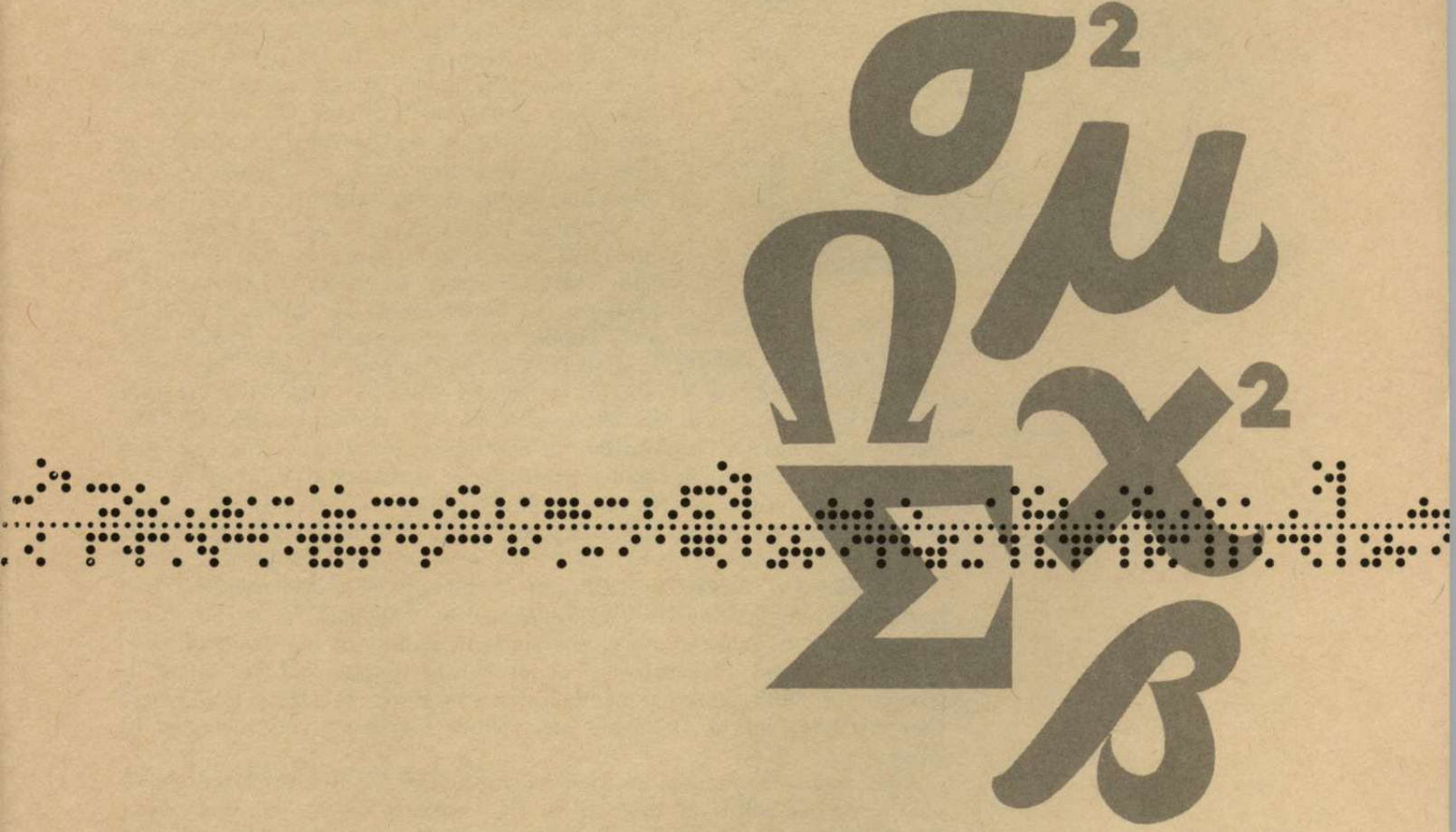
STATISTICAL LABORATORY

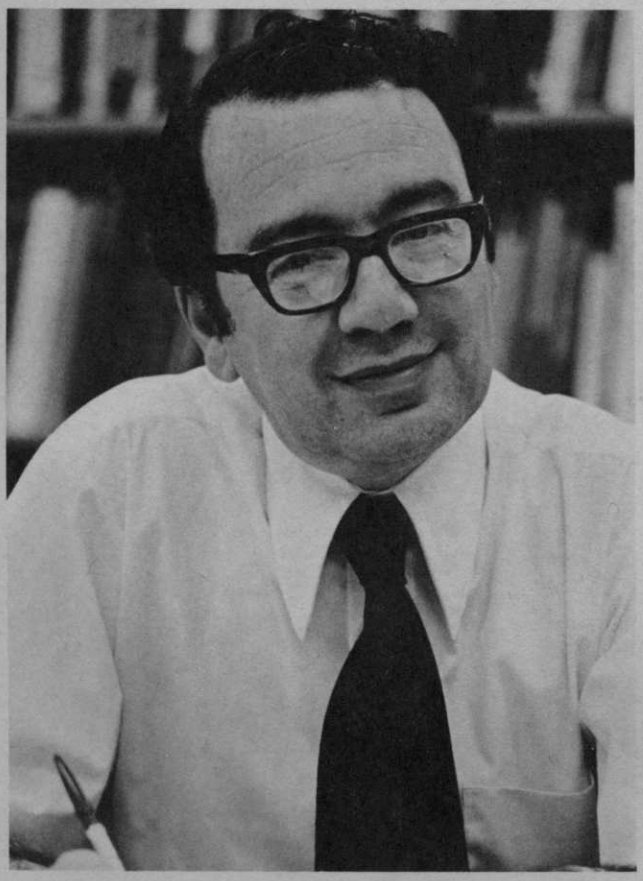
established 1933



annual report

July 1, 1972 to June 30, 1973

IOWA STATE UNIVERSITY, AMES



herbert a. david has assumed the position of Director of the Statistical Laboratory and Head of the Department of Statistics with the intention of keeping Iowa State's statistical center "in the forefront of the statistical world." Since joining the faculty in September, Dr. David has been "impressed by the unique blend of theory, application and service characterizing the statistical center, and by the spirit of cooperation among staff members."

A Fellow of ASA, AAAS and IMS, and a member of ISI, Dr. David came to Ames from the University of North Carolina, where he was a professor of biostatistics. He received a B.Sc. with honors in mathematics from Sydney University in 1947. His Ph.D. in statistics, 1953, is from London University, where he wrote his thesis at University College under H.O. Hartley.

Dr. David was research officer with the Commonwealth Scientific and Industrial Research Organization in Sydney, a senior lecturer in statistics at Melbourne University, and a professor of statistics at VPI before joining the University of North Carolina faculty in 1964. He has taught summer sessions at the University of Florida and the University of California, Berkeley.

In 1963 Dr. David received the J. Shelton Horsley Award for Meritorious Research from the Virginia Academy of Science. He is the author or co-author of more than 50 publications, mainly in the areas of order statistics, paired comparisons, experimental design and statistical inference. In 1963 Griffin published his monograph *The Method of Paired Comparisons* and in 1970 his book *Order Statistics* was published by Wiley.

Just before assuming his new position, Dr. David completed a five-year term as editor of *Biometrics;* he continues on the editorial board. Dr. David has also served as an Associate Editor of *JASA.* He was president of the Biometric Society (ENAR) in 1963 and recently was elected to a three-year term on the Council of the Biometric Society.

Commenting that he has long been aware of the worldwide reputation of statistics at Iowa State, he believes "the concentration of the teaching of statistics courses in the Department of Statistics, through the mechanism of joint appointments where appropriate, is particularly noteworthy." Dr. David feels that he is taking over from T.A. Bancroft "not only a distinguished department but also an extremely well-run organization." He is determined to effect such improvements as will keep it that way.

1972–73 statistical laboratory highlights

. . .and looking ahead to 1973-74:

• Theodore Bailey, Jr., consulting section; Robert Strahan, joint with psychology; and Michael Coveyou, joint with political science, fill existing faculty vacancies.

• The seventh annual symposium on the interface, "Computer Science and Statistics," will be hosted by the Statistical Laboratory and Department of Computer Science October 18-19 at Iowa State. The symposium will focus on the role of statistics in the design and improvement of computing systems and software, effective use of computational machinery to implement statistical methods, and using computer science and statistics in other applied sciences. Six concurrent workshops will encourage interchange between participants. Workshop topics include: Computer System Performance Evaluation, Statistical Design and Analysis of Simulation and Monte Carlo Experiments, Software for Statistical Computations, Education and Training in the Interface, Decision and Environmental Analysis and Programming Languages—Theory and Applications. W.J. Kennedy is symposium chairman.

personnel

are shared among all the components of Iowa State's statistical center: the Statistical Laboratory, an institute under the president's office; 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.

Resignations effective at the beginning of the fiscal year included: James Walsh (joint appointment with psychology) who accepted a position as professor and head of the Department of Psychology at the University of Montana; Jon Geadelmann, an AES consultant, who became an assistant professor and leader of the corn genetics and breeding project with the Department of Agronomy and Plant Genetics at the University of Minnesota; and John Sullivan (joint appointment with political science) who went to Indiana University as an assistant professor of political science.

The statistics-psychology position was held this year by assistant professor Terry Dickinson on a one-year appointment, and has now been filled by Robert Strahan of the University of Rochester. Strahan, who has a doctorate from the University of Minnesota and a B.A. from Kansas State College, will join the faculty as an associate professor.

Hans Zuuring did AES consulting and related teaching on a one-year appointment this year while completing work toward a doctorate in forestry. This position will be filled July 1 when Theodore Bailey, Jr., who teaches biology at St. Olaf College, begins his appointment as an assistant professor. He has a B.S. from Iowa State and M.S. and Ph.D. degrees from the University of Minnesota. Dr. Holly Fuchs rejoined the staff on a temporary part time basis to assist with consulting.

Michael R. Coveyou, who is completing his doctorate at the University of Rochester where he previously earned an M.A., will fill the statistics-political science position as an assistant professor. He holds an A.B. from the University of Michigan.

David Dickey was new to the faculty in 1972-73, serving as an instructor while working on his doctorate in statistics. Two associates, Robin Thompson, visiting from the University of Edinburgh, and Ting-Kwong Lin from the University of Malaysia, are working with Oscar Kempthorne on an AES-NIH research project.

Two staff members at the Mayo Clinic's Department of Medical Statistics have been given collaborator status as of May 1. Dr. William F. Taylor has been appointed professor (collaborator), and Dr. Peter O'Brien has been appointed assistant professor (collaborator). As collaborators they are eligible for membership on the graduate faculty, which will make it possible for them to serve on graduate committees and advise on theses. Students can go to Mayo's for direct experience in medical statistical consulting, to supplement their on-campus training.

A cooperative agreement with the Agricultural Research Service of the United States Department of Agriculture will extend statistical guidance and consulting to research scientists and develop improved statistical methodology. Two USDA employees, Gordon Booth and Charles Graham, now are housed in Snedecor Hall. With the assistance of graduate students partially supported by the agreement, they are working on problems which arise in their consultations with USDA employees from the National Animal Disease Laboratory, the ISU campus, and elsewhere.

Associate Jeff Goebel, who is completing his doctorate, has been given a two-year appointment to work with Roy Hickman of the Soil Conservation project. He will become an assistant professor when he earns his degree. Under a similar appointment, George Battese will serve as an assistant professor for one year, to work with Wayne Fuller.

Administrative assistant Margaret Kirwin announced her partial retirement from administrative responsibilities. After July 1 she will be working half time, concentrating on budget and personnel activities. Avonelle Jacobson will assume many of her duties.

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

statistical laboratory staff, fiscal year 1972-73

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..... Acting Dean, College of Sciences and Humanities; Acting Director, Sciences and Humanities Research Institute, through November 30
Wallace A. Russell, Ph.D...Dean, College of Sciences and Humanities; Director, Sciences and Humanities Research Institute, beginning December 1
Marvin Anderson, Ph.D.....Acting Dean, College of Agriculture; Acting Director, Iowa Agriculture and Home Economics Experiment Station, through February 28
Lee R. Kolmer, Ph.D...Dean, College of Agriculture; Director, Iowa Agriculture and Home Economics Experiment Station, beginning March 1
Herbert A. David, 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 F. Cox
Herbert A. David
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
Edward Pollak—joint appointment with Department of Genetics
George W. Snedecor—Professor Emeritus—in absentia
Norman J. Strand—Professor Emeritus—in absentia
B.V. Sukhatme
Richard D. Warren—joint appointment with Department of Sociology and Anthropology
Leroy Wolins—joint appointment with Department of Psychology
George Zyskind

J.K. Sengupta—faculty status in statistics as well as economics, on leave
William F. Taylor—Collaborator (in residence at Mayo Clinic), beginning May 1

associate professors

Barry C. Arnold—joint appointment with Department of Mathematics
Richard A. Groeneveld
Chien-Pai Han
Roy D. Hickman
Paul N. Hinz
Dean L. Isaacson—joint appointment with Department of Mathematics
C.C. Mosier—joint appointment with Computation Center
Glen D. Meeden

C.E. Fuchs—winter quarter through June 30
Janos Galambos—visiting, summer 1973

assistant professors

Harold D. Baker
Terry L. Dickinson—joint appointment with Department of Psychology for 1972-73
Richard M. Heiberger
William J. Kennedy
Richard W. Mensing
Vincent A. Sposito—joint appointment with Computation Center
Shashikala B. Sukhatme

Peter C. O'Brien—Collaborator (in residence at Mayo Clinic), beginning May 1

postdoctoral associates

A.B. Chia—through December
G.L. Ghai
W.G. Hill—through September
Louis Jensen—summer 1972
John J. Kinney—summer 1972
Willi Maurer—summer 1973
I.M.Z. VanAarde—winter quarter

instructors and associates

George E. Battese
Bruce L. Bowerman
David A. Dickey
Richard L. Dorsch
J. Jeff Goebel—beginning May 1
Joe E. Grimes—July 1972
Kazimierz F. Karpinski
Ting Kwong Lin
Jeff B. Meeker
James I. Mellon
Kenneth E. Merritt—summer 1972
Martin J. O'Connell
J. Richard Schmid
Wendell C. Smith
Richard A. Stein—summer 1972
Robin Thompson—visiting
William Warde—summer 1972
Hans R. Zuuring

graduate assistants

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

John Aleong
Michael Althaus
C. Asok
Harry Boncykowski
Cheryl Bowerman
Randy Carter
Richard Chung
Pamela Doctor
Frank Eaton
Mohamed El-Sabbagh
Ted Emigh
Jeff Goebel
Linda Gorman
Devendra Hajela
M.A. Hidiroglou
Elizabeth Huang
Her Tzai Huang
Robert Keyt
Geung Ho Kim
Larry Kinyon
Jan Lommele
Robert Mason
Thomas Moritz
Roger Mracheck
Antonio Oña
Shawki Salem
William Santy
Barry Simon
Melvin Stanard
Michael Szymczuk
Flora Tsang
Dale Umbach
Lonnie Vance
George H.K. Wang
Kirk Wolter

ibm fellow

Kirk Wolter

supported graduate students

Carlos Acuna, Latin American Scholarship Program
Zeyad Al-Rawi, Iraq Government
Humphrey Arthur, Population Council
Gordon Booth, USDA
Lal Chand, USAID

Elsa Contreras, Central Bank of Venezuela
Mohamed El-Sabbagh (joint statistics-industrial engineering), Department of Industrial Engineering
Jorge D. Fischman, FAO, United Nations
Alix Garcia, Venezuela Government
Joseph Grimes, Department of Mathematics
William Kelly, USDA
Clifford Lee, Department of Mathematics
Omar Martinez, Centro de Investigaciones Agronomicas, Venezuela
Raphael J. Michalski (joint statistics-economics), Department of Economics
Surin Phoeyglin, National Research Council of Thailand
Winston Richards, Ford Foundation
Julio Cesar Robles, AID, Peru
Arden Ross, Wisconsin State University, LaCrosse
Preecha Sakarindr (joint statistics-economics), Rockefeller Foundation, Thailand
A. Shawki Salem, UAR Government
Gary Sime, Department of Mathematics
John Trzeciak (joint statistics-industrial engineering), Engineering Research Institute
Choosak Udomsri (joint statistics-mathematics), Chulalongkorn University, Thailand
Jose Villasenor, Ford Foundation, Mexico

unsupported graduate students

Kou-Ping Cheng
Shyamal Chowdhury
Cynthia Clark
No Hoon Kwak
John Lin
Phantipar Sakarindr
Hernan Tejeda
Wai Wo Wong
Shyr-Ching Wung

statistical data processing service

Bud J. Meador, Supervisor
Data Processors:
Charlotte Bentley
Diane Chien—beginning fall quarter
Ruth Lammey—through fall quarter
Mary Wilson

survey section

Sylvia McNulty, Secretary
Marjorie Mason, Survey Supervisor
Hazel Cook, Survey Supervisor
Evelyn Green, Survey Supervisor
Anna B. Woodrow, Survey Supervisor
John McConeghey, Programmer
Harvey Terpstra, Junior Systems Analyst
Marcia Tilley, Statistical Data Processor

Statistical Clerks:
Carol Bell
Ava Klopf
Sylvia Larson
Margaret Nichols
Florance Osam
Helen Padellford

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—through spring quarter
Phyllis Carr, Secretary, Experimental Design-Genetic Statistics Section—beginning summer 1973
Sharon Bown, Secretary—through summer 1972
Norma Elwick, Secretary
Laurel Kushner, Secretary—beginning fall quarter
Peggy Nelson, Secretary
Nancy Orum, Secretary—beginning fall quarter
Barbara Williams, Secretary—through summer 1972

The needs of research workers in substantive fields for

statistical consulting services

vary in complexity and in the creative statistical methodology required of the consulting statistician. Some researchers need fairly routine assistance using known statistical techniques. Other projects require innovative and sophisticated application or the modification and adaptation of known statistical methodology. Some scientific investigations demand the creation of new statistical theory or methodology, specifically designed to provide a solution to an important problem.

