STATISTICAL LABORATORY

established 1933

annual report

July 1, 1986 to June 30, 1987

IOWA STATE UNIVERSITY, AMES

Contents

THE STATISTICAL LABORATORY
Iowa State University
1986-87 Annual Report

The Department: Forty Years Old

The First Years

It was a bold step in 1947—to set up the Department of Statistics as a distinct complex of faculty, separate from the Department of Mathematics. Certainly not everyone favored it. Rumors are that George W. Snedecor was uneasy about the separation. The college administration apparently backed it strongly. Once the step was taken, the faculty and staff were committed to the future, but determined to preserve their relationships with the Statistical Laboratory, the agricultural experiment station, and former colleagues in mathematics and the Graduate College.

The first three years were not easy. First there were questions of organization. George W. Snedecor had retired from his position as Statistical Laboratory director on June 30, 1947, at age 65. He was a research professor and president-elect of the American Statistical Association and working on the development of a basic general-education introductory course in statistics. Therefore he did not want to take on leadership in the new department. Initially the department and the other components of the statistical center were administered by a committee of three: Arnold J. King, Alexander M. Mood, and Raymond J. Jessen. Jessen was designated acting head and acting director.

In 1948 the faculty of the new department consisted of those three men, George Brown, Snedecor, Herbert C. S. Thom, Gerhard Tintner, Paul G. Homeyer, Leonid Hurwicz, Oscar Kempthorne, S. Lee Crump, Clifford Hildreth, C. C. Mosier, and instructors Clifford Maloney and Norman V. Strand.

Tintner held joint appointments in economics, mathematics, and statistics and specialized in econometric statistics and time series. Kempthorne had come from the Rothamsted Experimental Station in England in 1947. Hurwicz and Hildreth held joint appointments in economics. Thom was also a research meteorologist with the U.S. Weather Bureau.

The statistical center at Iowa State succeeds because it demonstrates that it is needed, that it is educationally important, and that it shares concerns with other segments of the university. Development of both the use of statistics and the study of statistics at Iowa State has been a cooperative effort from the start, never limited to one field or department. The first courses introduced reflected this. There was teaching and research in interpolation, probability, and mathematical statistics in the Department of Mathematics by 1915-1916. There was also a course in rural statistics listed under Economics. J. M. Evvard, from the Department of Animal Husbandry, has been credited for development of a course in agricultural statistics. By 1925 George Snedecor was teaching three courses, all within the Department of Mathematics, in statistical and biometric methods of interpreting agricultural data and a more advanced course on the method of least squares.

An educational institution tends to take a cautious stance toward setting up new programs or new curricula. Usually the need has been demonstrated, the need to a large degree is already met, and only an appropriate name change is required to recognize the ongoing functions. However, in the case of the new Department of Statistics, Iowa State adopted an ambitious, well-thought-out, elaborate scheme for undergraduate, M.S., and Ph.D. programs.

Part of the program had been in operation for a number of years, although the preemptive needs of World War II for trained statisticians had significantly reduced the size of the faculty. The Department of Mathematics had awarded its first Master of Science degree in mathematical statistics in 1931 to Gertrude M. Cox and its first Doctor of Philosophy degree in mathematical statistics in 1940 to Holly C. Fryer. (Development of the graduate program in statistics and research in sampling had been considerably stimulated by the addition of William G. Cochran to the staff in 1938.) By June 1947, 9 masters' degrees and 6 doctorates had been completed.

However, in 1947 the undergraduate program was new in that the majority of courses outlined for the program did not yet exist and the remainder existed as courses previously aimed primarily at graduate students in research areas other than statistics. Nevertheless, the need for an undergraduate program was there, and already four undergraduate students had completed or were in the middle of degree programs concentrating on mathematical statistics. Special problems courses had enabled these students to progress.

The 1948-49 catalog, the first one issued after the Department of Statistics was created, lists 47 quarter-system courses plus special topics and research. Courses included Statistical Quality Control, Industrial Statistics, Special Statistical Methods in Genetics, and courses on statistical methods, theory, processing of data, analysis of variance, design of experiments, design of samplings, statistical survey methods, economic statistics, probability, time series, multivariate analysis, biological applications, and modern developments. There was also the new three-quarter sequence on Principles of Statistics, being developed by Snedecor as a basic undergraduate course.

By 1950 a number of changes had occurred in the new department. Mood and his colleague, George Brown, had joined the Rand Corporation. King had left the Survey Group in the Statistical Laboratory to join Chilton in Philadelphia and had persuaded other members of the group to follow him. Crump joined the Department of Radiation Biology at the University of

Rochester. Bernard Ostle, Emil Jebe, and Stanley Isaacson had been added to the faculty. Gobind Ram Seth had come and left to take a position in India. Hildreth and Hurwicz had both taken positions with the Cowles Commission for Research in Economics. T. A. Bancroft returned to the campus to join the department in 1949 as an associate professor and became head and director in 1950. An increasing number of advanced graduate students were assisting with the teaching program. Snedecor had pioneered his introductory course, Stat 301, and had written two preliminary versions of a textbook for it.

With A. M. Mood's departure in 1948, Oscar Kempthorne became the principal figure in directing doctoral research for the next few years. He also wrote major textbooks on *The Design and Analysis of Experiments* and *An Introduction to Genetic Statistics*. Named as a Distinguished Professor of Sciences and Humanities and Agriculture in 1964, he continued to be a leader in the areas of design of experiments, linear models, genetic statistics, and statistical inference.

The Bancroft Years

T. A. Bancroft concentrated on reinforcing the interlocking structure of the statistical center and fleshing out the existing curriculum. The philosophy that had given rise to the Statistical Laboratory in the 1930s and the expansion of the graduate program in the 1940s was reaffirmed. The goal would be a balance of statistical theory and statistical methods with sound applications in the various research areas embraced by the university. A series of joint appointments and the appointment of some multifaceted individuals helped achieve this goal.

For instance, H. O. Hartley was brought to the department in 1953 from England as an expert in sample survey methodology. He also became a major figure in research in what was then called high-speed computer methodology. David Huntsberger began teaching in the department as a graduate student and became an assistant professor in 1953. He played a major role in spearheading further development of the undergraduate program for both statistics majors and nonmajors.

The first joint faculty appointment in psychology and statistics was set up in 1950 (and held by Richard McHugh). This was followed by other joint appointments with the social sciences, mathematics, genetics, industrial engineering, and the ISU Computation Center.

The first course in high-speed computing appears in the 1961-1963 catalog, taught by Howard Jespersen, who later joined the new ISU Computation Center and the Department of Computer Science, formed through the cooperative efforts of the departments of Electrical Engineering, Physics, and Statistics. That same catalog lists 19 faculty members in statistics (including 3 instructors). The next catalog lists a second course dealing with advanced computer topics.

1947-1987: A Few Teachers Remembered

Photos are identified from left to right in each tier.

1947: Raymond J. Jessen, who had been active in research in survey sampling and development of the Master Sample of Agriculture at Iowa State, became the Department of Statistics' first acting head. He was succeeded by T. A. Bancroft as first "permanent" head in 1950 (see p. 46). Jessen continued to teach and conduct research here and carried out various short international assignments until 1957 when he became director of statistical survey activities at General Analysis Corporation (later CEIR, Inc.) in California.

Gerhard Tintner, active in econometric statistics with a joint appointment in economics, mathematics, and statistics at ISU until 1963, was officed on the fourth floor of East Hall in a scholar's retreat crammed with international journals and stacks of articles. While here he wrote textbooks on *Econometrics* and *Mathematics and Statistics for Economists*. He eventually returned to Austria to the Technische Hochschule Institut für Okonometrie and died in Vienna in 1983.

1951: David V. Huntsberger joined the ISU statistics faculty as an instructor and soon played a key role in the undergraduate teaching program. His name became internationally known through several undergraduate textbooks. Most successful among these is his *Elements of Statistical Inference* first published in 1961 and now in its fifth edition with Patrick Billingsley as co-author. He became professor emeritus in 1979 and still lives in Ames.

Paul Homeyer and Emil Jebe were part of the early faculty of the Department of Statistics, heavily involved in teaching statistical methods for research workers in the agricultural sciences and economics. Both continued to give strong alumni support after leaving for other positions in the late 1950s. (Homeyer joined Jessen at General Analysis Corporation, while Jebe joined the University of Michigan's Willow Run Labs, now the Environmental Research Institute of Michigan.)

1953: H. O. Hartley came from University College, London. He taught and conducted research in survey methodology and high-speed computing applications here for ten years before becoming the first director of the Texas A&M Institute of Statistics.

1958: George Zyskind came to Iowa State from Canada after completing his Ph.D. He joined the faculty in 1959 after a year's post-doctoral study at the University of North Carolina. He died in Israel at the beginning of a year's faculty improvement leave. Born in Poland, he was his family's only survivor of Nazi concentration camps.

Shriram Biyani (Ph.D. 11/78) with his major professor, B. V. Sukhatme. Coming from India in 1967, Sukhatme joined the ISU statistics faculty in 1968 as full professor. Before his untimely death in 1979, he attained wide recognition for his work in survey sampling theory. With his brother P. V. Sukhatme, he co-authored the well-known text *Sampling Theory of Surveys with Applications* (3rd edition, 1984, co-authored by his wife, Shashikala Sukhatme, and C. Asok).

Between 1947 and 1956, the following courses had been introduced: Psychological Statistics, General Theory of Linear Hypothesis (later changed to Linear Models), Theory of Estimation and Testing of Hypotheses.

