetic Statistics	3	F	Pollak
537		3	W	Pollak
538	Econometric Statistics	3	F	Fuller
539	Operations Research	3	W	Mensing
540	Operations Research Methods and Economic Analysis	3	S	Sengupta
541,	Theory of Probability	3	F	Arnold
542,	and Statistics	3	W	Meeden
543		3	S	Arnold
544	Statistical Decision Theory	3	S	David
545	Stochastic Processes	3	SS_2	Isaacson
546	Nonparametric Statistical Theory	3	S	S. Sukhatme
549	Mathematical Programming	3	S	Sposito
580	Statistical Computations on Digital Computers I	3	W	Kennedy
581	Statistical Computations on Digital Computers II	3	S	Kennedy
590	Special Topics	Arr.	SS_2FWS, SS_1	
	A. Theory			Arnold, D. Cox, Isaacson, Meeden, Mensing
	B. Methods			D. Cox, Fuller, Hinz, Kennedy, Mensing, Sposito, Warren, Wolins
	C. Design of Experiments			Zyskind
	D. Design of Surveys			B. Sukhatme

Courses for Graduate Students, Major or Minor

601	Advanced Statistical Methods	3	F	C. P. Cox
608	Seminar on Statistical Methods	3	W	C. P. Cox
621	Advanced Design of Surveys	3	W	B. Sukhatme
622	Seminar on Design of Surveys	3	S	B. Sukhatme
638	Advanced Econometric Statistics	3	W	Fuller
639	Stochastic and Continuous Programming	3	W	David
641	General Theory of Linear Hypothesis	3	F	Zyskind
642	Probability and Distribution Theory	3	W	Isaacson
643	Theory of Estimation and Testing of Hypotheses	3	S	Meeden
647	Multivariate Analysis	3	F	Han
648	Seminar on the Theory of Statistics and Probability	3	S, SS_1	Arnold, Isaacson, Meeden
649	Recent Developments in Statistics and Probability	3	SS_2	Han
680	Seminar on Statistical Computations	3	F	Kennedy
699	Research	Arr.	SS_2FWS SS_1	Arnold, C. P. Cox, David, Fuller, Han, Isaacson, Kempthorne, Meeden, Mensing, B. Sukhatme, Warren, Zyskind

GRADUATE STUDENTS

Once again the graduate program in statistics has been recognized for its prominence in the field. The December issue of "Notices of the American Mathematical Society" ranks Iowa State first among 92 departments in U. S. and Canadian institutions in the number of advanced degrees in probability and statistics awarded in the last three years.

Ph.D. Candidates

Chaturedula Asok
Ray Bailey
George Battese
Bruce Bowerman
Leon Burmeister
Richard Chamberlain
Lal Chand
Isidoro David
Pamela Doctor*
Richard Dorsch
Mohamed El-Sabbagh
G. L. Ghai
Jeff Goebel
Joseph Grimes
Devendra Hajela
M. A. Hidiroglou
Elizabeth Hsu Huang
Her Tzai Huang
J. D. Jobson
Leon Jordan
Kazimierz Karpinski
Thomas Keefe
Geung Ho Kim*
John Kinney
John Lin
Ting Kwong Lin
Richard Madsen
Robert Mason*
Jeff Meeker
James Mellon
Gayle Meltesen
Kenneth Merritt
Roger Mrachek*
Martin J. O'Connell
David Pyne
A. Shawki Salem
J. Richard Schmid
Preecha Sakarindr
Gary Sime
Wendell Smith
Richard Stein
Malte Sund
Lonnie Vance
James Veale
Jose Villaseñor
George Wang
William Warde
James Whipple
Milton Winger
Kirk Wolter*
Shyr-Ching Wung
Richard Zeller

*received M.S. during the year

M.S. Candidates

Carlos Acuña
Michael Althaus
Claude Angers
Cheryl Bowerman
Robert Centner
Kuo Ping Cheng
Cynthia Clark
Peampan Davivongs
Pamela Doctor
Ted Emigh
Modesto Freites
Alix Garcia
Linda Gorman
Patricia Howard
Henry Kelker
Joan Keller
Geung Ho Kim
Thomas Kodey
Ona Antonio Landicho
Clifford Lee
Jan Lommele
Ricardo Longoria
Omar Martinez
Robert Mason
Roger Mrachek
Nimmagadda Murthy
Dennis Pierson
Winston Richards
Julio Robles
Phantipar Sakrindr
Terrance Svejda
Dennis Tsai
Kirk Wolter
Wai Wo Wong
Tetsuo Yamada
Rebecca Zeller

Degrees Granted and Positions Taken

Students who received advanced degrees during the year and their location after graduation are listed here. Abstracts of their theses, written as partial fulfillment of their requirements for graduation, appear in the publications section of this report.