Many faculty members with joint appointments are involved with consulting and cooperative research because their specialized training in a substantive area permits them to bridge the scientific language between statistics and their other discipline. Faculty members such as Wayne Fuller, who has status in economics as well as statistics, and joint appointees Richard D. Warren (sociology and anthropology) and Terry L. Dickinson and Leroy Wolins (psychology) are in this category.

The Iowa Agriculture and Home Economics Experiment Station 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.

Project 101, Statistical Services in the Animal Sciences and Plant Sciences, supported consulting done by D.F. Cox, Paul Hinz, D.K. Hotchkiss, Hans

Zuuring and graduate students John Aleong, Richard Chung, James Mellon, Thomas Moritz and Antonio Oña.

Edward Pollak, director of Project 1448, Consultation and Research in Mathematical and Statistical Genetics, served staff members in agronomy, animal science and genetics. Project 113, Statistical Services for Sampling Investigations, supports consulting done by many members of the Survey Section. Roy D. Hickman is project director. Harold D. Baker, George Battese and Richard Dorsch also are involved with consulting.

Other consulting is partially supported by the Sciences and Humanities Research Institute, the Engineering Research Institute (including some of the consulting of H.T. David and Richard Mensing) and of course by funds of the Statistical Laboratory itself.

Some staff members spend their entire nonteaching hours as consulting statisticans, working on well over a hundred projects during a fiscal year. Some consulting problems can be handled with a single phone call; others require weeks or months of meetings with research faculty and students. Frequently research is published and the consultant's contribution may be recognized by listing him as co-author or by an acknowledgement. There is no one typical consulting activity, nor is it possible or practical to report assistance given to each research project. This report is intended only to give an indication of the consulting done by the Statistical Laboratory staff.

A new system,

statistical analysis system

(SAS), seems capable of taking over the major part of the computing work required in the consulting. Several multivariate techniques not previously available have been introduced by the consultants, as the result of the acquisition and implementation of this computing package from North Carolina State University. While the staff continues to implement and test the features of SAS, older and more established computing tools such as general least squares programs and OMNITAB continue to be used extensively.

Considerable effort has been spent investigating the results of designs where experimental units are measured repeatedly over time. Computer simulations have been used to study the effects of various correlational structures in these designs, and recommendations based on the results have been applied to the consulting work. Seminars concerning the developments in several areas of application have been offered to the staff of the Experiment Station.

Direct consulting work with Experiment Station research workers continues across the entire spectrum of research activities in the Station, from the more typical studies of oat breeding, corn production functions and swine nutrition to more unusual investigations of penguin growth and behavior. Analysis of variance probably is the single most used statistical tool, but again an entire spectrum of techniques is needed to tackle each problem effectively.

Work continued on the analysis of data for a food and nutrition project involving data collected over a 25-year period. Nutrient intakes and physiological measurements were obtained from one to four times on 35 women who participated in the longitudinal study. The models used for the effects of aging on adult women were simple linear or quadratic functions of year of birth and age when the measurements were taken. Non-zero correlations were assumed between the multiple measurements for a given variable on the individual women, and a simple computational technique was applied to obtain efficient estimates of the parameters in the models for aging.

A graduate student in agronomy sought assistance with estimating the progress of an epiphytotic through populations of orchard grass with varying susceptibility. The grass was cut halfway through the growing period, resulting in two additive populations with insufficient observations before cutting. A logistic curve was estimated, fitting points ten or more days after cutting. Although the error variances were heterogeneous, it was determined that fits through non-transformed data gave the best representation. Weighted polynomial regression was used to determine the effect of the percent of the susceptible variety on the estimates of the parameters from the nonlinear regressions. It was concluded that after cutting there was a quadratic trend in the asymptote, a linear trend in the maximum infestation, and no change in the time of maximum infestation. The research will continue next year with additional data before cutting.

A fisheries student was assisted with research on the effects of DES on fish growth. Canonical analysis was used in a study of occurrence and abundance of invertebrate species in Northwest Iowa marshes. Cluster analysis was selected for food technology research on the influence of cold storage on the survival of certain bacterial strains, and for a botany and plant pathology investigation of occurrence and abundance of some nematode species in Iowa, Minnesota, Wisconsin and several eastern states.

Horticulture research was concerned with the optimum conditions for the ripening of strawberries to obtain maximum yield. A staff member subjected different varieties to different chemical ripeners, then recorded the yields and quality of fruit. Due to the scope of the experiment and the fluctuation in the ripening process, least squares analysis was used to determine which factors influenced berry yield.

Standard procedures for handling dried milk were evaluated in cooperation with a professor in food technology. Bacterial counts were recorded

on samples at 48 and 72 hours incubation by 13 laboratories. The laboratories received different quality milk which was subjected to several different reconstitution procedures and holding techniques. Because of numerous lost samples and uncontrollably spreading bacteria which obliterated the bacteria count, it was necessary to sort and select data from the very large experiment. Using data with a minimum of missing observations, the analysis pinpointed where variability was large and demonstrated differences among laboratories.

A student accumulated information from swine herdsmen regarding their management techniques and the infestation of mange. Statistical consultants helped him determine relationships among the classification variables, select interpretable combinations of variables and interpret the contingency table results.

Analysis of variance was used for a forestry study of the growth potential of several cottonwood clones, for entomology research on the economic influence of potato leaf hoppers on soybeans, for botany and plant pathology investigations of the influence of soil fungi on the growth of oak seedlings and the resistance of various elm species to Dutch elm disease, and for agricultural engineering studies of soil properties' influence on emergence of corn and soybeans and influence of herbicides and row spacing on soybean yield.

Analysis of variance of transformed data in a three-factor factorial with repeated measures on two factors in a randomized complete block design was selected for family environment research. Bacteria counts on carpeted and uncarpeted kitchen floors were compared for each of four areas in the kitchens, for five periods, for five pairs of houses. Problems occurred because of missing data and unequal sample sizes. Furthermore, the assumptions of normality, equal variance and uncorrelated errors are quite questionable. Since it is possible that blocks interact with treatments, there is a question of what terms should be included in the model. A more appropriate model is being investigated for future experiments. Decisions also are being made whether data from more than one dilution per treatment combination can be included in the analysis, if different dilutions affect the variance, and if the correlation structure of the observations is as assumed by the analysis of variance procedure.

Assistance with data analysis was provided for two agronomy experiments. A mathematical model was suggested for a study of the weight of second ears on corn plants: it is assumed that with probability p there is no ear. If there is an ear, it is assumed the weight distribution is generalized gamma distribution. Then three parameters must be estimated. The second experiment involved data on generation means of population started by crossing two inbred lines and continued by selfing.

A linear model and an associated analysis of variance were suggested for data on the covariances between first cousins and other relatives in a poultry population. Advice was also given on how to compute estimates of expected mean products and approximate variances of mean products from an analysis of covariance table. The use of a heterogeneity chi-square test was recommended to a genetics professor who wished to test if proportions of non-disjunction progeny among the offspring of 22 females differed.

Regression analysis was used for a chemical engineering study comparing the functional relationship between several physical properties and the speed necessary to attain the suspension of salts in a liquid. Several types of stirrers were studied, requiring the comparison of several regression equations. Analysis of variance and regression analysis were used on civil engineering data on the effect of several factors on the strength of asphalt concrete. Another civil engineering study, of channelization on accident rates at urban intersections, used analysis of variance and covariance analysis. Covariates encountered were traffic volume and speed of cars entering intersections.

A program to estimate regression equations containing autocorrelated errors was developed for staff members in economics. It has been incorporated into ECONPK, a group of programs heavily used by economists. The program tests for autocorrelation and, if the test rejects the hypothesis of independence, transforms the observations and reestimates the equation. It can handle equations containing lagged values of the dependent variable.

Consulting with graduate students in social sciences regarding statistical and methodological areas of their research included: discussions of conceptual models; assistance in writing operational definitions, empirical hypotheses and statistical hypotheses; assistance with questionnaire or schedule construction; discussions of empirical measures, research designs and settings; assistance with data coding, tabulation and analysis; and discussions of implications and interpretations of findings. Consulting time required ranged from one to 25 hours.

A psychology student planned a randomized group experiment using a covariate to reduce error. Both the variate and the covariate were subject to measurement error. The problem, which turned out to be tractable, arose with allocating time for measuring the two variables. Resources were allocated to reduce the measurement error in such a way as to maximize power. In other psychology research, analysis of variance was used for studies of concept formulation in the mentally retarded, especially the development of the concept "bigger." Regression and correlation analyses were selected for research on environmental factors in cognitive complexity: performance differences on multiple-cue tasks, and for an investigation of Fishbein's model of behavioral intentions.

off-campus consulting

services are provided when time permits: by phone, mail, and occasionally by on-site visits. Wayne Fuller spent a week in Peru in the fall and Roy Hickman was there two weeks as part of the ongoing project sponsored by the Agency for International Development. They consulted with the Ministry of Agriculture on survey design and analysis of a household consumption survey.

Staff members from the University of California, Berkeley, consulted with T.A. Bancroft by mail on medical and public health research. The study compared brain accumulation of methyl mercury in pregnant, fetal and non-mated female rats, and involved data with unequal numbers in the subclasses.

D.K. Hotchkiss assisted with the analysis of several experiments for the USDA corn borer laboratory. Most involved balanced split plot studies. Data were summarized to assess the importance of various environmental changes on the egg disposition and hatchability of different strains of corn borer. Multiple regression and correlation techniques determined how temperature stimulated the sexual activity and flight of the female moth. A series of quadratic functions were fit to corn borer activity data to describe the effect of raising several generations of corn borer on artificial diets.

The Iowa Highway Commission asked for help with a goodness of fit test to compare the distribution of trip destinations for trucks entering Iowa for two different years. Richard Mensing worked with them, and also consulted on the problem of sample size needed to audit reported gas usage for large trucking firms using Iowa roads.

V.A. Sposito was in St. Louis in September to test large-scale linear programming models on the very large computers at McDonnell Douglas Automation. This is part of the development and testing of efficient computer techniques for the eventual solution of the large-scale model required under an Experiment Station NSF contract.

A UNESCO study involved genetic crosses of rabbits. Oscar Kempthorne assisted with the analysis.

Statistical Numerical Analysis and Statistical Data Processing groups work together within the

statistical numerical analysis and data processing section

directed by W.J. Kennedy. Together the two groups assist research workers with computer applications of statistics.

For the past year members of both groups have been actively engaged in the development of the Career Education Needs Information System (CENIS). The system utilizes sample data to study student interest, labor demand, labor supply and student follow-up for the Iowa Department of Public Instruction. It will provide more complete information to graduating high school students and planners in the 15 area community colleges about the projected needs of Iowa employers and the projected number of technically trained persons to satisfy the needs.

Members of the Statistical Numerical Analysis group teach, consult and conduct research which frequently results in the development of general purpose computer programs. GAUR, developed this year, brings to 12 the number of programs in the current "zoo" program series maintained by the section. Reference manuals explain how to use the programs and briefly describe the procedures. Developed by Dean Isaacson and V.A. Sposito, GAUR provides a computational procedure to give a complete analysis of a Markov chain. Several options and strategies have been implemented.

The first steps have been taken to develop an educational support group within the section to help researchers with difficulties they encounter in using the computer for statistical problem-solving. Richard Heiberger, assisted by graduate students, maintains the Statistical Analysis System (SAS), supervises the Statistical Package for the Social Sciences (SPSS) and OMNITAB. Catalogued procedures have been installed for these active programs. Dr. Heiberger has added several needed features to SAS. PROC PUNCH allows a SAS data set to be punched on cards for later use in other programs. PROC DUMMYVAR prints the dummy variables created by the regression procedure for classification variables. When space and support funds become available, a help room for instructors and students will be equipped with terminal hard-

W.J. Kennedy, right, and V.A. Sposito. In the background: Bud J. Meador.

ware connected to the computer and will have a complete library of routines as well as adequate staff to answer questions. Instructors will be helped with classroom use of the computer.

As a part of this long-term assistance project, doctoral candidate Jeff Meeker has video-taped a short course on OMNITAB. These tapes are available through WOI-TV, which will arrange for viewing. The university library is purchasing video-tape-playing equipment which will make these tapes as accessible as books. Additional tapes will be made to describe all the major software programs.

In December the Statistical Numerical Analysis group began work on a long-term care data analysis and reporting system for the Iowa Hospital Association. Programmer supervisor Wendell Smith reports that the initial version of the system is operational and data are being processed. Funded by the National Institutes of Health, this project ultimately will provide an historical-data-based reporting system for all participating long-term care facilities in the state.

An extensive time cost study was developed by Dr. Sposito for the Computation Center and the Department of Agricultural Economics, to analyze IBM's mathematical programming system versus Management Service's linear programming software packages. The results will determine how to proceed next year with a significantly large linear programming problem for agricultural economics which involves 15,000 constraints with 90,000 variables.

Three projects were completed during the year for the Iowa Conservation Commission: a fish age and growth study which continued last year's work; a Mississippi River creel census which updated the 1968 survey; and waterfowl research.

The Statistical Data Processing group consults with research workers on problems in statistical data processing, and serves as a liaison with the Computation Center to see that data are processed through the computer. Bud J. Meador is group supervisor.

This year's typical project required more help from the group than in the past because many users previously had used the data processing services offered by the Computation Center, prior to the retirement of Mrs. Mary Clem. With the increased workload per project, the number of projects handled during the year decreased about 25 percent. Since some departments have established one unsponsored account for a number of research workers, several projects now may be reported as one. With the implementation and development of the SAS and SPSS programming systems, many research workers were able to do their own data processing for certain applications.

Statistics on the origin of projects indicates that 32 percent of the work came from home economics, an increase over last year's 27 percent. Projects from sciences and humanities decreased from 37 to 28 percent. This year's 20 percent of work from agriculture is about the same as last year's 22 percent. Other sources accounted for the remaining 20 percent.

The group has become more active in the analysis and processing of grain crop data as well as in generating randomizations for experiment books and planting and harvesting labels for randomized block and lattice experiments. The Iowa Corn Yield Test Report is such a project where the planting, harvesting and analysis is further automated by the use of computing equipment and applied statistical procedures.

survey section

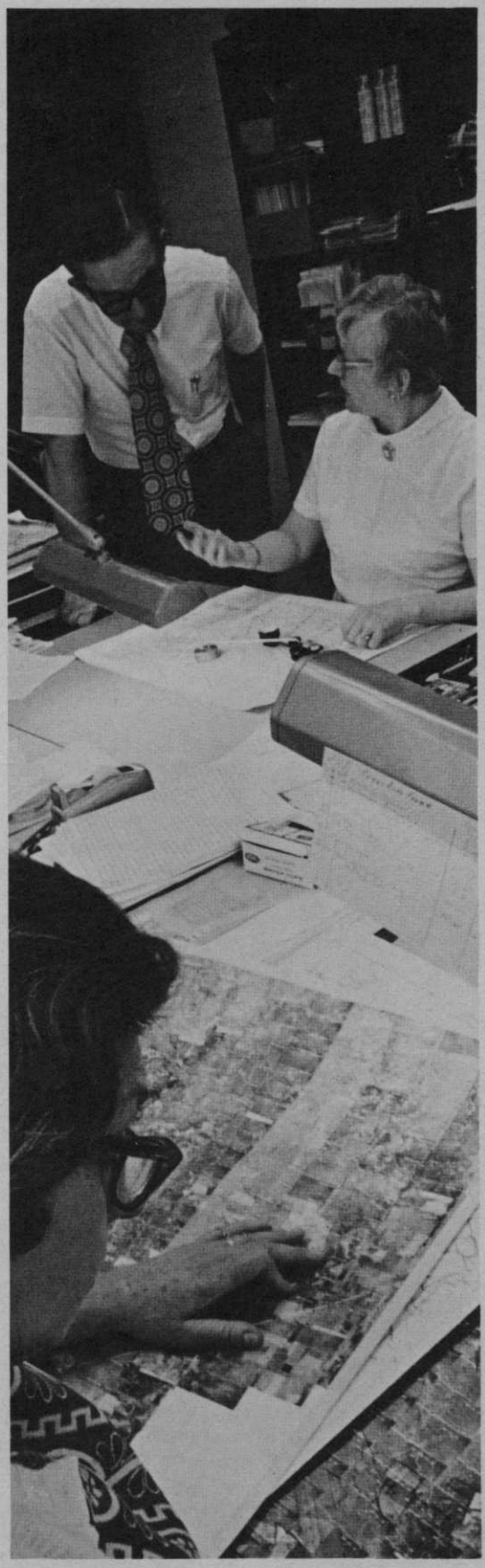
In addition to providing consulting support, the **survey section** provides direct operational services in sample design and survey methodology. Roy D. Hickman is in charge of the section. Staff members may assist in the planning of surveys; design and draw samples; aid with questionnaire construction and testing; train and supervise field personnel; collect data by personal interview, telephone or mail; edit and code data for processing; analyze data and maintain liaison with programmers and Computation Center staff on machine manipulation of data. Professional staff members also conduct research and teach courses in survey sampling.

The Survey Section has worked on some 35 projects during the year. About two thirds were for some campus department. Others were for the federal government, an Iowa governmental agency, another state or private agency such as the Mayo Clinic.

One large project for the Iowa Employment Security Commission will attempt to estimate the impact of extending unemployment compensation benefits to Iowa public employees at lower than federal and state levels. Samples were drawn to collect 400 names of potential beneficiaries in each of three classes. A pilot study ascertained the ability to locate the persons whose names appear on the sample list and tested the questionnaire. The interviewing has been conducted and estimates are now being developed.

The Survey Section participated in two studies related to the proposed reservoir on the Skunk River northeast of Ames. One sociological study was concerned with attitudes toward the proposal. Survey staff consulted on the design of the sample, drew the sample, carried out the field work and prepared the data for tabulation. The second study, conducted by the Institute of Urban and Regional Research at the University of Iowa, was concerned with the probable impact of the proposed reservoir on persons who would be forced to give up substantial amounts of land or who would be forced to move as a result of the reservoir construction.