By 1973 there were courses in elementary business statistics, factor analysis, sociometric statistics, reliability, operations research, decision theory, distribution theory, stochastic processes, nonparametrics, mathematical programming, Markov chains, and two courses on statistical computation on digital computers. At this time, 67 quarter-system courses were being offered, in addition to special problems, special topics, and research. Thirty-five faculty were listed (including four instructors and one emeritus professor).

Some notable national and international conferences were organized and/or held here: for example, the Heterosis Conference in 1950 and the Biostatistics Conference in 1952, involving the pooled efforts of researchers in statistics, agriculture, and biology; the spring 1972 joint statistical meetings of the American Statistical Association, Biometric Society (ENAR), and Institute of Mathematical Statistics (Central Region); the Seventh Annual Symposium on the Interface: Computer Science and Statistics in 1973; the first International Conference on Quantitative Genetics in 1976 followed by the Kingman Regional Conference in 1979; the Institute of Mathematical Statistics Special Topics Meeting on Time Series in 1979; and, in 1983, Statistics: An Appraisal, an international conference in honor of the 50th anniversary of the ISU Statistical Laboratory.

Over the years support for much of the graduate research has come from contractual agreements, arranged through the Statistical Laboratory or the Statistics Department of the Iowa Agriculture and Home Economics Experiment Station, and individual faculty grants from federal and other sources. A 14-year National Institutes of Health training grant program began here in 1958 to support graduate training in biostatistics. Unlike previous work in biostatistics at Iowa State, this program included periods of experience for trainees at off-campus medical and public health centers.

In 1966, a five-year cooperative teaching and training project was launched with the support of the Ford Foundation to improve the Statistics Center of the National School of Agriculture at Chapingo, Mexico. Statistics faculty from ISU went to Chapingo; graduate students came here for additional training.

Between 1964 and 1969, six summer institutes on survey sampling techniques were held, through the cooperation of the Statistical Laboratory and the U.S. Bureau of the Census, for international participants sponsored by the bureau, the U.S. Department of Agriculture and/or the United Nations. In 1969 and 1970, National Science Foundation-sponsored summer institutes on probability, statistics, and computer science were held here for mathematics teachers. A somewhat similar institute involving four universities had been held at ISU in 1961 for teachers of statistics. In 1977 an NSF-sponsored summer science training program on statistics, probability, and computing was held for mathematically talented high school students.

The Department of Statistics was instrumental in establishing Mu Sigma Rho as a national statistics honorary fraternity stressing both theoretical and applied statistics. The Iowa Alpha chapter was organized in 1968 at Iowa State University.

The H. A. David Years

Herbert A. David, educated in Australia and England, came from the University of North Carolina at Chapel Hill in 1972 to head the department and the Statistical Laboratory. Under his leadership during the next 12 years early goals were reaffirmed, but with an increased scope of applications. An extensive list of theoretical and applied courses was developed to provide a strong and broad program.

Changes in computational equipment and software available at Iowa State University led to numerous changes in the ways individual courses were taught and graduate research was conducted. By 1980 the ISU Computation Center's VAX system and mainframe system were being used in 300- and higher-level statistics courses through terminals located in Snedecor Hall.

David helped initiate three memorial series of lectures to honor George W. Snedecor, who died in 1974, and two younger members of the department, George Zyskind and B. V. Sukhatme, who died in 1974 and 1979 respectively.

During the 1970s a number of experimental and advanced special topics courses were developed. Service areas that had been offered for undergraduates were expanded; new courses were added in probability and statistical inference for engineers, applied time series, survey sampling for social scientists, and methods of multivariate analysis. Graduate courses in ecological statistics, statistical computing, multivariate analysis, order statistics, and nonparametric statistical theory were added, and an advanced sequence on time series was introduced.

Then in the fall of 1981 the university changed from a quarter system to a semester system. As a result, the department thoroughly overhauled its offerings. In the 1980s graduate-level courses in Bayesian decision theory, spatial statistics, and response surface methodology were added, and an updating and expansion of departmental offerings in industrial statistics was undertaken, to enhance the interface of statistics and engineering.

During the '80s the sizeable increase in undergraduate enrollment in service courses led to increased dependence on teaching assistants in introductory courses. Fortunately there has also been a growth in numbers of statistics graduate students and continued interaction of teaching assistants with senior faculty.

A number of significant books have been written wholly or in part at Iowa State University by members of the Department of Statistics. These include the Kempthorne titles already mentioned and later editions of George Snedecor's *Statistical Methods.* There are such textbooks as A. M. Mood's *Introduction to the Theory of Statistics,* Gerhard Tintner's *Econometrics* and *Mathematics and Statistics for Economists,* T. A. Bancroft's *Topics in Intermediate Statistical Methods, Vol. I* and *Statistical Theory and Inference in Research* by Bancroft and Chien-Pai Han. Also there are *Probability, Statistics, and Data Analysis* by O. Kempthorne (with J. L. Folks), *Statistical Computing* by William J. Kennedy (with James E. Gentle), *Markov Chains: Theory and Applications* by Dean L. Isaacson (with Richard W. Madsen), H. A. David's *Order Statistics* and monograph (with M. Moeschberger) *The Theory of Competing Risks,* Wayne Fuller's *Introduction to Statistical Time Series* and *Measurement Error Models,* Vincent

Sposito's *Linear and Nonlinear Programming,* and the three editions of *Sampling Theory of Surveys with Applications* coauthored by B. V. Sukhatme and/or Shashikala Sukhatme (with P. V. Sukhatme).

At a more introductory level are Snedecor's *Everyday Statistics—Facts and Fallacies,* David Huntsberger's *Elements of Statistical Inference* and its various spinoffs, and Richard Groeneveld's *An Introduction to Probability and Statistics Using BASIC.*

Other titles are W. Q. Meeker's *Selected Tables in Mathematical Statistics, Vol. VII: The Product of Two Normally Distributed Random Variables* (with Larry W. Corwell and Leo A. Aroian), C. P. Cox's *Handbook of Introductory Statistical Methods,* and Leroy Wolins' *Research Mistakes in the Social and Behavioral Sciences.* In addition there are the special volumes published as the result of the various international and professional conferences held here and edited volumes such as *Statistical Papers in Honor of George W. Snedecor* and *Contributions to Survey Sampling and Applied Statistics, Papers in Honor of H. A. Hartley.*

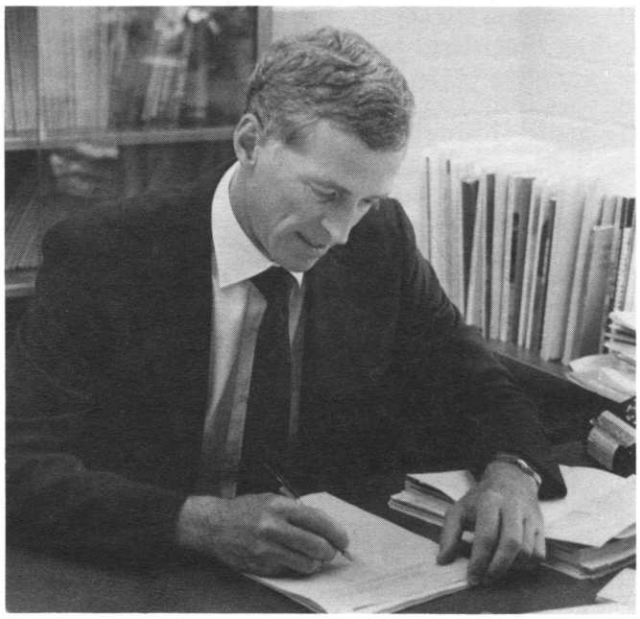
The Mid-Eighties

Since 1984, Dean L. Isaacson has headed the Department of Statistics. An affiliate program in productivity, quality, and reliability was approved in 1985 for the departments of Statistics and Industrial Engineering to cooperate with industry. The use of personal computers in graduate research and in the classrooms is increasing as equipment is added and terminal networks are set up to allow alternatives to mainframe and VAX data processing.

Over 1,000 degrees have been granted by the Department of Statistics in its first 40 years. The recipients now reside in over 50 countries and in all 50 states of the U.S.

Alumni have headed or now head university statistics, mathematics, or computer science departments or divisions in Florida, Kansas, Kentucky, Maryland, Mississippi, New York, North Dakota, Oklahoma, Rhode Island, Tennessee, Utah, Virginia, Washington, and Wyoming, as well as in Canada, Egypt, India, Taiwan, and Thailand. Government positions have ranged from heading Statistics Canada to holding key positions in the U.S. Bureau of the Census, Bureau of Labor Statistics, Public Health Service, Department of Agriculture, and the NASA/Johnson Space Center. Alumni have become presidents and vice presidents of scientific and technical consulting firms and major research centers. Others manage the statistics or biostatistics units of their companies' research divisions. They are involved with everything from electronic banking and artificial intelligence to statistical process control, pharmaceuticals and cancer research, market research, agricultural experimentation, and Third World planning and economic development.

We look forward to the next ten years and the challenges and changes they will bring.



Dean L. Isaacson, director and head

Personnel

Effective July 1, 1986, Dean Isaacson, acting director and head, became director and head of the Iowa State University statistical center. This was the culmination of a two-year search process that ended up as an internal search.

At the same time, the leadership of Iowa State University changed with the retirement of President W. Robert Parks and the installation of Gordon Eaton as his successor. As this year ends, it appears that the coming months will see changes in the administrative leadership of the Graduate College and the Agriculture and Home Economics Experiment Station, since search committees for a provost and a new dean of the College of Agriculture have been formed.