Recipients of the Ph.D. Degree

Leon Burmeister (February 1972, under Wayne Fuller) is employed by the Department of Preventive Medicine and Environmental Health, University of Iowa.

Richard Chamberlain (February 1972, under Oscar Kempthorne) accepted a position with Cyphernetics Corporation, Ann Arbor, Michigan.

Isidoro David (August 1971, under B. V. Sukhatme) returned to the University of the Philippines where he is employed by the Department of Applied Mathematics.

Gauri Ghai (November 1971, under Oscar Kempthorne) remains at the Statistical Laboratory as a research associate working with Dr. Kempthorne on an NIH-supported project.

Leon Jordan (August 1971, under Oscar Kempthorne) is working in the international program of the Tulane Health Services Institute in New Orleans.

John J. Kinney (August 1971, under George Zyskind) accepted a position with the Department of Mathematics at the University of Nebraska.

Richard Madsen (August 1971, under H. T. David and Dean Isaacson) is an assistant professor at the University of Missouri.

James Veale (May 1972, under Barry Arnold) accepted employment for the summer in Des Moines.

Milton Winger (May 1972, under H. T. David) returned to his position of associate professor with the Department of Mathematics at the University of North Dakota.

Recipients of the M.S. Degree

Claude Angers (February, 1972, non-thesis, under Richard Groeneveld) returned to his position in Canada.

Robert Centner (August 1971, under Vincent Sposito) accepted a job as development engineer with Uniroyal, Inc. in Detroit.

Peampan Davivongs (August 1971, non-thesis, under Dean Isaacson) returned to Thailand.

Pamela Doctor (May 1972, non-thesis, under Barry Arnold) remains at Iowa State working toward her doctorate.

Modesto Freites (February 1972, non-thesis, under D. K. Hotchkiss) returned to Venezuela where he's employed by the Central Bank.

Henry C. Kelker (November 1971, non-thesis, under D. F. Cox) is in Garrettsville, Ohio, where he's teaching at the high school level.

Joan Keller (May 1972, under Richard Warren) is a statistician with Consolidated Edison in Chicago.

Geung Ho Kim (August 1971, non-thesis, under H. T. David) remains at Iowa State working toward his doctorate.

Robert Mason (February 1972, non-thesis, under Barry Arold) remains at Iowa State, working toward his doctorate.

Roger Mrachek (February 1972, under Paul Hinz) remains at Iowa State where he is working toward a joint doctorate in statistics and ecology.

Nimmagadda Murthy (August 1971, under B. V. Sukhatme) returned to India where he teaches statistics at U. P. Agricultural University.

Terrance Svejda (February 1972, non-thesis, under Richard Mensing) accepted a position as statistician with Western Electric.

Kirk Wolter (May 1972, non-thesis, under Glen Meeden) remains at Iowa State, working toward his doctorate.

The George W. Snedecor Award in Statistics

The 1972 George W. Snedecor Award was presented to Thomas J. Keefe, who holds a National Science Foundation fellowship. The Award, which consists of a year's membership in the Institute of Mathematical Statistics, a subscription to the Institute's Annals and a cash gift, is given annually to the most outstanding candidate for the Ph.D. degree in statistics at Iowa State, as selected by the graduate faculty. It is named in honor of the Statistical Laboratory's founder and first director.

UNDERGRADUATES

The first undergraduate has been enrolled in the newly established cooperative program in statistics education. Diane Pierick will work this summer in the biostatistics office of the Upjohn Company in Kalamazoo, Michigan, under the direction of Dr. Joseph Assenzo.

This program is being developed to provide employment for undergraduates beginning in the summer following their junior year, after they've completed courses in statistical theory, methods and computation. Giving the student an opportunity to apply statistical methods to real data provides a clear connection between statistical theory and practice. It is felt this coordination between vocation and education will increase motivation toward academic work on the part of the students, and allow an employer to attract and identify persons with statistical ability. Potential employees can

be observed on the job without a long term commitment of employment.

D. V. Huntsberger, D. K. Hotchkiss and Richard Groeneveld continue as undergraduate advisors. In May Mary Benson was graduated with a B.S. in statistics. Robert W. Keyt and Emily Ann Swanson received joint degrees in statistics and computer science. Steven Perron was granted a joint degree in statistics and political science, and Robert Morgan a joint degree in statistics and psychology.