A project for the Des Moines Independent School



Maps are important tools in the Survey Section. Roy D. Hickman, top, checks on a current project.

District will evaluate the results of a driver training program for physically handicapped persons in Iowa and selected adjacent states. A study of driver education students and programs in the state, made in cooperation with the Iowa Department of Public Instruction, will attempt to determine the effect of such programs upon the frequency of accidents and violations of participants. Interviewing of some 3,000 students has been completed and coding and data tabulations are in progress.

Advice on questionnaire construction and sample design was provided a researcher in zoology and entomology for a mail survey of pesticide users in Iowa. Samples of pesticide dealers, pesticide applicators, farmers, and ordinary householders were drawn. Operational services were provided in mailing out and checking the questionnaires. Coding and tabulation will also be done by the Survey Section.

Consulting and operational services were provided to the Mayo Clinic in a survey of residents of Olmsted County, Minnesota, to determine sources and adequacy of medical care. A sample of Missouri residents was designed and constructed for use in a study of nutritional characteristics, food habits and dietary conditions.

Advice was given on the design of a sample and a sample drawn for an economics study of attitudes and desires with respect to rural community development in a five-county area of northeast Iowa. Similar assistance was given for a nutrition study in Marshalltown and Ft. Dodge by sociology and food and nutrition personnel, and for a study of transportation needs of older people in rural towns in Story County conducted by a graduate student in engineering graphics.

Responses to the faculty budgetary questionnaire were coded and tabulated. Staff members assisted with the design and execution of a survey of 435 married faculty and students to determine the need for day care service in Ames.

Political science research on political attitudes of persons in relatively conservative, moderate and liberal areas was carried out in Adair, Marshall and Polk counties. The Survey Section consulted on the design of the sample, drew the sample, completed the field work and processed the data preparatory to computer tabulation.

A sample was designed and drawn of various types of Iowa firms to investigate the potential demand for persons completing training programs offered at the area vocational schools, for the Iowa Department of Public Instruction. Surveys were designed for three forestry projects: research on multifamily housing, construction and attitudes toward housing preferences, and recreation preferences. Analysis assistance was provided on two of the projects.

Assistance on a smaller scale was given to others.

Each year when this report is written we stress that there is no such thing as "typical" consulting projects, and no way to report the full extent of consulting activities. When one professor received our request for information he commented that "I realize how poor a record I keep of what I do." He decided to keep a one-day "diary"; on May 9, 1973, he recorded his activities. At the end of the day he commented that if he were to do it every day he would have to stay up half the night making notes or hire a special secretary to keep track of his time. His personal evaluation is that the record is "not very impressive." We believe it reports very well the basic work of a consultant whose substantive-area specialty is agriculture.

The professor is David F. Cox, who joined the Statistical Laboratory from the Department of Animal Science. His consulting is partially supported by the Agriculture Experiment Station. On this day he taught, consulted with clients and with his colleagues Paul Hinz, Holly Fuchs and Hans Zuuring. He answered correspondence and took care of some departmental business. The record is not typical of all consulting statisticians. It is not even a "typical" day for Dr. Cox. It is, simply,

one day in the life of a consulting statistician. . .

I arrive at the office at 7:30 to review a lecture on split plots in experimental design and the nature of error in these designs, for my 8 o'clock class. This is probably the single most important topic in the course because so often the data we see have this structure. If the students can grasp the concepts of a split plot design, consulting later with them on their theses research will be substantially easier.

"Experimental Design for Research Workers" (Stat 411-A, 40 students) meets from 8 to 8:50. It's not possible to cover all the material and describe and assign a final homework problem which will involve a rather large analysis of data arranged in a split plot pattern. Hints on the use of available computer programs are required just to get the students started.

Three students stop after class with questions. One wants an appointment to discuss his research and I tell him to phone because I don't carry an appointment book; I'd never keep it and my desk calendar coordinated. The second asks if his data are in a split plot arrangement. He briefly describes his experiments with chalk diagrams not easily followed, but it looks like a split plot design. The third student doesn't understand a computing problem on his last assignment. He doesn't have his computer output sheets but I think I remember his difficulty; it was fairly common in the class. I try to explain but the room is rapidly filling with the next class and I'm almost sure my explanation is inadequate. I tell him to stop at the office if he still has problems.

Back at the office I check with two graduate assistants to whom I assigned a rather large problem yesterday. The data involved dogs fed two different diets over long time periods. All sorts of measurements were taken on blood, weight, body chemistry, heart rates and blood pressure. The students had completed an initial listing and summary of the data. Problems included missing values from deceased dogs which created unbalanced structures. We decide to list means and make some plots and call the clients for another conference. Some data involving angles measured on muscle contractions looked like real problems to me. I decide to consult first with Paul Hinz.

Several items of correspondence await attention. First, a letter of recommendation for a recent Ph.D. in agronomy. That's easy; he was an excellent student ideally suited for the job described. I wish they were all that way. Next a memo to the graduate committee chairman suggesting some handouts that might save time at next week's meeting. A call from the University of Nebraska asks if I could recommend a recent or near B.S. graduate with statistics and computing background to help with work flow through their consultants and do some light programming. I pass the information to our undergraduate counselors, thinking how much I'd like to hire just such a person to help here.

A client from biochemistry arrives with data on the blood characteristics of lambs that have been fed varying amounts of lead. It's well organized and neatly arranged data but it involves repeated measures on very few animals. It looks like the variability will allow few conclusions but we will try. The data seem quite natural for a multivariate analysis, which I use very little; at least we'll start there. I'll bring Paul in to help with the analysis. The initial problem is much more mundane. She has no account number for the computer so I must explain the steps and forms required. I must do this many times a month; some dittoed instruction sheet might be more efficient. Without such an account we are powerless to do anything. Most students have no idea how to obtain support for computing and often offer to pay themselves rather than process the "red tape." I have rather strong objections to that. I feel the computer should be as accessible as the library.

My final morning appointment is a student investigating wildlife on Alaska's north slope. He collected data last year on nesting patterns of waterbirds, vegetation and other aspects of small ponds. We did a cluster analysis which he found most helpful. I'm convinced such analyses are one of our best tools: simple, easily understood and almost always helpful. We badly need more programs and research since our tools in this area are very primitive.

We also had given him some summary statistics and he was back with well thought out hypotheses he wished to examine. He needed some chi-square test of large contigency tables and some basic analyses of variance.

These data involve some interesting problems in whether the birds oriented their nests with existing topography. He had taken azimuths readings from the nest to the peak and right and left ends of the nearest ground rise. He then moved at random 30 yards from the nest and repeated the readings. I believe he has a legitimate way of measuring orientation at the nest site, but the analysis will tell whether these azimuth readings are useful.

Seldom do we have clients as well organized; I can take the work directly to our graduate assistants for processing. The only problem: he's leaving for another summer of data collection in Alaska within the week.

Lunch is a quick sandwich at my desk reading the latest issue of Science. The attack on the quality of agricultural research continues and is disturbing. I see many weak research projects but not all are in agriculture. I believe U.S. agricultural research has paid its way in our nation more than many other areas.

An entomology student is the first afternoon visitor. He's measuring CO_2 output in soils treated with various herbicides. The data are repeated measures over a long time and the correlation structure looks like some multivariate analysis is in order. However, the problem is too big for any existing programs that I know about, so some

sort of univariate, split-plot-like analysis will be tried.

The next visitor , from agronomy, is quite concerned about an experiment utilizing treatments arranged in a systematic fashion. The treatments come from lights arranged on poles to illuminate corn. The light intensity varies with the distance from the pole in a systematic non-random manner. He has been well trained in the necessity of randomizing treatments and this causes him some concern. I show him sections in Cochran and Cox's design book that deal with the problem. I'm almost sure we can handle these data. He'll have split-plots for variety and density of planting treatments as well as the lighting effects. Preliminary work shows night lighting may well be effective in increasing yields. What will the energy situation be if we must light all the cornfields in Iowa?

A happy coincidence as Paul stops to discuss some results on handling experiments where treatments are arranged systematically. He has the expectations and the error structure all laid out showing the appropriate tests. As I've just talked a person into doing such a design without really being sure we could handle the analysis, it's reassuring to know that it should be possible. Paul can help when these data come to us in the fall.

Next, a visitor from horticulture with questions about field plot technique with vegetable experiments. I know so little it is embarassing. How large should the plot be, are guard rows necessary, are there competition effects? I advise him to talk with his colleagues in horticulture but he says he's looking for new approaches. I suggest some things from my knowledge of vegetables in backyard gardens. He's willing to try, perhaps too willing, but he leaves satisfied. I hope I haven't ruined a summer's work.

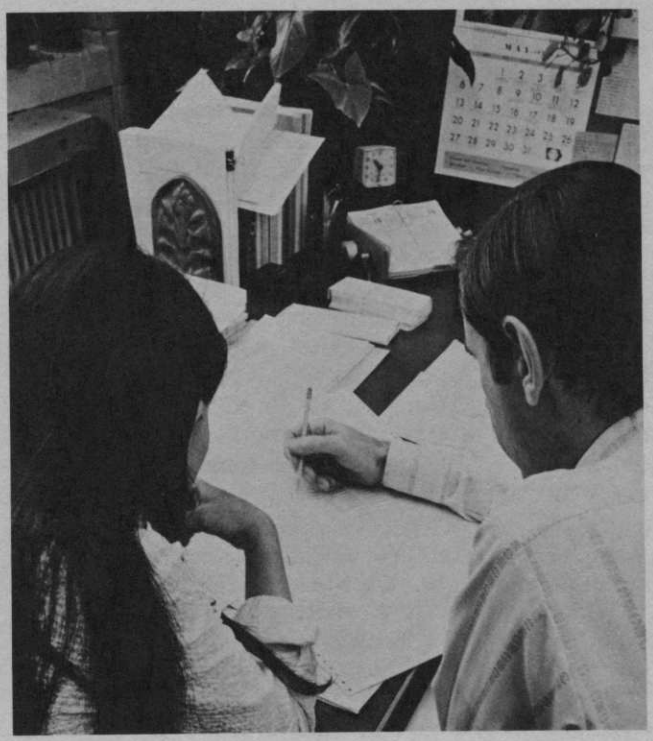
Hans Zuuring stops to ask how I cover incomplete block design in Statistics 411. He, too, is faced with too much material and too little time. I outline my general approach at the 411 level. I'm reminded of how primitive and inadequate the coverage is, but see no solution outside of more time to handle the situation.

Holly Fuchs is the last visitor of the afternoon. An extensive consulting project in home economics has led her into a large complex design. She is outlining the computing needed to handle the data and has many questions about the nature of the error in these experiments. She asks if we generally examine all the assumptions of additivity and homogeneity of variance. I must admit we do too little of such work mainly because there is not enough time or help for it.

The regular staff seminar comes at 4. Leroy Wolins discusses the allocation of resources in covariate designs when both dependent and independent variables are measured with error. The ideas seem quite useful and helpful.

In the evening I return to the office to set up the programs for three clients who are waiting longer than they should for data analyses. One is quite a complex genetic experiment that requires special programming as it fits no existing package program. Two are rather routine analyses but still require model specification and other details. To get a few program cards punched I go to the graduate-staff key punch room in the Computer Science basement. As usual there is a waiting line and it takes 10 minutes or so to get a machine. Every time that happens I wonder if it wouldn't be more efficient to rent one of these machines for our own use.

I leave at 9:30 p.m. and think about, but leave behind, the 165-page Ph.D. thesis that I should work over before the candidate's oral exam on Friday. Perhaps there will be some time tomorrow!



Dr. David F. Cox, consulting.

At a time when research funds are being widely cut, Statistical Laboratory staff have been awarded over $300,000 in grants and contracts for

current research

in statistics. Most grants are for continuation of current projects, indicating not only the importance of the statistical research, but illustrating the confidence shown in the principal investigators directing the research. Many have conducted research supported by the same agencies for many years. The Statistical Laboratory itself supports research of specific interest to regular university research programs. Other research is part of a continuing cooperative program with various campus research units.

T.A. Bancroft and Chien-Pai Han continued work on the power of analysis of variance test procedures for incompletely specified fixed models. A sometimes-pool test procedure is used when there is a doubtful error in the model. Power of the sometimes-pool test was computed and compared with the never-pool test. Based on these comparisons,

recommendations for the use of the preliminary test are being made.

Dr. Han has been investigating double sampling with partial information on auxiliary variables. He points out that it is well known that the precision of estimators can be improved if auxiliary variables are used. In particular, if the relationship is linear, a linear regression estimator is constructed. When the mean of the auxiliary variable is completely unknown, double sampling techniques can be adopted. If the experimenter has partial information about the mean, he may perform a preliminary test and construct a preliminary test estimator. Dr. Han has obtained the bias, mean square error and relative efficiency for the preliminary test estimator. He recommends levels of the preliminary test and optimum allocation of sample sizes. When the prior distribution of the mean of the auxiliary variable is normal, a maximum likelihood estimator is obtained.

While serving as a visiting professor in Japan from March 28 through May 31, sponsored by the Japan Society for the Promotion of Science, T.A. Bancroft and his host scientist, Masashi Okamoto of Osaka University, collaborated on research in the area of incompletely specified models in multivariate statistical analysis. Specifically, the problem considered involves investigating the performance of the procedure of testing the equality of mean vectors of two multivariate normal populations after a preliminary test of the equality of the two covariance matrices.

C.P. Cox has been concerned with research on the essentially linear regression model. It is well known that the model

$$y_i = \sum_{j=0}^{p} \phi_j(\underline{x})\ \psi_j(\underline{\beta}) + \epsilon_i,$$

whereby an observation is regarded as the sum of a random element ϵ and a sum of products of which one member consists entirely of input variables $\underline{x}$ and the other entirely of parameters $\underline{\beta}$, can be treated by essentially linear estimation procedures. As a still essentially linear model, the generalization

$$\phi_0(\underline{x}) + \sum_{j=1}^{p} \phi_j(\underline{x})\ \psi_j(\underline{\beta}) = \epsilon \text{ has}$$

been examined. The model has direct relevance when observations $\underline{x}$ are relatively error-free measures of inputs into a system operating in accordance with the left hand side and of which the end-point, such as the death of an organism, is subject to observational error variability. The model has been applied to fitting a rectangular hyperbola $(x-\beta_2)\ (x-\beta_1) = \beta_0$ in the form $x_i y_i + (\beta_1\beta_2 - \beta_0) - \beta_1 x_i - \beta_2 y_i = \epsilon_i$ to biological data. The results agree closely with those from a more complicated procedure requiring the iterative techniques usual in such non-linear situations.

order statistics and nonparametric statistics

A grant from the U.S. Army Research Office with the above title is under the direction of Dr. H.A. David, thus continuing his 15-year association with AROD. An investigation is being made of the properties of concomitants of order statistics, that is of the y-values paired with the *ordered* x-values in a sample from a bivariate, usually normal, distribution. Dr. David has prepared a paper on the asymptotic properties of such concomitants and together with Martin O'Connell is studying their small-sample properties as well as possible applications.

Dr. David has completed a short article on "Waiting time paradoxes and order statistics" to appear in JASA and is currently reviewing parametric approaches to the theory of competing risks, with special emphasis on the case when risks cannot be assumed to be independent.

linear models and analysis of variance research procedures

The National Science Foundation has supported research on the development and integration of linear model theory, design and analysis of experiments, and general problems of data analysis and inference from experimental and observational data. Drs. Oscar Kempthorne and George Zyskind are the principal investigators. The doctoral research of Kenneth Merritt, Richard Stein and William Warde was partially supported by this grant. Abstracts of their theses appear in the publications section.

Additional work resulted in a letter from Dr. Zyskind to the *American Statistician,* and in individual papers by Dr. Kempthorne and Dr. Zyskind in Mexico and at the International Symposium on Design and Linear Models in Colorado. Manuscripts are in various stages of preparation by former postdoctoral associate John Kinney on expanding and streamlining certain previous formulations concerning generalized polykays, by Drs. Kinney and Zyskind on experimental structures and expected mean squares, by Drs. Stein and Zyskind on conditional inverses and linear models.

Dr. Kempthorne has worked on the topic of best linear unbiased estimation and on general aspects of data collection and interpretation.

Dr. Zyskind has been exploring certain aspects of conditional inverses, has pursued further consequences of aspects of a possibly singular covariance matrix $\sigma^2 V$ in linear model work, has worked on relations among linear models partitioned according to various ways, and together with Dr. Kempthorne has been developing work on experimental models in which randomization is constrained.

Different characterizations of various subclasses of conditional inverses are also being investigated.

In the case of $X\hat{\beta} = Py$ arising from the solution of appropriate general normal equations $X'V^*X\beta = X'V^*y$ the operator $P = X(X'V^*X)^-X'V^*$ projects onto $\mathcal{C}(X)$, the column space of the design matrix X, but the direction along which it projects depends on the choice of the particular admissible V^* used. Thus, though $X\hat{\beta}$ is numerically invariant, yet various operators P, with $\mathcal{C}(P) = \mathcal{C}(X)$ result. The variable directions, $\mathcal{C}(I - P)$, along which projections are carried out, all contain the unique space of actually obtainable residuals $y - X\hat{\beta}$, when y is constrained to $\mathcal{C}(X) + \mathcal{C}(V)$, the vector space actually permitted it in view of the problem specification. Work on such matters and also on comparisons and unification with some recent formulations of Rao and Mitra (1971) and of Rao (1971) is currently in progress.

Research of graduate student Kazimierz Karpinski, directed by Dr. Zyskind, relates to the ideas of experimental structure and randomization. In previous work cap sigmas were introduced and widely used for simplicity of expression of expectations of quadratic forms, primarily in random model situations. Specialized forms of the cap sigmas, called conditional cap sigmas, are defined, and used to obtain simple expressions for variances and expected mean squares in mixed model situations. They are also used in deriving expected mean squares of single degree of freedom contrasts in randomized experiments. For p^m factorials additional cap sigmas are defined which allow simple expressions for expectations of quadratic forms associated with the (p-1)-degree of freedom partitions of the interactions. Applications of the cap sigmas to factorials, confounding, and fractional replication are examined. Some preliminary work has been done on the role of randomization in the missing value situation and the analysis of covariance.