Balvant K. Kale, who had been a visiting professor in statistics for the 1985-86 academic year, on leave from the University of Poona, India, remained for additional research during part of the summer before going to the University of Waterloo, Canada, for fall semester.

Thomas A. Bubolz resigned as adjunct associate professor on July 31, 1986, to remain at Dartmouth College in the Department of Community and Family Medicine. Kathleen Shelley has taken over his leadership responsibilities in the Statistical Laboratory's Statistical Numerical Analysis group.

Krishna Athreya was on faculty improvement leave for the academic year to engage in research on limit theorems in probability theory and statistics.

He spent the fall semester in India, primarily at the Indian Statistical Institute Bangalore Centre. In January he went to Berkeley, California, with partial support from the Mathematical Sciences Research Institute through National Science Foundation funding.

During the fall semester Edward Pollack was a visiting professor in the Department of Animal Sciences at the University of Illinois, Champaign/Urbana, where he taught a course on population genetics.

Fetih Yildirim, associate professor and chair, Department of Statistics, Middle East Technical University, Ankara, Turkey, came here in August as a visiting senior Fulbright research scholar. He extended his stay until July 1987 and served as visiting associate professor in the Department of Statistics spring semester.

Jingyu Liu spent the academic year here as a visiting scholar supported by the Science and Technology Commission of Inner Mongolia, China. He is on leave from his position as teacher of mathematics in the Inner Mongolia Forestry College, in Huhehot.

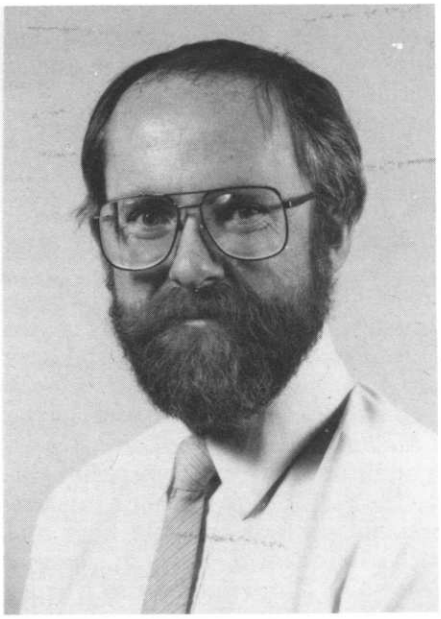
George E. Battese, senior lecturer in the Department of Econometrics, University of New England, Australia, returned to the Department of Statistics January 23, 1987, to begin a year as visiting professor in the Survey Section.

Two former staff members rejoined the Department of Statistics and Statistical Laboratory for short assignments as visiting professors. Ishay Weissman, head of the statistics area at Technion—Israel Institute of Technology, was here for the months of July and August 1986 for research. Then he went to the University of California-Davis for the academic year. Malay Ghosh came from the University of Florida for two weeks' research in July.

J. Tiago de Oliveira arrived in late May 1987 to engage in research as visiting professor for about one month. He is a member of the Academy of Science of Lisbon, Portugal, and has been on the faculty of the Departamento de Estatistíca, Investigaçao Operacional e Computaçao of the Escola Politécnica in Lisbon.

Noel A. C. Cressie and Glen Meeden were recognized as new Fellows of the American Statistical Association on August 19, 1986, at the Chicago annual meetings. Cressie was cited "for significant contributions to the theory and practice of statistics including spatial statistics, robust-resistant methods, and goodness-of-fit testing; for excellence in teaching; and for excellence in consulting." Meeden was cited "for significant contributions to Bayesian and empirical Bayesian procedures, calibration, and finite population theory; for elucidation of the concepts of sufficiency and admissibility."

W. Robert Stephenson was presented with the 1987 Award for Outstanding Academic Advising by the College of Sciences and Humanities, Iowa State University, on March 18. The award recognizes his commitment and achievements as adviser to statistics majors, advising coordinator, and faculty adviser to the Statistics Club.



Outstanding adviser W. R. Stephenson: "Dr. Bob's" open door policy, encouraging students to seek him out whenever he is in his office, illustrates his commitment to students.

William J. Kennedy received a Faculty Citation at the annual Honors and Awards Convocation held by the Alumni Association and Iowa State University on June 6. His citation reads as follows: "It is for his work in statistical computing that Dr. Kennedy is best known, particularly his research in numerical problems in computing. His national recognition as a leader in this area began with his chairing of the Symposium on the Interface of Computer Science and Statistics in 1973. Since then, as a member of the Board of Governors of the Interface and through various offices in the Statistical Computing Section of the American Statistical Association, he has continued to rank among the very top leaders in the field, providing organizational and editorial direction. On the ISU campus, he has had the crucial task of guiding the Department of Statistics in a rapidly changing field. Iowa State is indeed fortunate to have someone of Dr. Kennedy's stature on its faculty."

Dan Schnell was appointed as postdoctoral research associate in the Survey Section for summer 1987, following completion of his degree here. He had held a predoctoral research associateship during the academic year.

Looking toward next year: John Eltinge has accepted the position of assistant professor in the Survey Section left vacant by Ronald Iachan.

Kenneth J. Koehler has been promoted to full professor and Yasuo Amemiya to associate professor effective July 1, 1987.

Frederick Lorenz will be on faculty improvement leave for the academic year. He is establishing visiting scholar residence in the Department of Sociology, Stanford University, to work with W. Richard Scott and other organizational theory specialists on the study of human service organizations.

Statistical Laboratory Staff—Fiscal Year 1986-87 under the administrative direction of:

Gordon P. Eaton, Ph.D.—president of the university

Daniel J. Zaffarano, Ph.D.—vice president for research; dean of the Graduate College

William H. Kelly, Ph.D.—dean, College of Sciences and Humanities; director, Sciences and Humanities Research Institute

Lee R. Kolmer, Ph.D.—dean, College of Agriculture; director, Iowa Agriculture and Home Economics Experiment Station

Dean L. Isaacson, Ph.D.—director, Statistical Laboratory; head, Department of Statistics; head, Statistics Department, Iowa Agriculture and Home Economics Experiment Station

Professors

Krishna B. Athreya, joint appointment with Department of Mathematics
Theodore W. Bailey, Jr.
George E. Battese, visiting
C. Philip Cox
David F. Cox
Noel A. C. Cressie
Herbert A. David, Distinguished Professor in Sciences and Humanities
Herbert T. David, joint appointment with Department of Industrial Engineering
Wayne A. Fuller, Distinguished Professor in Sciences and Humanities; faculty status also in Department of Economics
Richard A. Groeneveld
David A. Harville
Roy D. Hickman
Paul N. Hinz, faculty status also in Department of Forestry
Donald K. Hotchkiss
David V. Huntsberger, professor emeritus
Dean L. Isaacson
Balvant K. Kale, visiting
Oscar Kempthorne, Distinguished Professor in Sciences and Humanities
William J. Kennedy
Glen D. Meeden
William Q. Meeker, Jr.
Edward Pollak, joint appointment with Department of Genetics
Vincent A. Sposito, joint appointment with Computation Center
Robert F. Strahan, joint appointment with Department of Psychology
Norman V. Strand, professor emeritus
Stephen B. Vardeman, joint appointment with Department of Industrial Engineering
Leroy Wolins, joint appointment with Department of Psychology

Associate Professors

Kenneth J. Koehler
Frederick O. Lorenz, joint appointment with Department of Sociology and Anthropology
Mervyn G. Marasinghe
Jerome M. Sacks, USDA collaborator
Mack C. Shelley II, joint appointment with Department of Political Science
Shaskikala Sukhatme
Fetih Yildirim, visiting, Fulbright Scholar

Assistant Professors

Yasuo Amemiya
Harold D. Baker
Mark R. Reiser
Carl W. Roberts, joint appointment with Department of Sociology and Anthropology
W. Robert Stephenson

Visiting Scholar

Jingyu Liu

Resident Collaborator

Arthur D. Kuhl, USDA Soil Conservation Service, joint appointment with Department of Agronomy

Postdoctoral Research Associate

Daniel J. Schnell

National Science Foundation Fellow

John L. Eltinge

Graduate Assistants

The status of graduate students often changes. Students holding appointments as graduate teaching or research assistants in statistics for part or all of the year are listed here.