Perron was recognized as the top graduate in statistics scholastically with a grade point average of 3.6. Two freshmen statistics majors were recognized at the spring honors program which cites the top two percent of each class. Lynn Alper led the freshman class with a perfect 4.0 average. Steven R. Johnson also was recognized. Both were also on the winter quarter dean's list which included Francis Diaz and Gordon Meyer.

Iowa State University Statistics Club

A fall get-acquainted picnic marked the first event for undergraduates affiliated with the Statistics Club. Speakers during the year included Gordon Booth of the National Animal Disease Laboratory; Dr. Oscar Kempthorne; Robert Walston, area manager for the U. S. Civil Service Commission; and Robert Kortz, editor of the College Poll in the Des Moines Register. Charles Rohm of Bankers Life Insurance discussed the role of actuaries at a joint meeting with the Mathematics and Computer Science Clubs. The spring field trip featured a visit to the Federal Building in Des Moines and a talk with Roger Southerland, state agricultural statistician. The Veishea display focused on frequency distributions and included an exhibit of the height differential of corn plants to illustrate the normal distribution of a biological population. Francis Diaz planned and supervised the exhibit.

Diane Pierick was named winner of the 1971-72 IBM-Stat Club Scholarship which pays in-state tuition costs for one school year.

New officers are: Francis Diaz, president; Gary McConnell, vice president; Lynn Alper, secretary and Deborah Klinkefus, treasurer.

Mu Sigma Rho

Sixteen students were initiated into Mu Sigma Rho, national statistical honor society, during special spring ceremonies. Dr. T. A. Bancroft spoke on "Some Statisticians I Have Known" at the initiation meeting. Newly elected officers include Joe Grimes, president; Jeff Meeker, vice president and Linda Gorman, secretary-treasurer.

SEMINARS

Statistical Laboratory—Department of Statistics Series

Paul Hinz, Glen Meeden and Richard Mensing were in charge of planning the 1971-72 weekly seminars sponsored by the Statistical Laboratory and Department of Statistics for all students and faculty members. These noncredit seminars provide an opportunity to report current research in statistics and to explain and discuss statistical theory and methodology. Guest speakers from other institutions frequently are featured. Topics and speakers presented during the year include:

Fall Quarter 1971

September 8	A Proposed Model for the Iowa State University Statistical Center. T. A. Bancroft.
September 15	Some Characterizations of the Exponential Distribution. Barry Arnold.
September 22	Numerical Optimization in the Presence of Random Variability. Basil Springer, University of West Indies, Trinidad.
September 29	Estimation for the Errors in Variables Model. Wayne Fuller.
October 6	Controlled Selection and Balanced Incomplete Block Designs. B. V. Sukhatme.
October 13	A Complicated Design, A Messy Analysis, and (Believe It or Not) RESULTS. Leroy Wolins and Dahlia Stockdale.
October 20	(joint Statistical Laboratory, Operation Research) Inequalities for Finite Sampling Plans. Samuel Karlin, Stanford University.
October 27	Sampling a Multi-Dimensional Lattice. Oscar Kempthorne.
November 1	(joint Statistical Laboratory, Political Science) A Theory of Electoral Equilibrium: A Spatial Analysis Based on the Theory of Games. Melvin Hinich, Carnegie Mellon University.
November 10	The Sampling Theory of Selectively Neutral Alleles. Warren J. Ewens, Latrobe University, Australia, and the University of Wisconsin.

Winter Quarter 1972

December 1	The Asymptotic Form of the Extinction Probabilities for Super-Critical, Multi-Type Branching Processes. Edward Pollak.
December 8	Projections, Partitioned Linear Models and a Covariance-Like Procedure for Incorporating Additional Observations. George Zyskind.
December 15	(joint Statistical Laboratory and Iowa Chapter, ASA) On Statistical Inference from Complex Samples. Leslie Kish, University of Michigan.
January 5	Transformations for Analyses of Correlated Observations. George Battese.
January 12	Estimation of Regression Models by MINQUE. J. N. K. Rao, University of Manitoba.
January 19	Meeting the Challenge in the Statistics Classroom. D. K. Hotchkiss.
January 26	Aspects of Kuhn-Tucker Duality. Vincent Sposito.
February 2	Uniform Integrability of Square Integrable Martingales. Dean Isaacson.
February 9	Bayesian Estimation of the Mixing Distribution —the Discrete Case. Glen Meeden.
February 16	A Multiple-Decision Approach to Selecting the Best Predictor Variates. John S. Ramberg, University of Iowa.