Robin Thompson, a visiting associate from Edinburgh, has extended procedures for estimating variance and covariance components to deal with data with hierarchal structure. The relationship of relatively well established procedures for the recovery of inter-block information with methods based on the fairly recent developments of MINQUE estimates and Fraser's structural inference has been considered.

mathematical and statistical genetics

Drs. Oscar Kempthorne and Edward Pollak direct research in mathematical and statistical genetics which is supported by the National Institutes of Health and by Agriculture Experiment Station Project 1669. Abstracts of papers by Drs. W.G. Hill and Pollak which report some of this work appear in the publications section.

Work has continued on the dynamics of genetic populations under a simple model involving mating, life tables, and reproductive abilities. The problem of the maintenance of polymorphism in a subdivided population was considered from a stochastic point of view. It was possible to compute survival probabilities, which is not possible with deterministic theories.

Dr. G.L. Ghai has done further research on the analysis of nonrandom mating models involving (i) partial inbreeding and (ii) partial assortative mating. Ted Emigh and Dr. Kempthorne have continued the logic and statistical methodology of studies investigating the role of heredity and environment in humans. The effective number of alleles that can be maintained in a population that varies in size was calculated by Drs. A.B. Chia and Pollak. Some work was done by Dr. Chia on the more difficult problem of determining the mean number of alleles that can be maintained in such a population.

Some theory of linkage disequilibrium in finite populations with more than two loci at which there is no selection has been developed by Dr. Hill. Results have been obtained for expected values of disequilibria for up to six loci and for their variances for up to three loci. The theory of change in frequency of a gene as a function of time when there is random fluctuation of selection intensities was reexamined by Dr. Louis Jensen. The currently used theory is wrong. A solution has been obtained for fixation probabilities in a special case.

Robin Thompson has developed formulae for estimating genetic parameters by maximum likelihood, when information on parents and their offspring is available for more than one trait. The effect of selection of parents and the family structure on the precision of the estimates has been investigated. Designs to estimate maternal effects have been considered. Typically in such cases a relatively large number of genetic parameters are of interest and these usually are imprecisely estimated. The effect of reparametrization suggested by Falconer is being studied.

Drs. Pollak and Kempthorne have shown that the rate of increase of the average Malthusian parameter tends as time increases to the genotypic variance in the parameter for a diploid random mating population with viability differences. With all matings equally fertile and suitable definitions of Malthusian parameters the relationship is shown to hold for all time.

design of experiments and analysis of data

Agriculture Experiment Station Project 890 continued to support research directed by Dr. Oscar Kempthorne. One area of concern during the year has been the theory of linear statistical models, which underlies most methods of analysis of experiments.

Further work has been done on the sampling of combinations in a factorial set-up. Other research explored relations and lack of them between ideas of data analysis and theories of inference; examined the validity and utility of neo-Bayesian ideas and proposals; and investigated aspects of the biometrical study of inheritance.

research to formulate improved techniques for estimating farm and related characteristics by sample surveys

A new research project for USDA was started this year under Agriculture Experiment Station Project 1753: to investigate the reasons why farmers respond or refuse to respond to requests for information in sample surveys. Project 1753 also supported continuing research in four areas during the year: sample frame construction, soil conservation needs inventory, response error studies and use of auxiliary data in surveys. Dr. Roy D. Hickman is project director.

Area sampling frames are being constructed based upon degree of cultivation to enable the Statistical Reporting Service, USDA, to design surveys which can be conducted at the lowest possible cost, by clustering, while reducing the variance of characteristics to be estimated. A stratification procedure subdivides land into two primary strata: non-open country areas (built-up areas for cities or towns and adjacent areas) and open country areas. The open country areas are substratified upon degree of cultivation into intensively farmed land, extensively farmed land, and nonagricultural land. After stratification, count units are formed, from which sampling units will be drawn. Nebraska and Arkansas frames were completed this year and work was started on Kansas and Oklahoma. The area frame for Texas is also being revised and updated.

Original data in the soil and water conservation inventory were updated for the remaining 20 states. Soil names for each of the three remaining states were assigned and added to the data sets. Watershed-land resource area diagnostics were run for 12 states and corrections made in three states. Experimental tabulations were produced for selected land resource areas and water basins. Data processing programs for storing and printing the interpretive analysis of the soil data are near completion, and further programs are being developed to produce cross-classification tabulations on soil characteristics.

Analysis of the data for the response error study in selected Iowa counties was completed. The final report was submitted to USDA.

Research on the use of auxiliary data in survey design and analysis of survey data to increase efficiency in estimation continued under the direction of Dr. B.V. Sukhatme. 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 with reference to data on fruit crops. The validity of approximations to the bias and mean square error of ratio-type estimators is also being investigated, through an empirical study with reference to data on fruit crops for a population of 1458 segments spread over 50 townships.

analysis of data and design of surveys

Research supported by Agriculture Experiment Station Project 1806 has been directed by Dr. Wayne Fuller. Abstracts of papers by Battese and Fuller, which report some of this work, appear in the publications section.

In the estimation of crop-response functions from crop-rotation experiments, estimators were constructed which take account of the correlations in the yield data arising from split-plot experiments. From the estimated, yearly response functions, average annual return and variance of annual return were estimated.

Estimation of linear regression models requiring the estimation of the variance of the residuals have been investigated and the limiting properties of the estimators derived.

mathematical statistics and probability

Drs. Barry Arnold, H.T. David, Dean Isaacson, Glen Meeden and Richard Mensing continued research in mathematical statistics and probability with Dr. David as project coordinator.

Dr. Arnold investigated certain characterizations of the exponential distribution based on univariate and multivariate geometric compounding. These characterizations are related to, and in part motivated by, corresponding characterizations of the Poisson process among renewal processes. He continued research on waiting time distributions in certain combinatorial problems related to learning models and simple tournaments.

Dr. Isaacson's continued interest in martingale theory resulted in a publication on decomposing

square integrable martingales. His work with Dr. Richard Madsen on the strong ergodicity of non-stationary Markov processes also was published. Abstracts of both papers appear in the publications section.

An abstract of Dr. Meeden's paper on Bayes estimation also appears. He has considered the problem of estimating θ with squared error loss when X is a normal $(\theta,1)$ random variable. Let $g(\theta)$ be a prior distribution for θ and let $\delta_g(X)$ be the Bayes estimate for θ relative to g. His research concerns relating the behavior of g to the behavior of δ_g, particularly to discover how the behavior of g for large values of θ affects δ_g for large values of x.

Dr. Mensing continued research in the area of probability models in saturated queues, in which Dr. David participated, studying applications of deterministic queueing theory to airport congestion problems. Dr. David also worked on computing algorithms for Markov decision problems and sequential design of experiments, on convergence rates for posterior distributions in Markov decision problems, and on questions of admissibility of multivariate normal observations according to criteria other than mean square error.

use of preliminary test(s) of significance in designing surveys and analysis of survey data

Principal investigator B.V. Sukhatme continued research on design and analysis of sample surveys, supported by the U.S. Office of Education.

In the area of allocation in stratified sampling based on preliminary test of significance, the efficiency of an allocation called "sometimes proportional allocation" depends upon the choice of level of significance of the preliminary test. A table now has been prepared recommending optimum levels for varying strata weights and initial sample sizes.

Graduate student Joseph Grimes continued research, under Dr. Sukhatme's guidance, on use of auxiliary data in providing an efficient estimate of the population mean. If information on an auxiliary variable X, correlated with the variable Y under study is available, regression type estimates are frequently used to obtain more efficient estimates of the population mean $\bar{y}_N$.

One of the estimates belonging to this class is the difference estimate which assumes knowledge of the true value of the regression coefficient of Y on X. If no knowledge is available concerning the true value of the regression coefficient, the usual practice is to estimate it from the sample and use the regression estimate. Based on past experience, it is often possible to make an intelligent guess about the true value of the regression coefficient. In this situation, a new regression-type estimate based on a preliminary test of significance of the regression coefficient has been proposed. If on the basis of the test of significance, the guessed value is accepted as the true value of the regression coefficient, the difference estimate is used to estimate the population mean $\bar{y}_N$. Otherwise, the regression estimate is used. An exact expression for the variance of the proposed estimate has been obtained and used to discuss its efficiency with respect to the difference estimate and the regression estimate.

usdc, bureau of the census research

Much of the research supported by the continuing cooperative agreement with the U.S. Bureau of the Census is reported in abstracts in the publications section. Project director Dr. Wayne Fuller directed the graduate research of doctoral candidates Her Tzai Huang and J.D. Jobson. Papers with Booth, Burmeister and Jobson also report research partially supported by the Census contract.

Estimation of the population total when the sampled population is listed on two frames was considered. Estimators were derived for the situation of unknown amount of duplication in the frames. The estimators have bias of smaller order and smaller mean square error than those in the literature.

Estimation of the individual "true values" and the population total was considered when two determinations are obtained from each of the sample units and response errors are present. Estimators of the weights which are a function of the response variances and covariances were constructed. The classification of sample units into one of two classes was considered when duplicate determinations contain classification errors.

Recently Dr. Fuller has worked on modification of the limited information estimator and demonstrates that the modified estimator possesses finite moments and that one member of the class has bias of order T^{-2}. The estimator is a member of the k-class estimators originally introduced by Theil (1958).

Restricting the modified fixed k-class estimator and the modified limited information estimator to have the same, but arbitrary, bias, it is shown that to order T^{-2} the modified limited information estimator dominates the fixed k-class estimator; there exists no set of parameters for which the fixed k-class estimator has a smaller mean square error.

Much of the research conducted at the Statistical Laboratory is reported in papers presented at professional meetings, which frequently are published, and in

publications

written for professional journals. Staff members take an active role in the publication of these journals, often serving as referees and editorial collaborators. Wayne Fuller has recently become an associate editor of the applications section of *JASA*. Oscar Kempthorne was named to the International Advisory Board of *Communications in Statistics*. He is an associate editor of *Biometrics*. Dr. Kempthorne and T.A. Bancroft continue on the editorial advisory board of the *Journal of Statistical Computation and Simulation*.

A Spanish translation of George Zyskind's class notes, "Teoria General de las Hipotesis Lineales," has been published by the Graduate College of the National School of Agriculture in Chapingo, Mexico, for use in classes at Centro de Estadistica y Calculo. The translation was prepared by ISU graduate Dr. Angel Martinez.

Abstracts of papers published during the fiscal year by staff members and graduate students appear in this

record of published research.

When the research was conducted at Iowa State but the author has since accepted a new position, his current location is listed in parentheses 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 (*).

*Barry C. Arnold: "Some Examples of Minimum Variance Unbiased Estimates." The American Statistician, 26:4, 34-36. October 1972. Statistical Laboratory Reprint Series No. 301.

An alternative, which retains the pedagogical value without the accompanying faults, is suggested to Tenenbein's (1971) example of construction of a minimum variance unbiased estimate of a certain integer valued parameter. An example is given in which a unique minimum variance unbiased estimate exists despite lack of completeness of the family of distributions of a minimal sufficient statistic.

*Barry C. Arnold: "The Waiting Time Until First Duplication." Journal of Applied Probability, 9, 841-846. 1972. Statistical Laboratory Reprint Series No. 305.

Balls are drawn with replacement from an urn containing m distinguishable balls until a match is noted. The distribution of the number of drawings required is considered in the case where only the last k balls drawn are remembered. The asymptotic behavior of this distribution, as m and k become large, is investigated. Two further variants of the problem are suggested.

*Barry C. Arnold: "Some Characterizations of the Exponential Distribution by Geometric Compounding." SIAM Journal of Applied Mathematics, 24:2, 242-244. March 1973. Statistical Laboratory Reprint Series No. 311.

If, for every $p \epsilon (0,1)$, p times a geometric (p) sum of independent identically distributed nonnegative random variables has the same distribution as the individual random variables, then the random variables are exponentially distributed. "For p every $p \epsilon (0,1)$" can be weakened somewhat; it can be replaced by "for some $p \epsilon (0,1)$" if first moments are assumed to exist. Related characterizations of the power function distribution and of the Poisson process, and the effects of dropping the assumption of nonnegativity of the random variables are discussed.

*T.A. Bancroft: "The Statistical Community and the Protection of Privacy." The American Statistician, 26:4, 13-16. October 1972. Statistical Laboratory Reprint Series No. 294.

The author discusses the individual's ability to control the circulation of information relating to himself in the official data programs of the federal government. He recommends the establishment of an American Statistical Association Committee on the Protection of Privacy.

*George E. Battese and Wayne A. Fuller: "Determination of Economic Optima from Crop-Rotation Experiments." Biometrics, 28:3, 781-792. September 1972. Statistical Laboratory Reprint Series No. 300.

Methodology is presented by which several crop rotations in a long-term rotation experiment may be compared. Response functions are specified for each of the crops in each of the rotations. The net-return and variance-of-return functions, which are defined for each crop rotation, are considered the basis for selecting optimal rotation and fertilization practices.

*C. Philip Cox: "On Estimating Relative Potency from Quadratic Log-Dose Response Relation-

ships." Biometrics, 28:3, 875-881. September 1972. Statistical Laboratory Reprint Series No. 299.

A simple method for estimating relative potency from a quadratic response log-dose bioassay has been proposed by Elston (1965). An equivalent, alternative, simpler analysis is described.

*H.A. David: "Enumeration of Cyclic Graphs and Cyclic Designs." Journal of Combinatorial Theory B, 13:3, 303-308. December 1972. Statistical Laboratory Reprint Series No. 304.

The close relationship of cyclic graphs and cyclic designs is pointed out. An explicit formula is given for the number of nonisomorphic cyclic graphs with a prime number of vertices, and a general constructive method of enumeration is developed. The problem is shown to be the same as that of enumerating cyclic paired-comparison designs previously considered by the author (1965). The earlier results are extended and modified.

Dah-yinn Lee, **Herbert T. David** and **Richard W. Mensing:** *Evaluation of Gap-Graded Asphalt Concrete Mixtures. Part I: Mechanical Properties,* 126 pp.; *Part III: Appendix,* 73 pp. January 1973.

Richard W. Mensing, Dah-yinn Lee and **Herbert T. David:** *Part II: Statistical Design and Analysis,* 56 pp. February 1973.

Results are presented of a comparative laboratory study between well- and gap-graded aggregates used in asphalt concrete paving mixtures. A total of 424 batches of asphalt concrete mixtures and 3,960 Marshall and Hveem specimens were examined.

There is strong evidence that, with proper combinations of aggregates and asphalts, both continuous- and gap-graded aggregates can produce high density mixtures which meet current design criteria. It is suggested that the unqualified acceptance of any particular particle size distribution, such as Fuller's curve $P = 100\ (d/D)^n$, is not justified.

The statistical analysis involved a calibration study, the design and analysis of an experiment, and a survey. The calibration study compared the compaction procedure of the Iowa State University and Iowa Highway Commission laboratories. By an analysis of the errors associated with the measurements, the "preparation" and "determination" errors were separated for each laboratory and a calibration curve describing the relationship between the compaction procedures at the two labs was developed. The experimental design phase involved a split plot fractional factorial experiment to measure several factors on asphalt concrete strength and weight. Half normal plotting techniques to indicate significant factors and interactions and estimate errors were outlined in this connection.

The survey phase involved the mailing of a questionnaire to a panel of 25 key civil engineers, asking each to rate a set of hypothetical concrete mixtures, as characterized by the values of five commonly used test measures. For each engineer a "rating function" was then derived on the basis of his responses. Finally, a "grand rating function" was developed by averaging the rating functions of all respondents. It's hoped this "grand rating function" may be used to evaluate actual mixtures after they have been tested by the five measures featured in the study.

James S. DeGracie and **Wayne A. Fuller:** "Estimation of the Slope and Analysis of Covariance When the Concomitant Variable Is Measured With Error." Journal of the American Statistical Association, 67:340, 930-937. December 1972.

Estimators of the slope for models with errors of observation in the explanatory variable are investigated. Estimators are developed which have a bias of smaller order and smaller mean square error than the common estimator. These estimators of slope are utilized in the analysis of covariance where the concomitant variable is measured with error. The procedure is applicable for any number of treatments or determinations per treatment. An example illustrates the computations.

Wayne A. Fuller and **Gordon D. Booth:** "The Errors-in-Variables Model When the Covariance Matrix Is Not Constant." Proceedings of the American Statistical Association, Business and Economic Statistics Section, 309-313. 1972.

The model $z_t\beta = 0$; $t = 1,2,\ldots,n$, where z_t and β are unobservable $(p+1)$ dimensional vectors, is considered. It is assumed that $Z_t = z_t + \epsilon_t$, $t = 1,2,\ldots,n$ can be observed, where $E(\epsilon_t) = 0$ and $E(\epsilon_t \epsilon_t') = \Sigma_t$, $t = 1,2,\ldots,n$ and $E(\epsilon_t \epsilon_m') = 0$ for $t \neq m$. The Σ_t, $t = 1,2,\ldots,n$ are assumed known.

An estimator of β is presented and its asymptotic properties are derived.

Wayne A. Fuller and Leon F. Burmeister: "Estimators for Samples Selected from Two Overlapping Frames." Proceedings of the American Statistical Association, Social Statistics Section, 245-249. 1972.

It is assumed the frame sizes, N_A and N_B, of two overlapping frames, A and B, are known. Samples of sizes n_A and n_B are drawn from frames A and B, respectively. Elements are contained in frame A only, in frame B only and in both frames. These sets of elements comprise domains a, b and ab respectively.

Estimators of the population total are developed for the size of domain ab unknown. It is shown that the mean square errors of the suggested

estimators are smaller than those for estimators previously suggested.

*A.R. Gallant (North Carolina State University, Raleigh) and Wayne A. Fuller: "Fitting Segmented Polynomial Regression Models Whose Join Points Have to Be Estimated." Journal of the American Statistical Association, 68:341, 144-147. March 1973. Statistical Laboratory Reprint Series No. 316.