Douglas Andrews
Craig Beam
Douglas Bearrood
Jonathan Biele
Kimberly Brown
Donna Busch
Michael R. Carley
Alicia Carriquiry
Barbara A. Chisolm
Joseph Croos
C. Janelle Dombek
Kimberly Erland
Carol A. Francisco
Eiichiro Funo
Jooi-Tow Goh
Carol A. Gotway
Deanna L. Graf
Eric A. Grau
Martin Grondona
In-Hye Ha
Nancy Hasab-El-Naby
Patrick Homblé
Chong Sun Hong
Zhaofeng Huang
Frederick Hulting
Philip Iversen
Jane Johnson
Yoou-Jen Kang
Song-Ho Kim
Alice Lay
Mong-Hong Lee
Klaus Lemke
Charles A. Liedtke
Jyh-Shiun Lin
Tsung-Hua Thomas Lin
Ge-Shean Albert Liou

Sharon K. Loubert
Chi-hsien Joseph Lu
Frederick Medak
Todd E. Melander
Stephen M. Miller
Jorge Morel
Terry Moy
Dennis J. Murphy
Neerchal K. Nagaraj
Nuwan Nanayakkara
Teresa Nelson
Sarah M. Nusser
Heon Jin Park
Kathrina Payton
Anne Poggeman
Stephen L. Rathbun
Jill L. Roesler
Sahadeb Sarkar
Mary E. Sayler
Darrell Schroeder
David Steenhard
Shiowlin Su
Gary R. Sullivan
Nae Kyung Sung
James T. Symanowski
Kathleen M. Taylor
M. Bridget Tirol
Margot Tollefson
Scott Vander Wiel
Shaw-Ling Wang (Chu)
Chung-Ching Morgan Wang
Kui-Jang William Wang
Susan Wettstein
Susan E. White
Eric R. Williams
Rahmat Zakaria
Dale L. Zimmerman

Supported Graduate Students

Danyal bin Abdul Malik—Government of Malaysia
Edi Abdurachman—USAID, Indonesia
Ahmad M. A. Al-Mahmoud—Mu-tah University, Jordan
Victor P. Brescia—National Institute of Agricultural Technology, Argentina
Mark F. Bryan—Department of Entomology, ISU
Yilin Cai—Southwest Agricultural College, China
B. Keith Cranford—College of Business Administration and Graduate College
Abdullah Fagih—Kingdom of Saudi Arabia
Kaisheng Fan—Government of China
Fredolin Tangang @ Tajudin Mahmud—National University of Malaysia
Clarice Freire—CAPES, Government of Brazil
Cheng-Der Fuh—Department of Mathematics, ISU
Renkuan Guo—Engineering Research Institute, ISU
Karen Jensen—Graduate College, ISU
Paula Lasack—Department of Entomology, ISU
Shwu-Fen Liu—Department of Child Development, ISU
Sami M. A. Masoud—University of Jordan
Sueli A. Mingoti—Federal University of Minas Gerais and CAPES, Government of Brazil
Astini Salihima—MUCIA-AID-Indonesia
Muhamad Sabran—Government of Indonesia
Kai-One Sriplung—Center for Agricultural and Rural Development, ISU
M. Katheleen Vasconcelas—Conselho Nacional de Desenvolvimento Cientifico e Tecnologico, Brazil
Jay Ver Hoef—Department of Botany, ISU

Self-Supporting Graduate Students

Keng-tang Chien
Tae-Kyoung Cho
Charles M. Farmer (in absentia)
Shiow-Lan Gau
Geun Shik Han
Mu-Yeh Huang
Shu-Mei Huang
Joo-Hwan Kim
Bojein Kuo
Kyung Hee Ghang Lee
Seung-Chun Li
Chiou-Hua Lin
Barnabas M. Misambo
Grecia Morel
Hussein Shamsuddin
John Thompson
Franklin Winters (in absentia)

Professional and Scientific Staff

Richard Dorsch, programming consultant, Survey Section
Mary Genalo, research associate, Survey Section
Avonelle Hefflefinger, administrative assistant
Hsueh-Foo (Sherry) Lin, research associate, Survey Section
Bud Meador, supervisor, Statistical Data Processing Services
Deborah Reed-Margetan, programmer-analyst, Survey Section
Kathleen Shelley, specialist, Statistical Numerical Analysis Services
Harvey Terpstra, data systems manager, Survey Section
John C. Thompson, data analyst, Statistical Numerical Analysis Services
Jauvanta Walker, information specialist

General Office Staff

Rose Ann Anderson, secretary
Norma Elwick, secretary
Jeanette Lagrange, clerk typist
Donna Nelson, clerk typist
Janice Peters, account specialist
Denise Riker, secretary
Sharon Shephard, clerk typist
Margaret Wheelock, clerk typist, beginning July 7, 1986
Darlene Wicks, clerk typist, Statistical Numerical Analysis and Data Processing Section

Survey Section Staff

Glenda Ashley, key entry operator
Kathryn Bottorff, field interviewer
Dorothy Edwards, statistical clerk
Sharon Erback, statistical clerk
Vimlesh Gupta, key entry operator
Nancy Heathman, account clerk
Marcia Luze, field interviewer
Helen Nelson, secretary
Christine Olson, clerk typist
Mary Rathbone, field interviewer
Kathie Reinertson, data technician
Jasmine Seagrave, data technician
Jeanne Sorenson, statistical data processor
Miriam Troyer, field interviewer
Susan E. Verkade, data technician
Carol West, key entry operator
Karon White, key entry operator

Consulting and Cooperative Research

The Statistical Laboratory and the statistics department of the Iowa Agriculture and Home Economics Experiment Station provide statistical consulting and research services to the rest of the university and to local, state, and federal agencies as time and funds permit. Some of this work is supported by contracts and grants. These are supplemented by individual consulting and by summer assignments taken on by nine-month faculty.

Within the university, service is supported by a series of joint appointments with other subject-matter areas, namely, faculty appointments with the Computation Center and departments of Economics, Forestry, Genetics, Industrial Engineering, Mathematics, Political Science, Psychology, and Sociology and Anthropology. These and similar arrangements made for support of statistics graduate students are one source of our vitality in applied statistics and strength in providing consulting service to the university.

Agriculture and Home Economics Experiment Station

Statistical consulting with researchers in the College of Veterinary Medicine and in the Agriculture and Home Economics Experiment Station is done by David F. Cox, Theodore B. Bailey, Paul N. Hinz, and Donald K. Hotchkiss on a regular, continuing basis. The graduate assistants working with the staff in consulting this year include Sarah Nusser, Stephen Rathbun, Carol Gotway, Mark Bryan, Paula Lasack, and Victor Brescia. Other members of the statistical center also consult with experiment station researchers from time to time.

Contacts between statistics faculty and biotechnology faculty increased. Assistantship support for a statistics graduate student has been arranged for next year to help give data processing and statistical consulting services to the biotechnology program.

Research projects in which D. F. Cox participated during the 1986-87 year, with help from the research assistants, include a study of the fate of bile acids in goats under control and various treatment conditions, investigations of the effects of induced labor in sows on the young pigs born, studies of plant hormones, sensory evaluation of beans following various cooking procedures, comparisons between uncultivated and cultivated soils and various fertilizer treatments as they affect yields of corn and barley, a project looking into the possibility of climatological effects influencing the time and difficulty of calving, and a study of the fatty acid concentrations in two tissues at three different temperatures. Some other examples are given below.

Two projects on which Paul Hinz worked emphasize the role multivariate methods can play in the analysis of data from the experiment station. In dairy cattle, type traits such as body size, body shape, and udder characteristics have long been used to judge show animals. Only recently, however, have quantitative measurements been made of these traits. Attempts are being made to establish a connection with characteristics of commercial importance, such as milk production. A joint project of the statistics and animal science departments used quantitative measurements on 18 type traits in a principal components analysis and a factor analysis to study the relationships among the traits and their connection to production variables.

In the second project, arising in the plant sciences, data were collected on 16 characteristics of pearl millet varieties, and principal components analysis and factor analysis were used to analyze the data. This crop species is relatively undeveloped. The objective of the study was to understand the relationships among the variables and therefore to help future plant breeding efforts.

Theodore Bailey has been using a new Zenith 158 desktop computer, with a SAS package and an IBM Proprinter, extensively since December in his experiment station consulting work. This has in part freed him from reliance on the university mainframe computer and, because the microcomputer enables easy use of materials from consulting, has potential for enhancing his teaching.

During the year Bailey consulted mainly with researchers in the plant sciences. For example, one study was investigating genotypic response of orchard grass to selection for in-vitro dry-matter digestibility (IVDMD) when selection was carried out in the greenhouse but response was determined in the field. Variability of experimental conditions was known to exist in the greenhouse. Therefore 11 incomplete blocks were used, each containing 36 plants, for the greenhouse portion of the study. Selection within blocks was practiced to pick the two best and two worst performers for IVDMD in each block. These 44 plants were then clonally propagated in the field, using a randomized complete block experimental design. Bailey advised on the analysis and interpretation of the field study. Each plot was harvested twice during the summer and, for each harvest, duplicate determinations were made for IVDMD. The interpretation involved, among other things, questions relative to the genetic nature of the plant materials included in the study.

Bailey consulted with a graduate student in agronomy about a genetic simulation study of linear

and nonlinear genetic effects in crosses of a number of hybrids to a series of inbred lines. In toto, 50,000 crosses were simulated. Guidance was provided to another student on the calculation of genotypic and phenotypic correlations for a study of indirect response to selection in forage species. The data came from a field investigation involving 51 polycross progenies.

Bailey helped a horticultural researcher design an experiment examining the best method of establishing field lilacs. The experiment included 13 treatments, including a $2 \times 3 \times 2$ factorial and a control. A randomized complete block design with five replications was recommended, and an appropriate statistical analysis including comparisons among treatment means was outlined.

A student in wetland ecology was advised on the analysis of an experiment Bailey had previously helped design. This experiment was carried out in India for a study concerned with the effects of goose feeding habits on the plant populations where they feed. Treatments consisted of all combinations of a 3×4 factorial with 6 replications.

Paula Lasack, a joint graduate major in statistics and entomology, spent the spring semester as an intern working in the AHEES statistical consulting section. Her assistantship is supported by the Department of Entomology. Lasack is one of the few statistical consultants who both collect and analyze their own data. She has a special understanding of randomization and replication, having spent many hours under the hot sun in the field. By the time she finishes her degree, the world should know a little more about stalk borers in corn, her particular focus in research.

Edward Pollak consulted with a faculty member in the Department of Agronomy and a former agronomy student now with Pioneer. This collaborative work is based on a model for quantitatively inherited traits influenced by nuclear-cytoplasmic interactions. Expressions for covariances between relatives were derived. These were shown to lead to a method for the estimation of at least some of the variability associated with cytoplasmic effects from reciprocal mating designs.