Spring Quarter 1972

March 8	Infinite Server Ques with Group Arrivals. Barry Arnold.
March 15	Pseudo Random Number Generation Using the Computer. William J. Kennedy.
March 22	Extensions to ANOVA: Fitting Unequal Cell Variances. Richard Heiberger.
March 29	On Bioassay from Two Paraboles; Hypothesis Testing for the Correlation Coefficients of Particular Bivariate Normal Distributions. C. P. Cox.
April 5	A Result Concerning the Neyman-Pearson Problem Using Mathematical Programming Techniques. David Pyne.
April 20	Exponential Decay of Excited Molecules, a Problem in Applied Statistics. Robert A. Wijsman, University of Illinois.
May 3	Sequential Tests of Mean Vectors Utilizing Concomitant Information. Tom Keefe.
May 9	(joint Statistical Laboratory and Department of Mathematics) The Law of Integrated Logarithms. James Taylor, University of Minnesota.
May 17	Improved Inference Procedures for Gamma Populations when Spurious or Additional Independent Observations Are Present. James Veale.

Applied Statistics Series

The Applied Statistics seminars, planned for research workers from substantive areas who use statistics as a primary research tool, took a new approach this year: the speakers took the programs directly to the users.

Five seminar topics were developed which deal with problems often encountered in the fields served by staff members responsible for consulting through the support of the Agriculture Experiment Station. These programs were made available to any interested groups of staff or graduate students. The objective was to fit the seminars into the needs and interests of specific groups by including examples and discussing special problems related to the area.

Response to the new format has been good. Five seminars were presented spring quarter and a number already have been booked for next fall. So far the staff has reached faculty members and students in agricultural engineering, animal science and horticulture. The five topics currently available are:

"Analysis of Experiments that Utilize the Design Techniques of Split Plots." D. F. Cox and Paul Hinz offer one or two seminars discussing the nature of the problem and suggested alternatives to the standard analysis of variance.

"The Use of the Statistical Analysis System, a Computing Facility Developed at North Carolina State." D. F. Cox provides a description of the basic concepts in this integrated package of programs widely used in data analysis. The use of this package requires no formal programming experience or knowledge of a particular language. The seminar includes examples of common problems such as analysis of variance and regression. The program manual and necessary control cards are supplied.

"Multivariate Analysis of Variance." Paul Hinz draws parallels between multivariate techniques described as analogs to common univariate procedures. The utility of some of the multivariate procedures is demonstrated.

"The Geometry of the Analysis of Variance." Paul Hinz, who offers one or two seminars on this topic, points out that analysis of variance can be described in geometric terms. Such a development assists in understanding and interpreting the components of a standard regression analysis and the ordinary analysis of variance table.

"The Applications of Cluster Analysis." Many problems require classification of units into groups on the basis of unit measurements. Many objective techniques are available to accomplish such classifications, and their use is explained and discussed by Jon Geadelmann, William Warde and Roger Mrachek in one or two seminars.

Other topics pertinent to specific fields could be developed into seminars and the staff welcomes suggestions for such efforts.

Quantitative Genetics Series

Oscar Kempthorne and Edward Pollak planned Quantitative Genetics seminars for staff members and graduate students in statistics, genetics, animal science, poultry science, agronomy and horticulture.

Dr. Samuel Karlin, Department of Mathematics, Stanford University, discussed "Polymorphisms and Interaction in Ecological and Genetic Systems" on October 19. The November 9 program featured Dr. W. J. Ewens of the Mathematics Research Center, University of Wisconsin. His topic was "The Genetic Load and the Theory of Non-Darwinian Evolution. "A General Selection Theory for a Single Autosomal Locus and Nonoverlapping Generations" was presented January 4 by Carl Z. Roux, here on leave from the Animal and Dairy Science Research Institute, Pretoria, Republic of South Africa.

Operations Research Seminars

H. T. David and J. K. Sengupta continued on the planning committee for this interdisciplinary seminar series, with Keith McRoberts from industrial engineering. The seminars are organized to appeal to individuals concerned with modeling and optimization.

On January 18 V. A. Sposito discussed "Saddlepoint Optimality Criteria of Nonlinear Programming Problems." Dr. David was the February 15 speaker. His topic was "Aspects of Passive Stochastic Programming." Other speakers during the year represented a variety of departments.

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