The problem of finding the least squares estimates for the unknown parameters of a regression model consisting of grafted polynomial submodels is considered. The abscissae of the join points are a subset of the unknown parameters. Examples illustrate how continuity and differentiability conditions can be used to reparameterize the model to allow Modified Gauss-Newton fitting to be extended to this problem.

Gauri L. Ghai and Oscar Kempthorne: "The Dynamics of Populations Under Partial Inbreeding." Journal of the Indian Society of Agricultural Statistics, 23, 142-151. Journal Paper J-6827, Iowa Agriculture and Home Economics Experiment Station, Project 1669.

In this paper theoretical models have been developed for populations under partial consanguineous matings. The genotypic distributions are discussed. It is determined that these mating systems can maintain a considerable amount of heterozygosity at equilibrium, in predominantly inbred populations. The level of heterozygosity depends upon the system of mixed mating, amount of inbreeding and the initial heterozygosity. Relative effects of different systems are discussed.

*Richard A. Groeneveld: "Asymptotically Optimal Group Rank Tests for Location." Journal of the American Statistical Association, 67:340, 847-849. December 1972. Statistical Laboratory Reprint Series No. 309.

The asymptotic efficiency of a simple group rank test is examined in the case of 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.

Richard M. Heiberger: "Remark on Algorithm 405–Roots of Matrix Pencils: The Generalized Eigenvalue Problem." CommACM 15:12, 1074. December 1972.

A distinction is drawn between the usual definition of "generalized eigenvalues" and the "rank-reducing numbers" calculated by Algorithm 405 (Dell et al., 1971). Modifications are suggested to the algorithm to permit it to calculate either generalized eigenvalues or rank-reducing numbers at the user's option.

William G. Hill (Institute of Animal Genetics, Edinburgh): "Estimation of Realised Heritabilities from Selection Experiments. I. Divergent Selection; II. Selection in One Direction." Biometrics, 28:3, 747-765; 767-780. September 1972.

I. Methods of estimating realised heritability from selection experiments are compared. It is found that for most relevant combinations of parameters, some simple linear estimators are almost as efficient as a maximum likelihood estimator, and can be recommended for practical use. Standard methods of calculating the variance of these estimators are shown to be very biased; methods using experimental data, which are almost unbiased, are described.

II. Two types of design are analyzed. When no control population is kept, the best linear estimator is usually the regression of cumulative response on cumulative selection differential. This estimator generally is satisfactory even when a control is maintained. Methods of estimating the sampling variance of the realised heritability and the variance due to common environment effects are described and discussed.

R.M. Wangen, W.W. Marion and D.K. Hotchkiss: "Influence of Age on the Fatty Acid Composition of Breast and Thigh Muscles of Male Turkeys." Agricultural and Biological Chemistry, 36:12, 2081-2086. 1972. Journal Paper J-7030, Iowa Agriculture and Home Economics Experiment Station, Project 1846.

Muscle samples were excised from 70 large white male turkeys. Fatty acid distribution in lipid of breast and thigh muscles was studied at 4-week intervals from 4-28 weeks of age. Advancing maturity and muscle type affected distribution.

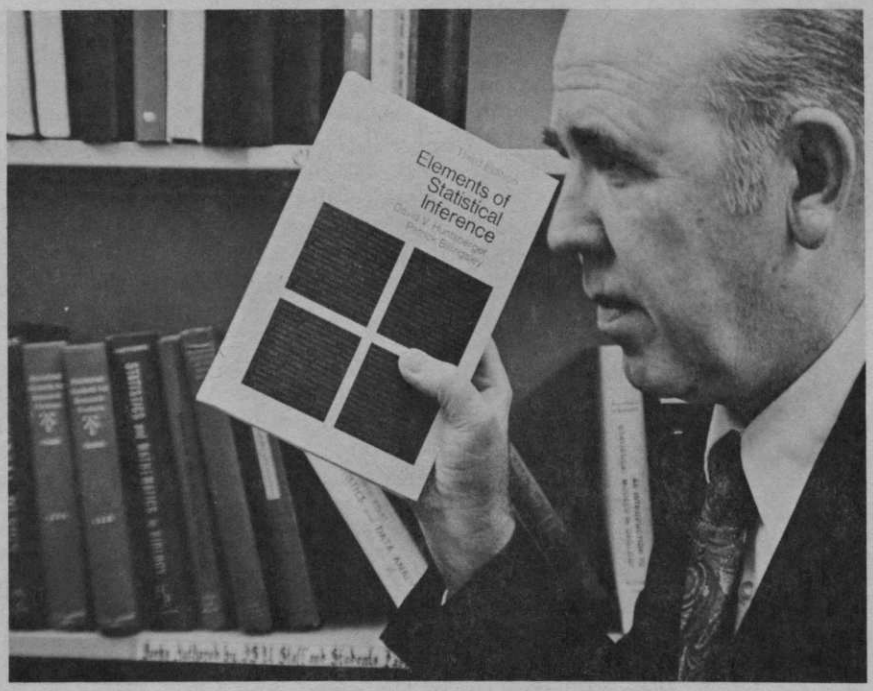
David V. Huntsberger and Patrick Billingsley: *Elements of Statistical Inference,* 3rd edition. 336 pp., Allyn and Bacon, Inc., Boston. 1973.

This introduction to the nature of statistics provides students with a sound understanding of fundamentals. Designed for an elementary statistics course, the concepts presented are applicable in all the quantitative sciences. Random variables, sampling and conceptual bases are emphasized in this new edition, and finite sample space is explicitly introduced. A workbook and instructor's manual are available.

*James L. Hutter (Department of Political Science, ISU): "Statistics and Political Science." Journal of the American Statistical Association, 67:340, 735-742. December 1972. Statistical Laboratory Reprint Series No. 314.

In a survey of articles and research notes in seven political science journals published over 2½ years, the author indicates the increase of political science's reliance on quantitative data and statistical and mathematical techniques. Statisticians' atten-

D.V. Huntsberger holds the newest addition to the Statistical Laboratory reading room, the third edition of his book.



tion is directed to the difficulties associated with political science data.

Dean Isaacson: "A Decomposition of Square Integrable Martingales." Z. Wahrscheinlichkeitstheourie verw. Geb., 23, 327-330. 1972.

Let $(M_t, \mathfrak{F}_t)_{t \geq 0}$ and $(N_t, \mathfrak{F}_t)_{t \geq 0}$ be continuous square integrable martingales on $(\Omega, \mathfrak{F})$. A well known decomposition theorem given by P. Meyer says that M_t can be uniquely written as $M_t = {}_0\int^t \phi_s dN_s + \alpha_t$ where $\langle \alpha, N \rangle_t \equiv 0$. In this paper we get a similar decomposition in which the integrator is not necessarily N_t but rather some square integrable martingale N_t^* with $\langle N \rangle_t \equiv \langle N^* \rangle_t$. The remainder term, α_t, in this case has the property that the measure induced on $[0, \infty]$ by $\langle \alpha \rangle_t$ is singular with respect to the measure induced by $\langle N \rangle_t$ for a.e.ω. This singularity condition is shown to imply $\langle \alpha, N \rangle_t \equiv 0$. The decomposition given in this paper is a generalization of the theorem that says M_t can be expressed as an integral with respect to *some* Brownian motion, X_t, if and only if $d\langle M \rangle_t << d\langle X \rangle_t$.

Dean Isaacson: "On a Subclass of Square Integrable Martingales. "Proceedings of the American Mathematical Society, 34:2, 521-526. August 1972.

Let $\mathcal{M}_2^*$ denote the class of continuous, nowhere constant, square integrable martingales, $M(t) = X(\langle M \rangle_t)$, for which $\langle M \rangle_t$ is a time change on the σ-fields generated by the Brownian motion X(t). It is shown that if $M(t) \in \mathcal{M}_2^*$ then the family of σ-fields generated by M(t) is a right continuous family. If $M(t) \in \mathcal{M}_2^*$ and if $\sigma\{M(s): s \leq t\}$ for some Brownian motion X(t), then $M(t) = \int_0^t \Phi(s) dX(s)$ and $X(t) = \int_0^t (1/\Phi(s)) dM(s)$ for some process $\Phi(s)$ with $\Phi(s) \neq 0$ a.e. dt × dP.

G.N. Lauer (Owens-Illinois Technical Center, Toledo) and **C.P. Han:** "Joint Distribution Function of Certain Ratios of Chi-Square Variates." Journal of Statistical Computation and Simulation, 1, 255-260. 1972.

Formulas are derived for the numerical computation of the joint distribution function of certain ratios of chi-square variates. The form is general enough to include the incomplete beta, F, t, and the distribution of certain Behrens-Fisher statistics.

Richard W. Madsen (University of Missouri, Columbia) and **Dean L. Isaacson:** "Strongly Ergodic Behavior for Non-stationary Markov Processes." Annals of Probability, 1:2, 329-335. April 1973.

The authors consider ergodic behavior of those non-stationary Markov processes which can be represented by a sequence of stochastic kernels, $\{P_n(x,y)\}$, defined on a σ-finite measure space $(S, \mathfrak{F}, \mu)$. In particular, the convergence of the superpositions, $P_1P_2P_3 \ldots P_n$, of these kernels is related to the convergence of their corresponding left eigenfunctions, Ψ_n, where $\Psi_n(y) = \int \Psi_n(x) P_n(x,y) \mu(dx)$ and $\int \Psi_n(y) \mu(dy) = 1$.

It is then shown how these results can be extended easily to the general case where densities are not assumed.

***Glen Meeden:** "Bayes Estimation of the Mixing Distribution, the Discrete Case." Annals of Mathematical Statistics, 43:6, 1993-1999. December 1972. Statistical Laboratory Reprint Series No. 307.

Let $X_1, X_2 \ldots$ be independent identically distributed random variables taking on values in the positive integers with a family of possible probability distributions indexed by $G \in \mathcal{G}$, the class of all probability distribution functions on $[0, +\infty)$. Under the assumption that the family is identifiable, the true but unknown G_0 is estimated by constructing a prior probability distribution on $\mathcal{G}$ and showing that the Bayes estimate corresponding to the prior is consistent.

*Takis Papaioannou (University of Georgia) and **Oscar Kempthorne:** "Parallel Tangents and Steepest Descent Optimization Algorithm—A Computer Implementation with Application to Linear, Partially Linear Models and Qualitative Data." Journal of Statistical Computation and Simulation, 1, 349-376. 1972. Statistical Laboratory Reprint Series No. 303.

A computer implementation of the "partan" and steepest descent optimization algorithms is presented. Problems solvable by the present routine are described, line minimization is discussed, and the results of test problems are given. The program is analyzed and documented. Some ideas on fitting partially linear models and minimum likelihood estimation of linear or nonlinear models with variance-covariance matrix depending on the parameters are also reported. Special attention is paid to the analysis of multidimensional contingency tables.

*Edward Pollak: "Some Effects of Two Types of Migration on the Survival of a Gene." Biometrics, 28:2, 385-400. 1972. Statistical Laboratory Reprint Series No. 298.

The fate of a mutant gene in a large population, living in K partially isolated niches, is considered. Two models are studied: when gametes migrate independently of each other and selection takes place before migration, and when adults migrate and then settle down to produce offspring and there is selection of the young. Conditions under which lines descended from mutant genes are certain to become extinct are the same for both models and are discussed in detail for $K = 2$. Survival probabilities of lines are calculated for particular offspring distributions when $K = 2$. Approximate formulas for these probabilities, based on first and second moments of the offspring distributions, work fairly well.

*Edward Pollak: "The Asymptotic Form of the Extinction Probabilities for Supercritical Multitype Branching Processes." Mathematical Biosciences, 15, 123-131. 1972. Journal Paper J-7135, Iowa Agriculture and Home Economics Experiment Station, Project 1669. Statistical Laboratory Reprint Series No. 298.

A positively regular branching process is considered for which there is a finite number T of types. It is assumed that ρ, the dominant characteristic root of the matrix of first moments, is larger than 1. Then if $q_i(n)$ is the probability that the line descended from an ancestor of type i has become extinct by generation n, $q_i = \lim_{n\to\infty} q_i(n)$, and $q_i > 0$, $i = 1, \ldots, T$, it can be shown that $\lim_{n\to\infty} (q_i - q_i(n))/\hat{\rho}^n = d_i > 0$, where $0 < \hat{\rho} > 1$. A consequence is that all of the moments of the conditional time to extinction of a line, given ultimate extinction, are finite, regardless of the type of the ancestral individual.

*Vince A. Sposito and H.T. David: "A Note on Farkas Lemmas Over Cone Domains." SIAM Journal of Applied Mathematics, 22:3, 356-358. 1972. Statistical Laboratory Reprint Series No. 295.

In this paper the authors develop a linear duality theorem for convex (not necessarily polyhedral) cones under an adapted Slater condition. A cone version of Farkas lemma then follows as a corollary.

*V.A. Sposito: "Solutions of a Special Class of Linear Programming Problems." Journal of Operations Research: Mathematical Programming and Its Application, 21:1, 386-388. January-February 1973. Statistical Laboratory Reprint Series No. 313.

Explicit solutions for linear problems of the form: maximize (h,x), subject to $Ax \leqslant b$, $b \in R(A)$, are given, as well as explicit solutions for its dual problem. This note replaces the full row rank assumption on A of earlier results of Ben-Israel and Charnes by the assumption $b \in R(A)$. With this assumption, explicit solutions are derived for the dual problem that are different from related results of Zlobec and Ben-Israel.

*Victor K.T. Tang (California State University, Humboldt) and B.V. Sukhatme: "Allocation in Stratified Sampling Based on Preliminary Test of Significance II." Proceedings of the American Statistical Association, Social Statistics Section, 442-445. 1972. Statistical Laboratory Reprint Series No. 306.

In a previous paper the efficiency of an allocation called "sometimes proportional allocation" with respect to proportional allocation and modified Neyman allocation was discussed for the case of two strata with $\sigma_1^2 \leqslant \sigma_2^2$. In this second paper in the sequence, some further results concerning sometimes proportional allocation are presented for the case of two strata with $\sigma_1^2 \neq \sigma_2^2$.

*M.S. Avadhani and B.V. Sukhatme: "Sampling on Several Successive Occasions with Equal and Unequal Probabilities and Without Replacement." Australian Journal of Statistics, 14:2, 109-119. August 1972. Statistical Laboratory Reprint Series No. 312.

The applicability of the technique of controlled selection with equal probabilities proposed by the

authors (1965, 1968), and that of unequal probability sampling suggested by Rao et al. (1962) to sampling on several successive occasions is investigated. Appropriate recurrence formulae for the optimum replacement fraction and the corresponding weight are derived.

*Ravindra Singh and **B.V. Sukhatme:** "Optimum Stratification in Sampling with Varying Probabilities." Annals of the Institute of Statistical Mathematics, 24:3, 485-494. 1972. Statistical Laboratory Reprint Series No. 310.

The problem of optimum stratification on an auxiliary variable x is considered when the units from the different strata are selected with probability proportional to the value of the auxiliary variable. Under a super-population set-up assuming the form of the regression of the estimation variable y on the auxiliary variable x as also the form of the variance function $V(y|x)$, minimal equations giving optimum strata boundaries are obtained for the Neyman allocation method. As these cannot be solved easily, methods are given to find approximate solutions. The effect of optimum stratification is numerically illustrated.

*Ravindra Singh and **B.V. Sukhatme:** "A Note on Optimum Stratification." Journal of the Indian Society of Agricultural Statistics, 24:2, 91-98. December 1972. Statistical Laboratory Reprint Series No. 315.

This note gives certain asymptotic properties of the approximate solutions to the optimum strata boundaries obtained in the previous publication.

***Shashikala Sukhatme:** "Fredholm Determinant of a Positive Definite Kernel of a Special Type and Its Application." Annals of Mathematical Statistics, 43:6, 1914-1926. December 1972. Statistical Laboratory Reprint Series No. 308.

Let $\rho(x,y)$ be a positive definite symmetric kernel defined over the unit square such that $\rho(x,y) = K(x,y) - \sum_{i=1}^{k} \phi_i(x)\phi_i(y)$, $0 \leq x,y \leq 1$, where $K(x,y)$ is a bounded symmetric positive definite kernel defined over the unit square, and $\phi_i(x) \epsilon L_2(0,1)$. Methods of finding Fredholm determinant $D(\lambda)$ of $\rho(x,y)$ in terms of the eigenvalues and the eigenfunctions of $K(x,y)$ are given. A kernel of the type of $\rho(x,y)$ arises as the covariance function of a Gaussian process in the limiting distribution of the modified Cramér-Smirnov test statistic in the k-parameter case which may be described as follows: Let $X_1,\ldots,X_n$ be n independent observations (random variables) from a population with a continuous distribution function $G(x)$. Suppose for every $\theta = (\theta_1,\ldots,\theta_k) \epsilon I$, I being an open interval in the k—dimensional Euclidean space R^k, $F(x, \theta)$ is a continuous distribution function. Let $\hat{\theta}_n$ be an estimate of θ obtained from the sample. A test of the hypothesis H: $G(x) = F(x,\theta)$ for some unspecified $\theta \epsilon I$ based on the statistic

$$C_{n^2} = n\int_{-\infty}^{+\infty} [F_n(x) - F(x,\hat{\theta}_n)]^2 dF(x,\hat{\theta}_n),$$

is considered and the characteristic function of the asymptotic distribution of C_n^2 is shown to be the Fredholm determinant of a kernel of the type of $\rho(x,y)$ with $K(x,y) = \min(x,y) - xy$ whose eigenvalues and eigenfunctions are known. Results are also used to obtain the limiting distribution of 1-sample analogue of C_{n^2}.

James R. Veale (California State University, Hayward) and B.K. Kale: "Tests of Hypotheses for Expected Life in the Presence of a Spurious Observation." Utilitas Mathematica, 2, 9-23. 1972.