Victor Brescia, here from Argentina, helped a staff member in plant pathology with the analysis of a split-split plot experiment on stalk rot of corn. Brescia was delighted when the staff member, who had spent two years in Uruguay, spoke with him in his native Spanish language.

During the year, V. A. Sposito assisted various members of the Center for Agricultural Research and Development (CARD) in formulating and solving several large-scale economic linear models. One project involved obtaining a solution incorporating three linear objective functions. Through the use of a Control Program written for IBM's MPX/370E Mathematical Programming System, the problem was solved, given a certain preemptive priority structure. This goal programming procedure was originally developed by Lee Ann Crowder.

Statistical Numerical Analysis and Data Processing Section

The resignation of Thomas Bubolz led to a reorganization of personnel in the section. The two-group structure—Statistical Data Processing and Statistical Numerical Analysis—was preserved, with Bud Meador and Kathleen Shelley responsible for the individual groups. John Thompson replaces Shelley as the section's full-time statistical computer analyst. The section continues to provide statistical computer programming and data processing service support for the university. Teaching and research activities of the section are carried out by William J. Kennedy, Vincent Sposito, and Mervyn Marasinghe.

Installation of, and consulting on, personal computer and mainframe-based software constituted a large component of the section's work this year. The "consulting room" seemed to be filled most of the time with people asking questions about nontrivial applications of computers.

Bud Meador, assisted by John Thompson, carried out the installation of PC/SAS on more than 40 workstations scattered throughout the campus. A large degree of satisfaction was reported by persons using this software. However, a large initial training requirement kept Meador and Thompson very busy for several months.

New versions of MINITAB and SPSSX were installed by Kathy Shelley, assisted by Albert Liou. Updates of various other software, including Turbo PASCAL, dBASEIII, and Lotus SYMPHONY were also installed. Thompson and Fred Hulting prepared and installed software and procedures that facilitated use of the section's HP laserjet+ laser printer for multiple-font applications.

Computer graphics are being employed more on campus each year because hardware and software support continues to improve. The SASGRAPH software installed on the NAS 9160 machine in the university Computation Center has been heavily used, especially during the latter part of this past year when SASGRAPH output could be routed to the laser printer. This new printing capability meets a previously unfulfilled need for high quality printing of figures and graphs.

An interesting application involving color graphics and multiple computer use was done by Morgan Wang as part of work for the ISU Center for Industrial Research and Service and the Iowa Small Business Development Center customers. Wang used the annotate facility in SASGRAPH to prepare a dataset containing an annotated multicolor Iowa county-specific map. The dataset was then copied to one of the section's IBM PC/ATs that drives the section's HP7475A color plotter. This enabled the generation of multicolor transparencies, which have now been used in several meetings. This initial success with production of color transparencies led to other applications, and attractive colorful overhead projector displays are now rather easily obtained by section personnel.

Fred Hulting developed a special-application PC modem communication program for the Iowa Small Business Development Centers. This user-friendly program is being used by all 11 subcenters to transfer text files and binary files, such as spreadsheets and database files, between subcenters. Hulting also produced an IBM PC/AT implementation of recently developed methodology for interactive graphic data analysis. This is a powerful graphics software system that incorporates brushing techniques and three-dimensional rotation.

Mike Carley wrote a utility program to rename files across subdirectories. He also used Hulting's interactive graphics program as one tool for analyzing the effectiveness of the SPEAK/TEACH tests for Iowa State University teaching assistants.

Development of database management systems using dBASEIII Plus took a large amount of the Shelley group's time. Albert Liou designed and implemented an in-house database system for the section's clients. Hulting and Carley did further database work for the Small Business Development Centers. Shelley and Carley developed a data entry and reporting system that tracks business activity, for Holthaus Associates, an Iowa manufacturing representative firm.

The section's involvement in agricultural and crop-related projects is less extensive than in the past, but is still substantial. Darrell Schroeder worked with a member of the Iowa Crop Improvement Association on the Corn Yield Trials, the Popcorn Project, and other tasks. Debora Jones worked on a corn breeding project from a private seed-corn company. Jones, a graduate student in child development, holds a research assistantship in the Statistical Numerical Analysis and Data Processing Section, supported by the Graduate College. She has also worked on projects originating in the Department of Family Environment and the Home Economics Extension Service.

Miriam Tirol spent considerable time on the personal computer software developed by the section for Iowa's State Forest Nursery. Most of her effort was directed toward modifications to make the software suitable for use in Colorado's Tree Order System. Jim Symanowski and Kathy Taylor worked briefly on this project before transferring to another section of the Statistical Laboratory.

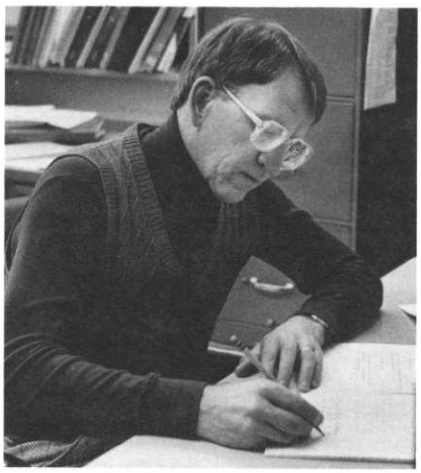
Klaus Lemke and Darrell Schroeder worked with a member of the Iowa Conservation Commission on the Breeding Bird Survey. Lemke also worked with Tirol to develop database software for the purchasing division of a large manufacturer of laundry equipment.

Other projects were completed for on-campus clients from the departments of Textiles and Clothing, Sociology and Anthropology, Food and Nutrition, English, and Child Development, and the Graduate College. In many of these projects both the mainframe and personal computers were used.

IBM's Mathematical Programming System was used to support various on-campus research projects. V. A. Sposito provided assistance in the use of this system. Some of the activities involved use of IBM's new system MPSX/370E.

As editorial assistant to William J. Kennedy, editor of *The American Statistician,* Darlene Wicks used several systems to support accounting and text processing activities. These include WORDPERFECT, dBASEIII, and SESAME, a program developed by Kennedy to make text processing of statistical equations relatively user friendly.

Survey Section



George Battese, visiting professor

Under the direction of Roy D. Hickman, the Survey Section of the Statistical Laboratory provides consultation and direct operational assistance to research workers in sample design and the planning and execution of sample surveys and censuses. Section staff engage in all areas pertaining to the operational conduct of surveys. Professional staff members also conduct research and teach courses in the areas of sampling, survey design, and statistical methods.

Two case-control studies of cancer incidence, conducted in collaboration with the Department of Preventive Medicine, University of Iowa, and the National Cancer Institute, were completed during the year. The first, a four-year study of males diagnosed with breast cancer, was conducted in eight states and coordinated by the Cancer Research Center in Seattle, Washington. The Survey Section interviewed all Iowa cases and controls. In a second study, designed to investigate the causal relationship of use of analgesics and cancer of the renal pelvis, section staff collected data from 200 cases and controls. Data from the three participating states, California, New Jersey, and Iowa, will be analyzed by National Cancer Institute epidemiologists.

Researchers at the Mayo Clinic, Rochester, Minnesota, were given assistance with the implementation of a lung health study of southeastern Minnesota residents. This investigation will attempt to assess the effects of certain medications used by cigarette smokers diagnosed as having chronic obstructive pulmonary disease. Guidance was given on sample design and selection and on design of the questionnaire used in screening subjects by telephone to determine

eligibility for the study. Section staff designed and conducted a pilot study of 300 households and then trained the clinic's staff of telephone interviewers.

For the third consecutive year, the Iowa Department of Natural Resources was given assistance on a pilot study to measure the effects of deer depredation in corn and soybean fields near a state park having a large population of deer. Some modifications in the sample design used previously were required because of a considerable increase in the number of fields put into the set-aside program and restrictions placed by the farm operators on the numbers of plots they were willing to allow in their fields.

Faculty members from the departments of Child Development, Food and Nutrition, and Hotel, Restaurant, and Institution Management collaborated with Survey Section staff in a study of licensed daycare providers who participated in a program of nutrition education. The nutrition program is sponsored by a group of public and private agencies promoting child nutrition, and this study was designed to assess the nutrition knowledge and practices of the daycare providers. Section staff designed and selected the sample, assisted with the development of methodology and field forms, completed the 844 telephone interviews, and coded and tabulated the data.

Members of the Survey Section worked with investigators from the ISU Department of Forestry on a study of forest land in eastern Iowa for the Energy Bureau of the Iowa Department of Natural Resources. The purpose of the study is (1) to estimate the amount of forest land being held by owners who would be willing to sell firewood to the State of Iowa as a source of fuel for heating state-owned facilities, and (2) to determine timber management practices being utilized by owners of forest land. A sample of 40-acre parcels of land was selected from a 17-county area. Tax records were used to determine the owners of the sample land, and the landowners were interviewed by telephone. Besides designing and selecting the sample, the Survey Section assisted in developing the questionnaire and other field forms and collected the data.

The National Academy of Arbitrators, under the direction of Clifford E. Smith, ISU Department of Industrial Engineering, is gathering data on the characteristics and practices of professional labor arbitrators in the U.S. and Canada. Section staff are assisting with development of a mail questionnaire, design and selection of a sample, management of the mail-out, and follow-up of nonresponders, and will code and tabulate the data.

Researchers in the Department of Family Environment collaborated with the Survey Section in a follow-up of respondents to a previous study of household money management practices. Of the 201 individuals who took part in a 1982 study, 151 were interviewed to ascertain changes in their financial status and household financial practices. Section staff assisted with development of study methodology, located previous respondents, completed the telephone interviews, and coded and tabulated the data. The principal investigators are conducting a longitudinal data analysis.

At the behest of the Iowa Board of Regents, a survey of the Iowa State University faculty was carried out to estimate the average number of hours worked per week by faculty members. A sample of 250 faculty members was selected. These were then assigned at random to one of 25 weeks during the 1986-87 academic year. Each week, questionnaires were sent to the ten designated sample subjects asking them to report their hours worked during the previous week. Sample selection, data collection, data processing, and analysis were all done by Survey Section personnel. A similar study had been carried out during the 1984-85 academic year.

In another study carried out for the university administration, all faculty members were surveyed regarding their opinions on the academic strengths and weaknesses within colleges and departments. The results will be used to help identify those disciplines that the faculty perceive to be strong and those that may need strengthening.

Iowa State University merit employees were the subjects of a survey under the auspices of the University Committee on Women. The Survey Section assisted in developing the questionnaire and designing the sample. An equal probability general sample of 533 employees was selected. A supplementary sample of 22 employees was chosen from those classified as supervisory-confidential to enable researchers to make separate estimates for that group. Samples from the other subgroups (blue collar, security-technical, and clerical) were already sufficiently large for this purpose. Section staff administered the survey, coded the responses, and tabulated the results.

Other consultative and operational services were provided to colleagues and students from various disciplines. For example, samples of grain elevators, feed-grain mills, and river barge terminals were designed and selected for a professor in agricultural economics studying grain marketing patterns in Iowa. Assistance with questionnaire development, pretesting, and graduate student training was provided for a faculty member from the Department of Family Environment who is implementing a benchmark study of similarities and differences between men and women who sexually abuse children. Sample design and selection, data collection, and analysis services were provided to colleagues in the University Library who were assessing the physical condition of the collections as part of a national program sponsored by the Association of Research Libraries. The Center for Agricultural Science and Technology was assisted with data coding, data entry procedures, and analysis in an evaluation of its magazine *Science of Food and Agriculture*. Similar help was given to graduate students in a study designed to assess the quality of life in the university's residence halls and student apartments.

Under a cooperative agreement between Iowa State University and the USDA Food and Nutrition Service, George Battese is serving as statistical consultant on a research project investigating meth-

odological factors affecting the measurement of dietary status. Sarah Nusser is also assisting. Stanley Johnson, director of the ISU Center for Agricultural and Rural Development, is principal investigator.

In June, Battese consulted with a colleague at Vanderbilt University on aspects of frontier production functions and visited the Statistics and Survey Research Sections of the Research Triangle Institute in North Carolina. He also consulted with USDA personnel in Washington, D.C., on June 25-26 concerning household surveys for the purpose of estimating the dietary and nutritional status of household members.

Zambia Project

Harold Baker spent six weeks in Zambia during January and February in connection with the ISU-USAID Zambian Agricultural Training, Planning, and Institutional Development (ZATPID) project. The primary purpose of this trip was to consult with ISU personnel on the final phases of the Small Farm Household benchmark and longitudinal studies being carried out as part of the ZATPID project. While there, Baker also consulted on an urban household survey in Lusaka and served on a team charged with assessing the impact of the assistance given to the Zambia Central Statistical Organization by the United States Bureau of the Census under the bureau's portion of the ZATPID project.

Industry and Engineering Sciences

Statistical consultation with engineering and physical science faculty and graduate students and with industry is supported by the Engineering Research Institute, the Statistical Laboratory, joint faculty appointments in statistics and industrial engineering, and a program of collaborative and affiliate industrial research and consulting. Much of this work is summarized in the sections that follow. (Also see p. 20.)

Oscar Kempthorne was one of four main speakers featured at a conference on Sources of Improvement of Quality and Productivity, held on November 21-22, 1986, at Iowa State University by the Engineering Extension Service. Kempthorne spoke on "Statistical design of experiments: Historical overview." The other main speakers were George E. P. Box, Vilas Research Professor of Statistics and director of research, Center for Quality and Productivity Improvement, University of Wisconsin-Madison; W. Edwards Deming, consultant and professor of statistics, New York University; and Myron Tribus, retired director of the Massachusetts Institute of Technology Center for Advanced Engineering Study.

The conference was designed to assist top and middle management in evaluating and installing quality engineering in their firms. The opening session was held in conjunction with a meeting of the Central Iowa Section of the American Society for Quality Control.

W. Robert Stephenson offered a two-day short course twice at Bandag, Inc., Muscatine, Iowa in July 1986. The course on introductory statistics for industry and manufacturing was given to R&D and management staff. Bandag subsequently joined the affiliate program discussed below.

The ideas of productivity, quality, and reliability were also extended to other areas of industrial application. For example, Donald Hotchkiss presented two sessions on basic statistics and statistical aspects of process control to approximately 35 quality control specialists from the meats industry on December 3 and 4, 1986. This was part of a Quality Assurance Short Course sponsored by the American Meat Institute and held at Iowa State University.

Industrial Consulting

William Q. Meeker, Jr., served as a consultant to the AT&T Bell Laboratories Quality Assurance Center for their project to develop software for life data analysis. This work was done mainly during the summer months in 1986 and 1987 at Holmdel, New Jersey.

Herbert T. David went to the National Bureau of Standards in Washington, D.C., in June for 25 days as a visiting professor to interact with staff of the Statistical Engineering Division on problems of multiple tolerancing and other engineering statistics issues.

Work continues in the ISU Industry/University Affiliate Program for Productivity, Quality, and Reliability, supported this year partly by membership fees provided by six affiliate companies and partly by a research assistantship provided by Graduate College high technology funds. Karen Jensen held the assistantship from July through May, doing research in the area of optimal control, continuing the development of statistical software for the affiliate program, and preparing materials for short courses.

Two affiliate program short courses on introductory engineering probability and statistics were given by Stephen Vardeman at Rockwell-Collins Avionics in Cedar Rapids, Iowa, during August and September 1986. The attendees were Rockwell Reliability and Maintainability engineers. A third short course was given in Moline, Illinois, on October 8 by William Q. Meeker, Jr., to John Deere Reliability engineers. The course dealt with the planning and analysis of accelerated life testing. A fourth course was given for affiliates and others in March 1987 on the Iowa State University campus in cooperation with Engineering Extension. It was taught by Vardeman, W. Robert Stephenson, Jensen, and industrial engineering faculty member Roger Berger. The short course covered the fundamentals of experimental design.

The addition of Webster City Products, a manufacturer of major appliances, and Bandag Incorporated of Muscatine, Iowa, a leading truck tire recapper, brought the affiliate roster to six companies. In November an affiliate luncheon was held on campus with major ISU officials meeting with representatives of all affiliate companies except Bandag,

which joined the program later in the year. Accomplishments of the previous year were discussed, and input was solicited regarding program direction and research topics of broad interest to affiliates. Two topics drawing interest from most affiliates were the use of feedback control methodologies in the automatic compensation of machine tools and practical techniques for manual monitoring of multiple head or cavity machines.

Besides teaching and research activities related to the program, direct consulting on specialized affiliate problems was provided in the startup phase of this program. Berger and Vardeman consulted with Kooima Manufacturing, Rock Valley, Iowa (a division of Hayes-Albion Corporation), on their implementation of statistical process control on their screw machines. Berger and Pete Cyr, an industrial engineering graduate student, aided in the recruitment and training of a permanent process control specialist at Kooima.

Glen Meeden consulted with a John Deere engineer on Bayesian reliability calculations. Stephenson, Jensen, and Vardeman consulted with a Webster City Products engineer on experimentation to support next-generation clothes dryer electronics. Cyr is currently working closely with John Deere personnel to implement and empirically evaluate a machine tool compensation algorithm developed in Jensen's thesis research.

The affiliate program is one that the university and the departments of Statistics and Industrial Engineering hope will grow. Readers who want more information about the program and/or who feel that their companies might be interested in joining the program are encouraged to contact the Department of Statistics.

Engineering Research Institute

Consulting on the following projects, by Herbert T. David, Stephen Vardeman, and Renkuan Guo, was largely made possible through the support of the Engineering Research Institute, which provided an assistantship held by Guo. (During summer 1986 this assistantship had been held by Noel Artiles, an industrial engineering graduate student.)

Advice was given to nuclear engineering researchers on assessment of fit for a simple linear regression analysis of strain/stress data. A faculty member in mechanical engineering was advised on sample size determination and quantification of accuracy in the estimation of material properties. Both statistical analysis and statistical advice were provided to a member of the Engineering Research Institute Analytical Services Laboratory in the comparison of three brands of a product in dispensing machines.

A project in chemical engineering involved the design and development of a capacitive closed loop positional sensor that could be used, say, for accurate measurement of the angular position of a shaft. Consultation dealt with analysis aspects, including data plotting and interpretation, and extensive assistance with computation.

Other chemical engineering problems led to consultation on model building, model fitting, data processing, and analysis. For instance, an engineer and his graduate student brought in the data from an experiment involving six variables to which they had fit a model with only limited success. It was suggested that they look at various selection procedures, e.g., forward selection, backward elimination, maximum R^2 improvement, and selection using the C_p statistic, to select three variables for the model. Computations were performed, and results were discussed with the student in both statistical and physical senses. This led to a revised model. Another chemical engineering experiment had involved repeated sequences of spectrographic analysis. It was convenient to handle the analysis in two stages, first reducing the number of observations by means of personal computer computations and then using the mainframe computer for the nonlinear model fitting.