A modified life testing model is assumed where $(n-1)$ of $(X_1,\ldots,X_n)$ are distributed as $f(x;\sigma) = \sigma^{-1}\exp\{-x\sigma^{-1}\}$, while one is distributed as $f(x;\sigma/k)$, $0<k\leq 1$. Tests of hypotheses $H_o:\sigma=\sigma_o$ vs. $H_a:\sigma>\sigma_o$ based on $\sum_{i=1}^{m-1} X_{(i)} + (n-m+1)X_{(m)}$, $m \leq n$, are considered. The (standard) test based on T_n is shown to have size equal to one. The exact distribution of T_m has been obtained for any (k,σ) and the test based on T_m, for $m \leq n-1$, is shown to have size less than one. An approximation to the power function of $T_n - 1$ is suggested and tables of "premium," "protection," and difference in power (T_n and T_{n-1}) are provided for various parameter values.

Charles Lee Mulford, Gerald E. Klonglan, **Richard D. Warren** and Paul F. Schmitz: "A Causal Model of Effectiveness in Organizations." Social Science Research, 1:1, 61-78. 1972. Journal Paper J-6978, Iowa Agriculture and Home Economics Experiment Station, Project 1754.

Research to develop and test a causal model of organizational effectiveness in normative organizations is discussed. The variables included in the model were selected from Etzioni's propositions relating correlates of compliance to effectiveness. Other causal relations were added. Path analysis techniques were applied to available data to test the postulated causal ordering and estimate path values. Considerable empirical support was found for the causal ordering.

Damaris Pease, **Leroy Wolins** and Dahlia Stockdale: "Relationship and Prediction of Infant Tests." Journal of Genetic Psychology, 122, 31-35. 1973. Journal Paper J-6858, Iowa Agriculture and Home Economics Experiment Station, Project 1787.

A battery of infant psychological tests was administered to 77 infants at ages 3, 6, 9, 12, 18 and 24 months to evaluate the usefulness of early testing to predict test performance after 48 months of age. Polynomial regression and other procedures were selected to be sensitive to differences among individuals in the function that relates test per-

formances to age. There is no evidence that the measures taken at 18 months and before improve the prediction beyond that made by the 24-month measurements alone.

letter

George Zyskind and Paul A. Johnson. On A Zero Residual Sum in Regression. The American Statistician, 27:1, 43-44. February 1973.

theses abstracts

Gordon D. Booth: "The Errors-in-Variables Model When the Covariance Matrix Is Not Constant." Ph.D. thesis. Iowa State University Library. May 1973.

The errors-in-variables model investigated is based on the exact mathematical relationships $y_t = x_t\beta_1$, $t = 1,2,\ldots,n$, where the y_t are scalars, the x_t are $(1 \times p)$ vectors and β_1 is a $(p \times 1)$ vector. The y_t and the elements of the x_t cannot be observed directly, but only with error. The covariance matrix of the errors in observing y_t and x_t is denoted by the $(p+1) \times (p+1)$ matrix, Σ_t, $t = 1,2,\ldots,n$. It is assumed that errors for $t = i$ are independent of those for $t = j$, when $i \neq j$. The mean $\bar{\Sigma} = \frac{1}{n}\sum_{t=1}^{n} \Sigma_t$ of the n covariance matrices is assumed known. A consistent estimator of β_1, denoted by $\hat{\beta}_1$, is constructed and the large-sample mean and variance of $\hat{\beta}_1$ derived, both under the assumption of normality and without that assumption.

The likelihood function, assuming normality and known Σ_t's, is investigated. The value of β which maximizes this function is the solution of a very complicated system of equations. Because of this complexity, no explicit expression for the estimator has been obtained. Therefore, an alternative estimator, β_1^*, suggested by the likelihood equations, is introduced. This "Pseudo Maximum-Likelihood Estimator" is a two-step estimator. To compute it, a preliminary consistent estimate, such as $\hat{\beta}_1$ is required. The final estimate is computed as a function of $\hat{\beta}_1$ in a second step.

The large-sample mean and variance of β_1^* are evaluated for a general class of the errors of observation. When the errors are assumed to have a multivariate normal distribution, β_1^* is shown to be asymptotically normal, and a test for the appropriateness of the model is presented. The large-sample variance of β_1^* is found to be less than or equal to that of $\hat{\beta}_1$.

The estimators $\hat{\beta}_1$ and β_1^* were compared in a small Monte Carlo study. The sample distribution function of both $\hat{\beta}_1$ and β_1^* displayed heavy tail properties associated with occasional estimates which are quite different from the known parameter values. Therefore, $\hat{\beta}_1$ and β_1^* were modified to $\hat{\beta}_1(k)$ and $\beta_1^*(k)$ respectively, where both of these modified estimators are functions of a fixed, positive number, k. It was found that by the proper choice of k, the mean square error of each estimator could be reduced, without causing a marked departure from normality.

In summary, the results of the Monte Carlo study were in general agreement with the large-sample theory.

Thomas Ray Fears: "Chernoff-Savage Theorems for Dependent Sequences of Random Variables and Applications to Asymptotic Relative Efficiency." Ph.D. thesis. Iowa State University Library. August 1972.

Let $\{X_i\}$ and $\{Y_j\}$ be two stationary sequences of real random variables with each X_i (each Y_j) having a continuous marginal distribution function. Further, assume that with probability 1, no two of the X's or Y's are equal.

Two sample rank-order statistics are now shown to be asymptotically normal under Pyke-Shorack conditions (1968) if the sequence $\{(X_i, Y_i)\}$ is p-dependent or if the independent sequences $\{X_i\}$ and $\{Y_j\}$ are ϕ-mixing. Next, the case of double sequences specially constructed for use on the scale problem is considered. Finally, the robustness properties of the relative efficiency of certain nonparametric tests are studied for p-dependent and mixing sequences.

The method used by Pyke and Shorack is used in this thesis. It is based upon properties of empirical distribution functions and requires weaker conditions than the Chernoff-Savage method (1958).

Her Tzai Huang: "Combining Multiple Responses in Sample Surveys." Ph.D. thesis. Iowa State University Library. November 1972.

In this thesis it is assumed that a super-population of responses exists for each individual in a finite population. A questionnaire with two questions on the characteristic of interest is used to obtain survey responses for a sample of individuals selected from the population.

An estimator of the population mean is suggested. Expressions for the variance of this estimator are given for different model assumptions.

When the two determinations have values 0 or 1, the classification of the sample individuals into the two classes, and the estimation of the associated population proportions, are considered. Using a third 0-1 variable, a rule is presented to maximize the probability of correct classification. A procedure for estimating the parameters in the response model is presented.

John David Jobson: "Estimation for Linear Models with Unknown Diagonal Covariance Matrix." Ph.D. thesis. Iowa State University Library. November 1972.

The problem of estimation in the linear model

$Y = X\beta + e$ with unknown diagonal covariance matrix G is considered. Two common methods, a maximum likelihood procedure and a least squares procedure, are discussed. The least squares procedure uses residuals from a simple least squares fit to estimate G. A weighted least squares procedure is then used to obtain a new estimate of β. The weights are obtained from the estimates of the diagonal elements of G. The maximum likelihood procedure is employed under the additional assumption that the errors are normally distributed. It is demonstrated that the maximum likelihood estimator of θ exists and is weakly consistent.

A joint least squares procedure is developed which uses preliminary estimates of β and G to obtain new estimates. This joint least squares estimator is shown to have the same asymptotic distribution as the maximum likelihood estimator. It is demonstrated that by repeatedly applying the joint least squares procedure, a sequence of estimators can be obtained that converge to a local maximum of the likelihood function.

The performances of the simple and joint least squares estimators are compared for a random coefficient model. A measure of the adequacy of the large-sample results for samples of size 40 is obtained from a Monte Carlo study.

Thomas Joseph Keefe: "The Use of Concomitant Information in Multivariate Sequential Tests of Statistical Hypotheses." Ph.D. thesis. Iowa State University Library. August 1972.

In this study sequential test procedures are developed for the comparison of two treatments, wherein the response and covariate metameters are both vector-valued.

The design is first considered where the experimental units are paired and receive one of the two treatments at random. The response metameter of interest is the vector difference of the within-pair response vectors and the covariate metameter is the vector difference of the corresponding within-pair covariate vectors. Essentially, this is a single-sample sequential test for discriminating between two composite hypotheses about a mean vector adjusted for covariate-effects of the sequential T^2-test type proposed by Jackson and Bradley.

Subsequently, the restriction requiring pairing of the experimental units is removed, and a two-sample sequential T^2-test is derived where it is assumed that, at each stage, $r_1 \geqslant 1$ and $r_2 \geqslant 1$ observations are sampled from the first and second multivariate-normal populations, respectively. This is a generalization of the two-sample sequential T^2-test suggested by Hall, Wijsman and Ghosh, for which $r_1 = r_2 = 1$. Then a two-sample sequential T^2-test is constructed for statistical hypotheses about the difference of two mean vectors adjusted for covariates.

Sequential tests utilizing the information in a preliminary estimate of the covariance matrix are derived for each procedure, and for Jackson and Bradley's sequential T^2-test.

Kenneth Earl Merritt: "Some Aspects of Combinability of Information." Ph.D. thesis. Iowa State University Library. August 1972.

General problems of combining information sampled from two or more sources were studied under a wide variety of population structures. Developments made in linear estimation, variances, and estimates of variances are directed toward numerical implementation on a high-speed digital computer so that numerical, as well as mathematical, comparisons can be made between various proposed estimators. This research illustrates the importance and effectiveness of utilizing a high-speed computer for studying estimation techniques under various simulated model conditions.

Unconditional variance is formulated and estimated for estimators of the parameter β from the general linear model $Y = X\beta + \epsilon$, where Y is an $(n \times 1)$ vector of observations, X is an $(n \times p)$ matrix of known coefficients, β is a $(p \times 1)$ vector of unknown parameters, and ϵ is an $(n \times 1)$ vector of residuals such that $E\,\epsilon\,\epsilon' = V$.

Applications of combining information using random weights are extended to a wide class of incomplete block designs. Special attention is given to the implementation of general algorithms for solving problems involving both single and multiple incomplete block experimental designs. The implemented algorithms are reasonably efficient and provide good numerical accuracy.

Partial integration was used to derive general formulations for the variance of a combined estimator of a single parameter, μ, over two heterogeneous normal populations. The resulting expression was compared numerically with existing formulations for a wide range of specified sample sizes and population parameter values.

John Sigmund Meyer: "Confidence Intervals for Quantities in Stratified Random Sampling." Ph.D. thesis. Iowa State University Library. November 1972.

The first part of this study reviews and extends known results when a simple random sample of size n is drawn from π_N, a finite population of N elements, $Y_{(1)} < Y_{(2)} < \ldots < Y_{(n)}$, and the observed values ordered as $y_{(1)} < y_{(2)} < \ldots < y_{(n)}$. A confidence interval of the form $[y_{(k)}, y_{(r)}]$ is considered for $Y_{(t)}$.

The second part deals with three methods of constructing a confidence interval for $Y_{(t)}$ when π_N has been stratified into two strata and a simple random sample drawn from each stratum. The "combined method" combines and orders the sample values and then uses two of these values for the endpoints of the confidence interval. The "C.D.F. method" employs the empirical distribution function to find the sample values to be used as endpoints

of the desired interval. The "separate method" uses one value from each of the stratum samples to form the interval.

Exact formulas for the confidence coefficients are derived for each of the methods under two different assumptions about the nature of the stratification. Approximations for the confidence coefficients are given, and the three methods are compared, both by theoretical work and Monte Carlo studies. Brief tables illustrating the methods are included.

The "combined" and "C.D.F." methods are then extended to three strata. Applications discussed include tolerance regions and the "best population problem." The work is also extended to cluster sampling.

David Albert Pyne: "Duality in Abstract Mathematical Programming"

Necessary and sufficient conditions for $X(ZX)^- Z$ to be a projection operator are given. The projection space and the direction space of the operator $X(ZX)^- Z$ are investigated. Also given is a representation of a matrix X with column span equal to the intersection of the column spans of two matrices U and V having the same number of rows.

Best linear unbiased estimation in the fixed linear model $y = X\beta + e$ is investigated under design and covariance matrices, X, V, respectively, which may contain row and/or column linear dependencies. The expression found for the best linear unbiased estimator of $X\beta$, BLUE($X\beta$), is $(I - VT'(TVT')^- T)y$, where T is any matrix satisfying $R(T) = \mathcal{C}^{\perp}(X)$, with symbols R and $\mathcal{C}$ denoting, respectively, rows and column spaces of matrices. It is also shown that the observation vector y must come from the space $\mathcal{C}(X) + \mathcal{C}(V)$

hX'Xt. Some theorems on the efficiency defined above were developed.

Hernan R. Tejeda-Sanhueza: "Statistical Analysis and Model Building for a Wheat Production System in Chile." Ph.D. thesis. Iowa State University Library. February 1973.

This thesis reviews current methods and procedures of building models relating crop yield to fertilizer, soil, climatic and management factors; investigates the problem of making statistical assumptions compatible with agronomic knowledge when building the model; and considers the functional form and validation of the model, the variables to be included, and the estimation procedures.

The crop production system concept, an abstract representation of the factors influencing yield in a given region, was elaborated. It facilitates the analysis of variables affecting yield and the use of agronomic knowledge to build the model. A model for a wheat production system in Chile was generated with data from 34 N and P wheat fertilization experiments.

Alternative models for the system were built with a quadratic polynomial and an inverse polynomial, fitted separately to the data of the 34 sites. The model was estimated by regressing the site regression coefficients on correlated system variables. This estimation procedure recognizes the existence of site and within-site components of variance. A quadratic model with 22 terms in the variables: fertilizer N and P; soil N, P and K; soil depth; previous crop; and date of planting; explained 70 percent of the observed yield variation.

Dennis Kang-Ping Tsai: "Binomial Minimax Sequential Estimation." M.S. thesis. Iowa State University Library. August 1972.

This thesis is concerned with showing the existence of and providing numerical solution algorithms for a minimax estimation strategy when the sampling plan is sequential (other than a single sampling plan).

Nikaido's theorem first is applied to show the existence of a bounded minimax sufficient estimation strategy for simple binomial sequential sampling plans with bounded sample size. Two subsequent chapters are devoted to two solution algorithms for such minimax strategies. The first of these, based on the initial assumption that the minimax strategy is constant-risk, is more successful. This assumption simplifies the solution without restricting the problem.

Lonnie Charles Vance: "Distribution of Discriminant Functions with Unequal Covariance Matrices Under Intraclass Correlation Models." Ph.D. thesis. Iowa State University Library. May 1973.

Discriminant function analysis is developed for two multivariate normal populations with unequal covariance matrices which have intraclass correlation structure. In this study the utilization of covariates in the quadratic rather than the linear discriminant function is examined.

Assuming covariates are available, three classification procedures are considered: discriminant function using (1) p unadjusted discriminators, (2) p adjusted (for q covariates) discriminators, and (3) p+q unadjusted discriminators. Under the assumption that the difference between the covariance matrices is positive-definite, the distribution of the discriminant function is obtained for the first two classification procedures when all parameters are known and the means are unknown, but the covariance matrices are known. For the p unadjusted discriminators procedure, an asymptotic expansion for this distribution is obtained. Further, when all parameters are known or when the means are unknown, but the covariance matrices are known, the distribution is given for the p+q unadjusted discriminators procedure. The limiting distribution of the discriminant function is found for the second and third procedures when all parameters are unknown.

Assuming all parameters are known, the probabilities of misclassification for the three classification procedures are obtained using numerical integration procedures when feasible, as well as Monte Carlo procedures. It appears that if covariates are available it is advantageous to use them either as discriminators or as covariates under intraclass correlation models.

William Douglas Warde: "Simple Linear Regression Estimation with Inequality Constraints on the Parameters." Ph.D. thesis. Iowa State University Library. November 1972.

The behavior of various Bayesian estimators is examined for the situation when an inequality constraint is placed on the slope parameter in simple linear regression, and compared with the constrained least squares estimator.

For the disperse prior, the Bayesian posterior mean, median and mode estimators are obtained, the constrained least squares, maximum likelihood and Bayesian posterior mode estimators being identical. When σ^2 is unknown, the Bayesian posterior mean and median estimators are not well behaved. No single estimator is uniformly best in the sense of having the smallest mean square error for all values of the true parameter.

The three estimators are examined from the viewpoint of closeness. For the semi-infinite interval constraint, the constrained least squares estimator is closer than the Bayesian posterior median estimator, which is closer than the Bayesian posterior mean estimator. When σ^2 is known and the constraint interval is finite, no single estimator is closer than any other for all permissible values of the true parameter.

Alternative specifications of the prior distribution for σ^2 known were chosen from two viewpoints: priors which yield posterior means "close to" the

constrained least squares estimator, and "natural" priors. The "natural" priors yield estimators with extremely large mean square errors in the regions of the parameter space on which the prior places small probability, and extremely small mean square error elsewhere. The other priors are less extreme in their behavior.

Wai Wo Wong: "A Statistical Model for a Signalized Intersection." M.S. thesis. Iowa State University Library. May 1973.

In this thesis a model is proposed for studying the waiting time distribution for vehicles arriving at a fixed-cycle intersection. This problem is related to standard queueing and congestion problems; however, the present approach departs from standard treatments in that driver reactions and strategies near the intersection are taken into account. The resulting intricacies make a closed mathematical solution difficult. Hence the present approach is in effect to propose a model, hopefully realistic, for which the resulting waiting time distributions will have to be ascertained by Monte Carlo methods.

papers and speeches

. . .a record of staff members' presentations at scientific and professional meetings. Many of these papers will be published.

At statistical society meetings in Montreal, Canada, August 14-17:

Gordon D. Booth and **Wayne A. Fuller:** "Estimators for the Errors-in-Variables Model When the Covariance Matrix Is Not Constant;"

Wayne A. Fuller and J.N.K. Rao: "Some Asymptotic Theory of MINQUE;"

Leon F. Burmeister and **Wayne A. Fuller:** "Estimators for Samples Drawn from Multiple Overlapping Frames;"

Richard M. Heiberger: "Extensions to ANOVA, Fitting Unequal Cell Variances;"

Dean Isaacson: "A Decomposition of Continuous Square-Integrable Martingales;"

J.D. Jobson and **Wayne A. Fuller:** "Estimation in Linear Models with Unknown Diagonal Covariance Matrix;"

Oscar Kempthorne: "Sampling a Lattice and Random Balance;" and

Victor K.T. Tang and **B.V. Sukhatme:** "Allocation in Stratified Sampling Based on Preliminary Test of Significance. II."