An industrial engineering staff member and his graduate student were advised on the application of semiparametric regression analysis for prediction of electrical consumption peak loads. In response to questions arising from an ISU industrial engineering technical report on a human factors study, prepared for the U.S. Air Force, statistics staff supported choice of a particular error structure.

Social Sciences and Humanities

Leroy Wolins advises graduate students and faculty researchers in the social and behavioral sciences on statistical applications. He has spent much of his time this year learning to use microcomputers and the associated software. This has improved both the quality and the efficiency of his consulting.

The increased efficiency comes, in part, from the fact that, since most clients have access to microcomputers, Wolins can instruct a client about how the data are to be recorded during initial visits. That is, the client is asked to return with the data on a floppy disk or a WYLBUR file rather than with flow sheets. Whatever format the data are in, it is convenient to up- or download the data from the mainframe computer for use with MS/DOS.

Programming is done jointly by the client and Wolins. For example, if many "if-then" statements are necessary, the client does that part. Wolins interacts with both the computer and the client. It is easy to make diagnostic runs and, if outliers or other peculiarities about the data are observed, the client is right beside Wolins to answer questions. Wolins uses the time between runs to explain prior results or the reasoning behind the current run. It is easy to modify analyses based on these diagnostic runs.

The output appears immediately on the screen, and hard copy is immediately available from the printer. Tables and figures constructed by the computer can be filed into the client's floppy disk and modified by the client in a word processor for inclusion in manuscripts.

Kenneth J. Koehler is a coinvestigator with Department of Psychology members Harry Lando and Paul McGovern on a grant project supported by the National Institute on Drug Abuse for the period July 1985-June 1988. Koehler is serving as a statistical consultant for the social learning analysis of smoking cessation clinics. (Also see p. 20.)

Koehler, Mike Carley, and Kathleen Shelley assisted members of the Department of English and the Office of the Dean of the Graduate College in the analysis of data concerning the effects of training on the performance of nonnative teaching assistants at Iowa State University. Koehler has also worked with another Department of English faculty member on a project to assess the effects of accent and speaking rates on student comprehension. Nonnative speakers with several levels of English proficiency were compared with a native speaker at normal, enhanced, and reduced speaking rates. Both projects are part of a continuing university effort to improve performance of nonnative instructors and teaching assistants.

Robert Strahan consulted with students and faculty in psychology, child development, education, speech, food and nutrition, counseling, and design. Some of the topics involved were the vocational interests of ISU graduates (a national survey of alumni); perceptions of school psychologists regarding acceptance of behavioral intervention; the political beliefs of Mormon women; the relative efficacies of different presentations of traffic signs (an Iowa Department of Transportation study); the senory impact of reheating cooked turkey; personality differences among student athletes, residence hall advisors, and nonathlete students; factors influencing maintenance of an exercise program; the incidence of bulimia and related eating disorders in high school students; attitudes toward homosexuality; and evaluation of a music training program.

In addition, Strahan is a project member of a three-year, half-million dollar grant investigation funded by the U.S. Office of Educational Research and Improvement. Titled "The Effects of Differential Course Work on Student Learning in College," the project is primarily aimed at determining the particular courses or sets of courses that enhance learning in college students, as indexed by Graduate Record Examination improvement. Strahan has been advising on statistical aspects of the design and analysis of the study. Iowa State University is responsible for collection and analysis of data from Stanford, Georgia State University, Ithaca College, Evergreen State College, and Mills College.

One of Frederick Lorenz's major consulting activities this past year was to do a confirmatory factor analysis of 14 perceived stress items. The authors of the original scale claimed that it was unidimensional, but a close inspection of responses from 1700 Iowa farm operators suggests that there are actually two subscales, which have tentatively been labeled "self-efficacy" and "psychological distress."

Carl Roberts provides ongoing consulting on thesis and research projects, involving questions related to statistical and computer applications, primarily for students, staff, and faculty in the social sciences, but also in physical education. He has also consulted by telephone with a staff member of an Iowa juvenile correction center on the feasibility of evaluating the center's program.

Mack C. Shelley II worked with faculty, staff, and students in the University Student Apartments residence service, Department of Political Science, Towers Residence Halls, and departments of History and Family Environment, and at the Heartland Education Agency. His consulting thus dealt with a variety of research topics: e.g., the analysis of regression results using a mix of continuous and categoric predictor variables, a survey of student satisfaction with living conditions in the ISU student apartments system, discriminant analysis of nations' support for the nuclear Non-Proliferation Treaty, and an employee satisfaction survey administered to Residence Hall merit, professional, and scientific employees. Advice was also given on discriminant analysis of a study of labor market experience and life satisfaction among mature women, analysis of a survey on life stressors among a sample of Iowa husbands and wives, and a study of "young-old" and "old-old" Iowans aged 65 and over.

In his capacity as a member of the Graduate College's Bioethics Committee, Shelley participated in a large-scale survey of faculty and graduate student perceptions regarding the effects of biotechnology funding at Iowa State University on curriculum, research, and faculty/student relations.

Shelley also worked with the newly-formed national Center for Transportation of the Council of State Governments. One result was a monograph on transportation policy needs of state executive officers, executive staff, legislators, transportation agency or division heads, legislative committee staff, and others concerned with policy-making.

Other Consulting/Cooperation

William Q. Meeker, Jr., consulted with researchers in animal ecology studying survival rate of raccoons in Iowa and the effects of harvest by hunting and trapping. Somewhat similar statistical problems arose in consultations with a graduate student studying population dynamics that involved survivability and reproduction and the effects of acid rain on freshwater crustaceans. Meeker advised a soil scientist on the use of time series methods with a problem involving the rate with which water percolates into the ground.

Kenneth J. Koehler consulted with researchers in entomology, animal science, animal ecology, textiles and clothing, economics, and agricultural engineering. He advised members of the College of Business Administration on logit problems and a study of entrance requirements for the college.

Noel Cressie consulted with a graduate student in chemical engineering on numerical simulations for reacting turbulent flow. He and Herbert T. David interacted with a civil engineering professor on non-

stochastic models in spatial interpolation. Wayne Fuller and William Q. Meeker consulted with graduate students in electrical engineering, industrial engineering, and agricultural engineering on time series problems arising in their research.

A faculty member in the Parks Library was advised on the use of SAS in his investigation of control variation in the temperature and humidity of book storage rooms. A graduate student in industrial education and technology was counseled on what FORTRAN program to use to compute two regression intercept points from repeated observations.

This past year Keith Cranford and Alice Lay provided statistical consulting support to the College of Business Administration. Cranford's responsibilities included consulting with administration, faculty, and graduate students. A data analysis of undergraduate business students was performed last fall. This was to aid in policy decisions concerning new entry requirements into the college and to assess their possible impact. In conjunction with this study, Cranford helped with a followup through the Division of Institutional Research. His work with faculty ranged from a canonical correlation analysis on balance sheet information to a multinomial logit modeling of corporate financing, which was done jointly with Alice Lay. The consulting work also entailed computer support in the form of SAS programming for several faculty members and updating the University of Chicago CRSP (Center for Research in Security Prices) data and access files for the college. Finally, graduate students were provided help on the data analysis portions of their creative components.

The U.S. Department of Agriculture Agricultural Research Service has arranged a five-year contract with the Department of Statistics for provision of statistical guidance and improved statistical methodology to USDA-ARS research staff. Project leaders are Dean Isaacson and resident collaborator Jerome Sacks. Research assistants Chong Sun Hong and James Symanowski are working under Sacks' guidance to give consultative support.

Statistical consulting at times develops into collaborative research. For example, consulting by Noel Cressie with Peter D. Shaughnessy at the Sea Fisheries Research Institute in Cape Town, South Africa, led to collaborative research after Shaughnessy moved to the CSIRO Institute of Biological Resources, Canberra, Australia. Statistical methods were developed for estimating numbers of Cape fur seal pups from aerial surveys. There are sufficiently comprehensive data from surveys carried out in the breeding seasons of December 1971 and 1976 to make comparisons between the total populations for each of those years. A statistically significant increase in the number of seal pups (estimated annual growth rate of 3.2 percent per annum) shows that the Cape fur seal population has been recovering during a controlled harvesting regime, from reduced levels brought about by past harvesting.

Some collaborative work by the statistics faculty has been described in this section of the annual report. Some is mentioned in the next section.

Current Research

Individual research and research projects supported by grants or contractual agreements are summarized in this section. Within the university, funds were provided for research by the budgets of the Statistical Laboratory, the Iowa Agriculture and Home Economics Experiment Station (AES), the Sciences and Humanities Research Institute, and the Engineering Research Institute.

AES Project 890

Oscar Kempthorne continued to explore the role and nature of randomization in comparative experiments. During the year, as an invited speaker at various conferences, he gave basic philosophic papers on that topic, the relationships between mathematics and statistics, the nature and function of applied statistics, and a historical overview of the statistical design of experiments. An essay on the impact of cross-disciplinary activity in statistics and agriculture has been accepted for publication.

Kempthorne also prepared an overview of the theory of quantitative genetics for the Second International Conference on Quantitative Genetics. He was unable to present the invited paper in Raleigh, North Carolina, because of illness.

AES Project 2588

Edward Pollak continued his research on mathematical and statistical genetics under Project 2588 of the Iowa Agriculture and Home Economics Experiment Station. This is a report on two years of research.