At a special seminar series on the teaching of statistics, in conjunction with the inauguration of the new physical plant of the Statistical Center, National School of Agriculture, Chapingo, Mexico, November 6-9:

T.A. Bancroft: "Statistics Education in Latin America;"

Wayne Fuller: "Transformations in Regression Analysis with Applications to Survey Data;"

Oscar Kempthorne: "Teaching Statistics at the M.S. Level;"

B.V. Sukhatme: "Use of Preliminary Test of Significance in Designing Sample Surveys and Analysis of Survey Data;" and

George Zyskind: "The Teaching of Statistical Linear Model Theory."

As visiting lecturers at Baylor University, January 22-23:

T.A. Bancroft: "The Dual Nature of Statistics: A Mathematical Science and a Part of Scientific Methodology;" and

R.A. Groeneveld: "A Mathematical Model for Investments with Stochastic Returns."

At the International Symposium on Statistical Design and Linear Models in Fort Collins, Colorado, March 19-24:

Oscar Kempthorne: "Inference from Experiments and Randomization;" and

George Zyskind: "Error Structures, Projections, and Conditional Inverses in Linear Model Theory."

At the Midwestern Psychological Association meeting in Chicago, May 10-12:

E.F. Knowles, R.L. Hendricks and **T.L. Dickinson:** "A Comparison of Idiographic and Nomothetic Models of Job Preference;" and

R.M. Mendel and **T.L. Dickinson:** "An Experimental Analysis of Vroom's Model of Work Motivation."

At the statistical societies' spring regional meetings in Ithaca, New York, May 29-June 1:

G.L. Ghai and **Edward Pollak:** "On Some Results for a Bivariate Branching Process;" and

Richard Heiberger: "The Generation of Randomly Distributed Orthogonal Matrices."

Barry Arnold: "Response Distributions for a Generalized Urn-Scheme Under Non-Contingent Reinforcement," at the fifth annual Mathematical Psychology meeting, La-Jolla, California, August 10.

T.A. Bancroft and **W.J. Kennedy:** "Consultation and Education Programs in Statistical Computing for Colleges and Universities," at the Sixth Annual Symposium on the Interface of Computer Science and Statistics, University of California at Berkeley, October 16-17.

Susan Alice Brown: "Finances and Fund-raising," at the Midwest Professional Conference for Communicators in Madison, Wisconsin, May 5.

David F. Cox: "Teaching Statistics for Biologists," at meetings of the American Institute of Biological Science and Biometric Society, ENAR, at the University of Minnesota, August 27-31.

H.A. David: "Paired Comparison and Tournaments" and "Order Statistics: An Overview," under the Visiting Lecturer Program, at Southern Illinois University, Edwardsville, April 5-6.

H.T. David: "Statistical and Mathematical Programming," at Virginia Polytechnic Institute March 2, and at Northern Illinois University, April 6.

Richard Heiberger: "SAS", a short course in the use of the Statistical Analysis System, presented in cooperation with the ISU Computation Center during March.

Roy Hickman: "The Estimation of Agricultural Areas and Crop Yields," a workshop session for the Sampling Program for Foreign Statisticians, conducted by the Survey Research Center, Institute for Social Research at the University of Michigan August 14-15.

Oscar Kempthorne: "Statistics, Data Analysis, Probability and Measure Theory," a seminar for the Department of Mathematics, ISU, March 13; "Computers and Man's Personhood," a lenten program at the Episcopal church, Ames, March 28;

"What is Statistical Thinking," at the University of Michigan April 27 and at Statistics Day, Carleton University, Ottawa, Canada, April 28; "Minimum Variance Unbiased Estimation with Linear Models," at the University of Waterloo, Canada, May 9;

"Statistics and the Philosophers," at the International Conference on Foundations of Probability and Statistics and Statistical Theories of Science, London, Canada, May 10-13.

Jeff Meeker: "OMNITAB," a lecture at the NSF Workshop in Regional Network Computing at the University of Iowa August 9, and a short course for statistics faculty at the University of Iowa October 3-4 and at the University of Nebraska, February 28-March 2.

Richard Mensing: "Statistics of Quality Control," three sessions presented during the Engineering and Management Institute short course on Quality Control, for personnel in food processing, metal and plastic manufacturing which met at Iowa State May 9-10.

Richard Mensing and John W. Patterson: "Why Should Statistical Inference Be Taught in Materials Curricula,"

at the annual meeting of the American Society for Engineering Education in Ames June 25-28.

Robin Thompson: "The Recovery of Inter-block Information When Block Sizes Are Unequal," a seminar for the Biometrics Unit at Cornell University June 6.

Richard D. Warren, Gerald L. Klonglan and Judy Winkelpleck: "Application of an Adoption Model to Smoking and Health," at the Third World Congress for Rural Sociology, August 22-27; and "Implications for Instigated Social Action Programs in Smoking and Health," at the Rural Sociological Society meeting August 25-27, both in Baton Rouge.

William Kuvlesky, **Richard Warren** and George Ragland: "Orientations Toward Racial Prejudice Among Metropolitan and Nonmetropolitan Blacks," at the Rural Sociological Society meeting in Baton Rouge August 25-27.

Leroy Wolins: "A Procedure for Suppressing Response Set in Personality Inventories," at a meeting of the Psychometric Society in Chicago March 29.

George Zyskind: "Experiments, Randomization and Linear Models," an informal seminar at the National Bureau of Standards, Washington, D.C., April 12.

participation in professional activities

At the statistical society meetings in Montreal in August, Richard Heiberger, Dean Isaacson, Oscar Kempthorne and George Zyskind chaired sessions; D.K. Hotchkiss represented Iowa State at the Teaching Section and participated in the Training Section as a Director.

Dr. Hotchkiss continues on the executive committee of the Section of Training of Statisticians and is chairing a subcommittee to develop a program of study for secondary school teachers; Dr. Zyskind was elected this year to a two-year term on the executive committee. Other faculty serving on ASA committees include H.A. David, Committee on Fellows and Honorary Members; H.T. David, District 8 representative to the ASA Council and a member of the advisory board of the Section on Physical and Engineering Sciences; Dr. Kempthorne, Wilks Memorial Medal Committee; and Richard Mensing, Committee on Membership. Dr. Zyskind is serving as IMS program chairman for the 1973 statistical society annual meetings, which will be in New York in December.

H.T. David continues on the Committee of Presidents of Statistical Societies Visiting Lecturer Program; Dr. Kempthorne continues as chairman of the COPSS Fisher Memorial Lecture Committee.

David F. Cox has been named to the regional advisory board of the Biometric Society, ENAR.

T.A. Bancroft and D.K. Hotchkiss are working with the State Project ASSIST In-Service Committee. Centers are being established throughout the state to study high school needs in an effort to provide more effective training of secondary teachers.

Dr. Bancroft has been elected a Fellow of the Institute of Mathematical Statistics. He was appointed a member of the Ad Hoc Committee on Statistical Education of the Inter-American Statistical Institute, which met in Santiago, Chile in July to review activities and make recommendations for the Sixth Inter-American Statistical Conference. He continued to serve on the Advisory Committee on Statistical Policy established by the ASA to consult with the Statistical Policy Division, Office of Management and Budget.

Dr. Bancroft went to Japan in March under a visiting professorship program organized by the Japan Society for the Promotion of Science. He spent five weeks at Osaka University with his host, Professor Masashi Okamoto, who was a visiting professor at Iowa State during 1967-68. He then visited and presented papers on statistics at Okayama, Hiroshima and Kyushu Universities, the Institute of Statistical Mathematics and the Japan Union of Scientists and Engineers in Tokyo, and the Atomic Bomb Casualty Commission in Hiroshima. He lectured at the Statistical Center of the University of the Philippines in Manila on his way back to the United States.

H.T. David was honored with one of the two Wilton Park Awards to ISU faculty members. He will participate in a two-week Wilton Park Conference in Sussex, England.

Wayne A. Fuller has been elected a Fellow of the American Statistical Association. He was cited for significant research achievements in econometrics, survey sampling and statistical methodology; and for his outstanding performance as a teacher and supervisor of Ph.D. candidates. In November he participated in a Cooperative State Research Service review team which visited the Agricultural Experiment Station at North Carolina State University.

W.J. Kennedy has been appointed to a Technical Statistical Advisory Committee to the Iowa Health Care Council, sponsored by the governor's office of planning and programming. He served during the year as vice president of the Iowa Chapter, ASA. Dr. Kennedy is chairman of the seventh annual symposium on the interface, "Computer Science and Statistics," which will meet at Iowa State October 18-19.

B.V. Sukhatme was elected to membership in the International Statistical Institute.

Leroy Wolins was in Marburg, Germany during June as a guest professor at the University of Marburg.

Susan Alice Brown continues as treasurer of the Iowa Home Economics Association and was named one of 8 Iowa delegates to the annual meeting of the American Home Economics Association in Atlantic City in June. She served as chairman of the national nominations committee for Women in Communications, Inc.

C.P. Cox served during the year as chairman

of the Ames Conservation Council. He participated in the spring Seminar 72 student-faculty inquiry series as one of the leaders for a seminar on "Local Environmental Action."

Several faculty members have been active on Iowa State committees. H.T. David continued on the Faculty Council, on the Annuities and Insurance Committee and as a member of the executive committee of the ISU chapter of Sigma Xi. He was named to the Sciences and Humanities Committee on Faculty Improvement Leaves and Foreign Travel Grants. Sciences and Humanities Faculty Committee members include Barry Arnold, Honors Program; Wayne Fuller, Curriculum; D.K. Hotchkiss, Academic Standards (chairman); and George Zyskind, Nominating. Dr. Hotchkiss also serves on the University Academic Standards Committee, and he completed his term on the auditing committee of the ISU Employees Credit Union.

Course work in the

department of statistics

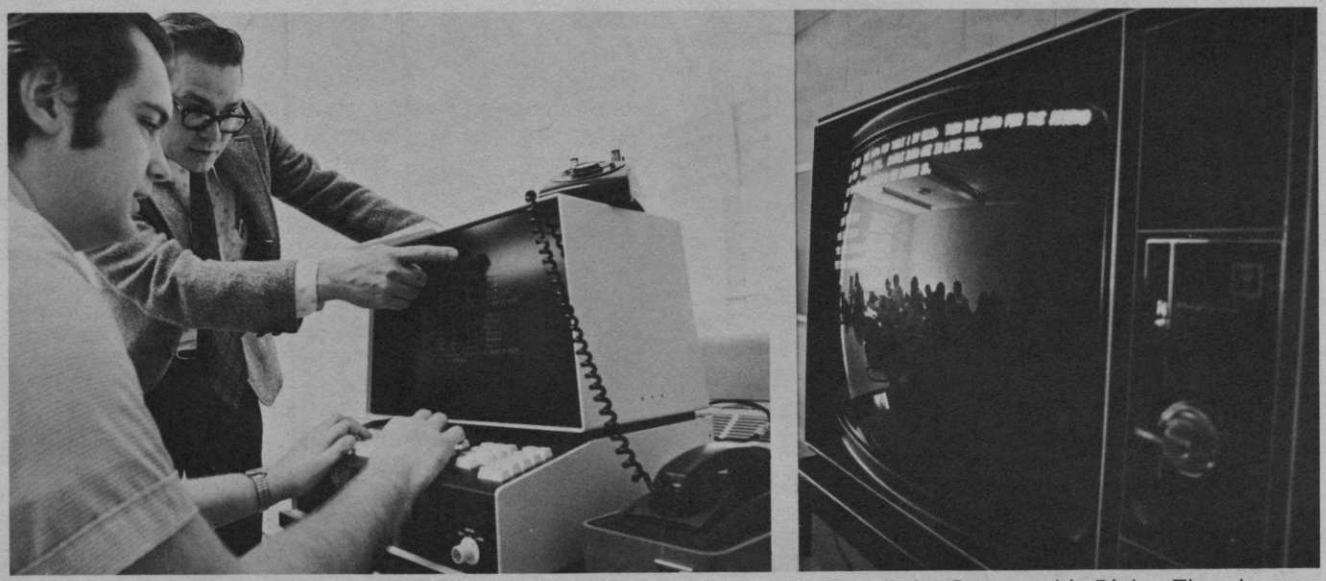
emphasizes modern statistical theory and its role in sound applications. B.S., M.S. and Ph.D. degree programs in statistics are offered through the College of Sciences and Humanities.

A specialized curriculum in biometry leads to a B.S. degree in the College of Agriculture. The program provides a career option for students from farm areas with particular interests and aptitudes in the mathematical sciences, who might not otherwise take advantage of their agricultural backgrounds.

The Department has received two grants during the year for specialized equipment to enhance teaching effectiveness. One contract, administered by Richard Groeneveld, provides for the purchase of computer terminal equipment under a matching funds agreement between Iowa State and the National Science Foundation Undergraduate Instructional Scientific Equipment Program. Each of the three third floor laboratories will be equipped with a Cathode Ray Tube terminal to be used with the IBM 360/65 computer in the time-sharing mode. Television monitors will extend visual coverage to all class members.

This equipment allows the teaching staff to illustrate quickly and vividly such statistical principles as sampling variation, the meaning and interpretation of confidence intervals, the central limit theorem, simple analysis of variance and linear regression analysis. By using several programs written for the present Conversational Programming System, the instructor can input the data from the terminal or call it from a peripheral device, the computer then carries out the required calculations, and the output is displayed instantly in the classroom.

Extremely mobile, the terminal, with an acoustic coupler, can be used wherever a standard desk



New specialized equipment purchased with the aid of NSF funds enhance teaching effectiveness. Left: Laboratory instructor Harry Boncykowski at the computer terminal, with Dr. R.A. Groeneveld. Right: The class reflected in one of the television monitors which display the output from the computer.

phone is installed. The terminal and monitor equipment was used in this year's Veishea display, to demonstrate to the public certain statistical ideas employing the calculating power of the IBM 360.

Iowa State is one of the first locations to have the IBM Time Sharing Option system installed. This will allow instructors to demonstrate in the classroom the use of a statistical computing language such as OMNITAB. This language currently is used in the senior level methods course, with students submitting their programs to be run in batch mode. By allowing instructors to run sample programs in the classroom, this language will be taught more efficiently. Furthermore, realistic data sets can be employed in classroom examples, providing a more convincing demonstration of the power of statistical analysis.

A small grant, funded by Iowa State's Council on Instruction, has been made to D.K. Hotchkiss. This will enable the Statistical Laboratory to prepare 10-20-minute video tape programs which will supplement classwork in Statistics 104. Students will have an opportunity to follow a research worker in agriculture throughout the steps of an actual experiment: first describing the importance and objectives of his research, then illustrating the concepts of experimental design and randomization by showing the actual conditions under which the experiment was conducted. As data are collected the researcher will explain the meaning of the results, and stress the importance of sound statistical methods as a tool for the scientist who needs valid conclusions.

Several experimental courses have been offered during the year, reflecting special interests of the faculty and special needs to supplement current courses. Such experimental courses as prove valuable will later be considered for permanent listing.

A spring quarter course on Applied Probability Models drew an enrollment of 17. During winter quarter 11 enrolled in Survey Sampling for Social Scientists, which was offered at the request of the Sociology Department. Also during winter quarter H.T. David and Richard Mensing teamed with Roger Berger of Industrial Engineering to teach an off-campus course, Reliability Analysis, at the Rock Island Arsenal for 30 students. Other experimental courses included Methods of Multivariate Analysis, Ecological Statistics and Order Statistics. Fifteen faculty members assisted Richard Heiberger with a Seminar in Statistical Consulting. Non-textbook problems that arise in statistical consulting were presented and discussed.

The Department of Industrial Administration has added Statistics 327 (Elementary Business Statistics) to Statistics 127 (Business Administration Statistics) as a core requirement in statistics for its majors. This represents a substantial increase in service teaching.

The courses offered by the Department of Statistics during the 1972-73 academic year were:

courses for undergraduate students only

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

courses for graduate minors and undergraduates

401,	Statistical Methods for Research Workers	4	FWSS_1	Arnold, Bancroft, C.P. Cox, D. Cox, Dickinson, Groeneveld, Hotchkiss, Mensing, Pollak, Warren, Zuuring
402		4	SS_2WS	Arnold, D. Cox, Dickinson, Groeneveld, Heiberger, Hickman, Hotchkiss, Mensing, Warren, Zuuring
403	Nonparametric Statistical Methods	3	F	Groeneveld
407x	Methods of Multivariate Analysis	3	W	Hinz
411	Experimental Design for Research Workers	3	S,SS_1	D. Cox, Dickinson, Zuuring
421	Survey Design for Research Workers	3	SS_2S	B. Sukhatme
422x	Survey Sampling for Social Scientists	4	W	Hickman
431	Elementary Statistical Quality Control	3	S	Mensing
432x	Applied Probability Models	3	S	Mensing

*Because the fiscal year began July 1, 1972, and ended June 30, 1973, the courses taught in the second summer session of 1972 through the first summer session of 1973 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.

446,	Statistical Theory for	3	F	Hinz
447,	Research Workers	3	WSS_1	Hinz
448		3	SS_2S	Hinz, Huntsberger
481,	Processing of	2	W	Mosier
482	Statistical Data	2	S	Mosier
490	Special Problems	Arr.	SS_2WS	Heiberger, Huntsberger, Kennedy, Mensing, Wolins
490H	Special Problems (Honors Program)			Groeneveld

courses primarily for graduate students, major and minor

501	Intermediate Statistical Methods	3	F	Bancroft
503x	Seminar in Statistical Consulting	3	W	Heiberger
505	Psychometrics	3	S	Wolins
506	Factor Analysis	3	F	Wolins
508	Sociometric Statistics	3	F	Warren
511,	Design of Experiments	3	W	Kempthorne
512		3	S	Zyskind
521,	Design of Surveys	3	W	B. Sukhatme
522		3	S	Han
531	Industrial Statistics Process Control	3	F	H. T. David
534x	Ecological Statistics	3	S	Pollak
535	Biological Statistics	3	S	C.P. Cox
538	Econometric Statistics	3	F	Fuller
539	Operations Research	3	W	Mensing
541,	Theory of Probability	3	F	Meeden
542,	and Statistics	3	W	Han
543		3	S	Meeden
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			H.T. David, Han, Mensing, Pollak, Sposito, Wolins
	B. Methods			C.P. Cox, D. Cox, H.T. David, Hinz, Kennedy, Sposito
	C. Design of Experiments			Kempthorne, Zyskind
	D. Design of Surveys			B. Sukhatme

courses for graduate students, major or minor

601	Advanced Statistical Methods	3	F	C.P. Cox
611,	Advanced Design of	3	W	Zyskind
612	Experiments	3	S	Kempthorne
641	General Theory of Linear Hypothesis	3	F	Zyskind
642	Probability and Distribution Theory	3	W	Meeden
643	Theory of Estimation and Testing of Hypotheses	3	S	Arnold
645x	Order Statistics	3	W	H.A. David
646	Time Series	3	S	Fuller
647	Multivariate Analysis	3	F	Han
648	Seminar on the Theory of Statistics and Probability	3	SS_1	Meeden
649	Recent Developments in Statistics and Probability	3	SS_1	Han
661	Theories of Inference	3	SS_1	Kempthorne
699	Research	Arr.	SS_2FWS,SS_1	Arnold, C.P. Cox, H.A. David, H.T. David, Fuller, Han, Kempthorne, Meeden, Mensing, Sposito, B. Sukhatme, Zyskind

graduate students

In addition to students enrolled in the statistics masters and doctoral degree programs, some 50 graduate students have declared a minor in statistics. This involves statistics faculty as minor professors and members of the students' graduate committees.

This year the Graduate College established Premium for Academic Excellence (PACE) Awards to supplement the stipends of superior students beginning graduate study. The PACE stipend of $120 per quarter is in addition to funds paid for assistantships or other duties. Seven incoming statistics majors were selected as PACE scholars for fall 1973.

ph.d. candidates

John Aleong	Thomas Keefe
Chaturedula Asok	Geung Ho Kim
George Battese	Robert Mason
Emmanuel Boateng	Jeff Meeker
Gordon Booth	James Mellon
Bruce Bowerman	Kenneth Merritt
Randy Carter	John Meyer
Lal Chand	Martin J. O'Connell
Shyamal Chowdhury	David Pyne
Richard Chung	Winston Richards*
David Dickey	A. Shawki Salem
Pamela Doctor	J. Richard Schmid
Mohamed El-Sabbagh	Preecha Sakarindr
Thomas Fears	Wendell Smith
Jeff Goebel	Richard Stein
Joseph Grimes	Hernan Tejeda
Devendra Hajela*	Lonnie Vance
M.A. Hidiroglou	Jose Villasenor
Elizabeth Hsu Huang	George Wang
Her Tzai Huang	William Warde
J.D. Jobson	Kirk Wolter
Kazimierz Karpinski	Shyr-Ching Wung

*received M.S. during the year

m.s. candidates

Carlos Acuña	Devendra Hajela
Zeyad Al-Rawi	William Kelly
Michael Althaus	Robert Keyt
Humphrey Arthur	Larry Kinyon
Harry Boncykowski	No Hoon Kwak
Cheryl Bowerman	Clifford Lee
Kuo Ping Cheng	John Lin
Cynthia Clark	Ting Kwong Lin
Elsa Contreras	Jan Lommele
Frank Eaton	Omar Martinez
Ted Emigh	Thomas Moritz
Jorge Fischman	Antonio Oña
Alix Garcia	Surin Phoeyglin
Linda Gorman	Winston Richards

Arden Ross
Julio Robles
Phantipar Sakarindr
William Santy
Gary Sime
Barry Simon
Melvin Stanard
Michael Szymczuk
Dennis Tsai
John Trzeciak
Choosak Udomsri
Dale Umbach
Wai Wo Wong
Rebecca Zeller

Twenty-two graduate students received advanced degrees during the year. Abstracts of theses written in partial fulfillment of graduation requirements appear in the publications section. Positions accepted by graduates are reported as follows:

Ph.D. Degree Recipients

Gordon Booth (May 1973, under Wayne Fuller) remains a mathematical statistician with the U.S. Department of Agriculture, currently housed in the Statistical Laboratory.

Tom Fears (August 1972, under K.L. Mehra) is employed by the Operations Research Division, Central Computer Department, Continental Oil Company in Ponca City, Oklahoma.

Her Tzai Huang (November 1972, under Wayne Fuller) is an assistant professor in the Department of Mathematics at Grambling College, Louisiana.

John David Jobson (November 1972, under Wayne Fuller) returned to his position on the faculty of business administration and commerce, University of Alberta, Edmonton, Canada.

Tom Keefe (August 1972, under C.P. Cox) is an assistant professor at Colorado State University

Ken Merritt (August 1972, under George Zyskind) went to the University of South Carolina as an assistant professor in the College of Business Administration.

John Meyer (November 1972, under J.H. Sedransk) is an assistant professor in the Department of Mathematics, Cornell College.

David Pyne (November 1972, under H.T. David) is at Johns Hopkins University as a visiting assistant professor in the Department of Mathematical Sciences.

Richard Stein (August 1972, under George Zyskind) is an assistant professor in the College of Agriculture, University of Arizona.

Hernan R. Tejeda (February 1973, joint agronomy-statistics under J.T. Pesek, agronomy and Wayne Fuller, statistics) returned to Chile.

Lonnie Vance (May 1973, under C.P. Han) joined the General Motors Corporation Research Laboratories, Warren, Michigan.

William Warde (November 1972, under Oscar Kempthorne) accepted a position as assistant professor with the Department of Statistics, Oklahoma State University.

M.S. Degree Recipients

Michael Althaus (August 1972, non-thesis, under Richard Mensing) took a job with Pratt-Whitney in Hartford, Connecticut.

Cheryl Bowerman (May 1973, non-thesis, under C.P. Han) will remain at Iowa State while her husband completes his doctorate.

Cynthia Clark (May 1973, non-thesis, under Glen Meeden) is living in Des Moines where her husband is employed.

Linda Gorman (May 1973, non-thesis, under Wayne Fuller) accepted a position with Computer Statistics Inc. in Des Moines.

Devendra Hajela (November 1972, non-thesis, under B.V. Sukhatme) remains at Iowa State working toward his doctorate.

John Lin (November 1972, non-thesis, under H.T. David) continued at Iowa State working on his doctorate and is now planning to accept employment.

Jan Lommele (May 1973, non-thesis, under C.P. Cox) will be working with Aetna Life and Casualty in Hartford, Connecticut.

Winston Richards (February 1973, non-thesis, under Barry Arnold) remains at Iowa State working toward his doctorate.

Dennis Tsai (August 1972, joint statistics-industrial engineering, under H.T. David, statistics and Keith McRoberts, industrial engineering) is employed by Eastern Airlines in Miami.

Wai Wo Wong (May 1973, joint statistics-industrial engineering, under H.T. David, statistics and Keith McRoberts, industrial engineering) plans to enter the restaurant business.

T.A. Bancroft, who last year relinquished his administrative position as director of the Statistical Laboratory and head of the Department of Statistics, has been honored with the establishment of the

t.a. bancroft statistics award

The award will annually recognize the most outstanding doctoral candidate who has a joint major or declared minor in statistics. Initially the winner will receive a year's membership in the statistically-oriented organization of his choice, with an accompanying subscription to the organization's journal.

Michael L. McGilliard is the first recipient of the new award. An animal breeding major in the Department of Animal Science, he has a strong minor in statistics. McGilliard selected membership in the Biometric Society.

Joint winners were selected for the 1973

george w. snedecor award

which honors the Statistical Laboratory's founder and first director. Kazimierz Karpinski and Kirk Wolter were named by the graduate faculty as the most outstanding candidates for the Ph.D. degree in statistics. They received a year's membership in the Institute of Mathematical Statistics and a cash award.

undergraduates

As a result of the recruiting effort of the undergraduate committee, enrollment not only increased this year but more freshmen with high gradepoints selected statistics as their major. Already 17 undergraduates enrolling for fall 1973 have elected to major in statistics or biometry. Four are in the top 4 percent of their class.

King Yin Kong, who was graduated with a 3.97 gradepoint and majored in computer science, mathematics and statistics, was one of 13 college students in the nation to receive a $3000 fellowship from Phi Kappa Phi, national honor society. The department's first biometry major, Kreg Leymaster, who has a joint major in animal science, received a George W. Catt, Lane-Wells scholarship in recognition of his academic achievements. Another biometry major, Diane Fitz, is studying under a Goke Estate Advanced Curriculum Scholarship, a $900 award which provides partial support for the sophomore, junior and senior years.

The cooperative program between the Department of Statistics and the Upjohn Company in

Kalamazoo, Michigan, proved mutually satisfactory during last summer's trial employment of an undergraduate statistics major. As a result, Upjohn has renewed its agreement and Gordon Meyer will be employed this summer in the biostatistics office. The program employs a student following the sophomore or junior year, providing opportunities to apply statistical methods in actual research and consulting situations.

D.V. Huntsberger, D.K. Hotchkiss and Richard Groeneveld are undergraduate advisors. Students who received B.S. degrees during the year include:

Timothy Balm (joint mathematics-statistics), November
Nguyen Huu Khiem (joint French-statistics), May
King Yin Kong (joint computer science-mathematics-statistics), May
Kreg Leymaster (joint animal science-biometry), May
Diane Pierick, May
Ruth Pleak, May
Gerald Steffen, May
Robbie Sue Wear, May

Guest speakers at the

iowa state university statistics club

programs during the year included Barry Arnold, who discussed his summer consulting activities with the Skylab project; Paul Leaverton of the University of Iowa, who reported on opportunities in health services for statistics undergraduates; and Duane Wait of Procter and Gamble who outlined the duties, training and opportunities for his work as head of the Mathematics and Computation Section of the Engineering Division.

In other activities, the club continued its annual fall get-acquainted picnic. President Francis Diaz again organized the Veishea exhibit, which featured the department's new computer terminal equipment. Senior Diane Pierick reported on her summer work as a biostatistician under the cooperative program with the Upjohn Company.

Diaz was awarded the 1972-73 Statistics Club-Science Council $100 scholarship; Gordon Meyer has been named 1973-74 recipient. David Lowe and Diaz received the IBM-Statistics Club scholarships for 1972-73 and 1973-74, respectively. The award pays in-state tuition costs for one year.

Officers for 1973-74 are: Gary McConnell, president; Steve Johnson, vice president; Martha Johnston, secretary; and Francis Diaz, treasurer.

Statistical honor society

mu sigma rho

became truly national when Colorado Alpha Chapter was installed March 21 at Colorado State University. Oscar Kempthorne, national director, presided at ceremonies which welcomed 26 students and 21 faculty members.

Mu Sigma Rho was organized to promote and encourage scholarly activity and recognize worthwhile achievement in statistics. The constitution provides that new chapters may be chartered in academic institutions "whose standards are excellent in all departments and particularly so in statistics." Provisions also are made for the establishment of affiliate chapters at non-academic institutions. Information about organizing chapters is available from national president D.K. Hotchkiss at Snedecor Hall ISU.

The Iowa Alpha Chapter at Iowa State initiated 23 members during the year. At a fall meeting H.A. David discussed "Tournaments and Paired Comparisons." In the spring the chapter co-sponsored a seminar featuring Dr. Robert Hogg, chairman of the Statistics Department at the University of Iowa. Ted Emigh has been elected chapter president for 1973-74. Other new officers are Lynn Alper, vice president; and David Dickey, secretary-treasurer.

seminars

statistical laboratory—department of statistics series

Weekly noncredit seminars for faculty and students 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. Richard Groeneveld, V.A. Sposito and George Zyskind planned the 1972-73 series, which included the following topics and speakers:

fall quarter 1972

September 13	Opening Seminar. H.A. David.
September 20	Human Protein and Calorie Needs—How Far Are They Met? P.V. Sukhatme, Gokhale Institute of Politics and Economics, Poona, India.
September 27	Estimation of Genetic Parameters from Selection Experiments. William G. Hill.
October 4	Projection Operators and Linear Model Estimation. Richard A. Stein.
October 11	Binomial Sequential Estimation. H.T. David.
October 18	A Day in the Life of an Applied Statistician. Irving Hall, Sandia Laboratories.
October 25	A Two-Phase Sample Design for Treating Nonresponse. J.H. Sedransk, University of Wisconsin.
November 1	On Error Analysis for a Mineral Balance Experiment—Clean Your Plate and Lick the Spoon. Barry C. Arnold.
November 8	Current Statistical Activities in Medical Research at the Mayo Clinic. William Taylor, Mayo Clinic.

winter quarter 1973

November 29	Distribution-free Confidence Intervals for Quantiles. John Meyer, Cornell College.
December 6	Highlights of the 6th Annual Symposium on the Interface of Computer Science and Statistics. T.A. Bancroft and William Kennedy.
December 13	Some Statistical Aspects of Dairy Cattle Feeding Trials. C. Philip Cox.

January 5	Tests for Normality Based On Its Characterization. S.K. Katti, University of Missouri.
January 10	The Use of Differences and Transformation in the Estimation of Econometric Relationships. Gerhard Tintner, University of Southern California.
January 17	Statistical Practice at a Health Center. Paul Leaverton, University of Iowa.
January 24	Contractions of Generalized Bayes' Estimates. Glen Meeden.
January 31	The Recovery of Inter-block Information When Block Sizes Are Unequal. Robin Thompson.
February 8	Some Infinite Models in Group Testing. Milton Sobel, University of Minnesota.
February 14	Large Deviations of Markov Chains, with Application to Decision Processes. Mohamed F. El-Sabbagh.

spring quarter 1973

March 7	Combining a Large Number of Estimates Using Estimated Variances. Wayne A. Fuller.
March 14	Current Activities of the Survey Section. Roy D. Hickman. Sample Design for the Population of Iowa Public Employees. Richard Dorsch.
March 21	Multivariate Analysis—An Example. Paul Hinz.
March 28	The Inbreeding Effective Number and the Effective Number of Alleles in a Population that Varies in Size. Edward Pollak.
April 4	The Large-Sample Behavior of Functions of Order Statistics. Stephen Stigler, University of Wisconsin.
April 11	The Generation of Randomly Distributed Orthogonal Matrices. Richard Heiberger.
April 18	(joint Statistical Laboratory, Mu Sigma Rho) Adaptative Statistical Inference. Robert Hogg, University of Iowa.
April 25	A Latin Square in which the Block Assumptions May Not Hold. Jeff Meeker.
May 2	Unequal Probability Sampling in Forest Inventory. Larry Promnitz, Forestry Department, ISU.
May 9	Allocation of Resources to Reduce Measurement Error in Covariance Experiments. Leroy Wolins and Boonplook Chaiket.
May 16	Modified Cramér-Smirnov Tests. Shashikala Sukhatme.
May 21	Special report on the May international conference in London, Ontario, Canada. Oscar Kempthorne.

first summer session

June 12	The Distribution of the Number of Occurrences in a Given Sequence of Events—the Sieve Method. Janos Galambos, visiting from Temple University.
June 14	Optimal Ranking in Tournaments. Willi Maurer, visiting from Yale University.
June 19	Methods for Proving Inequalities Among Probabilities of Boolean Functions. Janos Galambos, visiting from Temple University.
June 21	Ranking and Design in Knock-Out Tournaments. Willi Maurer, visiting from Yale University.
June 26	Graph Sieve Theorems and Related Problems. Janos Galambos, visiting from Temple University.

applied statistics series

Following up on last year's successful plan to take seminars in applied statistics directly to the users, D.F. Cox and Paul Hinz expanded the topics available. These seminars are especially developed to be pertinent for research workers from substantive areas who use statistics as a primary research tool, and who consistently use the services of consulting statisticians. Each presentation is tailored to the needs and interests of each particular audience. This not only increases the research workers' awareness of statistical procedures, but also results in valuable contacts throughout the university. During the year seminars were presented in the Colleges of Agriculture, Home Economics, Sciences and Humanities and Veterinary Medicine.

Dr. Cox discussed "The Analysis of Data Using the Design Technique of Split Plots" for agronomy research workers in crop science, soils and soil-plant-climate programs, and for horticulture personnel. A seminar on "The Use of the Statistical Analysis System" (in data analysis, in foods research and in horticulture research) was tailored for zoology, home economics and horticulture, respectively. Veterinary physiology researchers heard about "The Analysis of Physiological Responses" and "The Analysis of Data Utilizing Repeated Measures on the Same Experimental Units."

Dr. Hinz spoke to agronomy staff and students in crop science and soils on "A Geometrical Approach to the Analysis of Variance," "Multivariate Analysis of Variance," and "Cluster Analysis."

In a similar cooperative program to take statistical information directly to the users, Dr. Hinz gave an informal seminar on cluster analysis when he and Glen Meeden participated in a History Department workshop April 25 on the uses of quantitative methods in historical studies. Data provided by a history staff member were used to illustrate the application of cluster analysis. Information such as place of residence, religion, value of estate, etc. of individuals serving in the Pennsylvania Assembly during 1703-1743 successfully distinguished between the activists and non-activists.

quantitative genetics—operations research series

Statistical Laboratory members continue to take an active role in other seminar series on campus. The long-running Quantitative Genetics series features topics of special interest for staff in statistics, genetics, animal science, poultry science, agronomy and horticulture. On May 18 Glenys Thomson of Stanford University discussed "Selection in Complex Genetic Systems." Oscar Kempthorne and Edward Pollak schedule the series.

H.T. David remains on the planning committee for the Operations Research seminar series, organized for individuals concerned with modeling and optimization. J. Richard Schmid addressed the seminar March 13 on "Markov Decision Processes: Parameter Known."

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