Further work was done on theory for a finite monoecious population of size N in which there are probabilities β and $1 - \beta$ of reproduction by selfing and by random mating. It was found that a general expression for the effective population number is $N_e = N'/(1 + F_{IS})$, where F_{IS} is the inbreeding coefficient at equilibrium when N is infinite and N' is the reciprocal of the probability that two gametes contributing to random separate adults come from the same parent. This reduces to $N/(1 + F_{IS})$ when there is a binomial distribution of successful gametes emanating from each adult.

It was found that, if selection is not intense, a good approximation to the probability that an allele A survives if it is originally present in one $A\bar{A}$ heterozygote is $2(N'/N)[F_{IS}s_1 + (1 - F_{IS})s_2]$, where s_1 and s_2 are, respectively, the selective advantages of AA and $A\bar{A}$ in comparision with $\bar{A}\bar{A}$.

A study was also made of the sampling theory for finite dioecious populations in which there are N family units with one male and one or more of his mates. Then if a male mates with another offspring of the same family with probability β and mates randomly with probability $1 - \beta$, the effective population number is given by $N_e \doteq \alpha N/[1 + (2\alpha - 1)F_{IS}]$. In this expression α depends upon the probabilities that males mate with full sisters and half sisters, and F_{IS} is the inbreeding coefficient that would be attained in the long run if N were infinite.

In addition, an approximation to the probability that an allele A survives was derived under the assumptions that A is initially present in the $A\bar{A}$ adult, selection is not intense, and the relative viabilities of AA, $A\bar{A}$, and $\bar{A}\bar{A}$ genotypes are $1 + s_1$, $1 + s_2$, and 1. It is proportional to $F_{IS}s_1 + (1 - F_{IS})s_2$. The theory that was used to derive this probability can also be used to calculate the probability that a mutant of type A survives in an age-structured, dioecious random-mating finite population, whether the locus in question is autosomal or sex-linked.

Work was done by Kaisheng Fan, working under the direction of E. Pollak, on theory for finite populations in which there is cytoplasmic inheritance.

Measurement and Sampling Error

The U.S. Bureau of the Census and, through AES Project 2699, the Iowa Agriculture and Home Economics Experiment Station support joint research in measurement error models, time series, and survey design. Support from the Bureau of the Census for the 1986-1987 year came through Joint Statistical Agreements J.S.A. 86-2 and J.S.A. 87-1. Wayne Fuller is principal investigator. Other personnel working on the project include Yasuo Amemiya, Nancy Hasab-El-Naby, John Eltinge, Heon Jin Park, and Dan Schnell.

Research is under way on the use of measurement error to protect confidentiality of individuals responding in a survey where a microdata file will be released. Different correlation structures for measurement error to be added to the collected data are being studied. Software is being developed to estimate regression equations from data containing measurement error.

Studies of properties of predictors for small areas based upon the random measurement error model were conducted. The properties of alternative predictors are functions of the unknown variance components. Hence, it does not seem possible to specify uniformly superior procedures.

Dan Schnell studied estimators for the parameters of the nonlinear measurement error model. He also developed statistics that can be used to check the original error specification of the model. A Monte Carlo study of the statistics was conducted, using the quadratic function.

In many surveys conducted over time, repeated observations are made on the same sample units. Such "panel studies" result in data that contain serially correlated measurement and sampling errors. Similar serially correlated instrument errors arise in industrial process control. John Eltinge studied estimation of regression and autocovariance parameters for such situations. Weighted and unweighted method-of-moments estimators have desirable asymptotic properties under a very general model. For structured models with multivariate autoregressive moving average components, a state-space representation of the observations can be used to construct maximum likelihood estimators.

EV CARP

Developmental work on a personal computer program for measurement error models is nearing completion. Programming is under the direction of Dan Schnell. Gary Sullivan, Heon Jin Park, Nancy Hasab-El-Naby, and Douglas Bearrood are also assisting on the project.

EV CARP is designed as a companion program for the text *Measurement Error Models* by Wayne Fuller. The program will enable users to compute estimators for regression equations with explanatory variables measured with error. The program has capabilities for data collected in complex surveys, as well as for simple random samples.

It is planned to release EV CARP in September 1987. Persons interested in the program should write to Wayne Fuller.

PC CARP

Work was completed on development of variance estimation software for complex surveys under a Statistical Laboratory contract with the International Statistical Programs Center, U.S. Bureau of the Census. This project has been directed by Wayne Fuller and William J. Kennedy. Dan Schnell, Gary Sullivan, Heon Jin Park, and Jorge Morel worked on the project.

The software is now available in two versions: PC CARP for the IBM PC/AT with math co-processor and PC CARP as a package for the IBM PC or IBM PC/XT with math co-processor. The software fits most compatibles with math co-processor, at least 410k RAM, and two disk drives.

It is designed for multistage stratified sample surveys and provides flexible subpopulation options. The program can be used to construct estimates and standard errors for totals, means, quantiles, proportions, the difference of ratios, and two-way table entries. It also can give estimates of covariance matrices and weighted regression equations. Additional details are available from the Survey Section.

Copies of either version or both versions of the program with a manual are available for purchase. PC CARP represents a revision and updating of algorithms in SUPER CARP, developed earlier at Iowa State for use with a main frame computer. Further extensions of the program, including algorithms for logistic regression and post-stratified samples, are planned.

Crop Production Estimation

Under the direction of Wayne Fuller and Mark Reiser, cooperative research continued with the National Agricultural Statistics Service (NASS), U.S. Department of Agriculture. Zhaofeng Huang, Kathleen Taylor, and Shaw-Ling Wang worked on the project.

Procedures are under development to combine estimates from several different surveys and from different years to improve the estimates of animal numbers produced by NASS.

Research was conducted on forecasting models used with the Objective Yield Survey for corn in Iowa. Gross yield for corn is calculated as the product of number of ears and grain weight per ear. The models currently in use give predictions, based on linear models, from early-season plant characteristics such as length of the corn cob. The parameters for the prediction equations are obtained by ordinary least squares, using data from the five years preceding the current crop year. The ordinary least squares error structure is assumed, which implies that observations within year are independent.

The currently used forecasting models were evaluated, using 1984 as the prediction year. For very early season prediction, it was found that the historical average from the previous five years performed nearly as well as predictions from plant characteristics. It was also found that most of the error in the predictions was due to grain weight, since number of ears is fairly well predicted from number of stalks.

A generalized least squares estimator for the parameters of the prediction equations was proposed. This model specifies a nested error structure, where observations within years are correlated and observations across years are independent. Bounds on the forecast error were established under the new model.

AES Project 2739

The Survey Section continued cooperative research with the U.S. Soil Conservation Service (SCS). This joint work has been an important part of the activities of the survey group since 1956. The current project is supported through Project 2739 of the Iowa Agriculture and Home Economics Experiment Station and is directed by Roy D. Hickman.

An important part of the cooperative work is the maintenance, updating, and continuing development of the soil interpretations database of soil series in the United States. Harvey Terpstra directs this work, assisted by Deborah Reed-Margetan, Jan Seagrave, Jeanne Sorenson, and Fred Medak. With the addition of 1,500 new records, the database now contains over 28,000 records, of which approximately 13,000 were revised this year. A second file, the soil map unit file, contains information for 2,350 soil surveys. Sizable revisions were performed on this file during the year.

The SCS soil series classification file was transferred to ISU and stored in the SPIRES database management system. This file, containing the official classification of all soil series, allows SCS to query and update the data interactively from remote sites. Batch access for obtaining standard reports is also available. Plans for a second SPIRES database, the SCS official series description file, are in progress. That large text file will contain the official description of all soil series in the United States. Deborah Reed-Margetan has led the work on this project.

These files are being transferred to the Statistical Laboratory as part of a long-range plan to centralize data on soils maintained by SCS. Survey Section and ISU Computation Center personnel are investigating the installation of a relational database management system for managing the data files.

Another major task was the distribution of soils data to AT&T UNIX™-based microcomputers in SCS state offices to be used in automated local planning activities. Normal data transmission between the mainframe computer and a microcomputer was not feasible because of the large volume of information. With assistance from the Department of Computer Engineering, the Survey Section was able to transfer several million bytes of information from a 9-track tape to a microcomputer in a few minutes, using a high-speed data network. By this method, the goal of distributing soils data to each state was accomplished in a timely manner.

Plans were made to provide soil property and soil interpretation data to be used in conjunction with digitized general soils maps as input into a geographic information system. Programs were developed to perform additional edit checks of existing data elements to improve data consistency. The database was used to produce lists of hydric soils and of highly erodible soils in the United States. These data will be used in implementing the National Farm Security Act.

In work carried out on SCS resource inventory and monitoring activities, Survey Section staff assisted in the preparation of the SCS national publication on the 1982 National Resources Inventory (NRI). Final estimates and tables were completed for county and multi-county resource inventories carried out by some states in conjunction with the 1982 NRI. Identification and resolution of discrepancies in 1982 NRI estimates of number of acres by major land resource area and federally owned acreage was also completed. Several tables were produced for the Texas Brush Inventory. Estimates concerning woody canopy cover by plant species were constructed for major land resource areas.

Section staff completed sample selection for the 1987 NRI and transmitted computer files containing 1982 NRI data items to SCS state offices. The 1982 NRI data items will be printed on the 1987 worksheets. The sample is a post-stratified subsample of some 100,000 primary sampling units (PSUs) from the 330,000 used in the 1982 NRI. The sample was supplemented with 2,500 new PSUs selected in swiftly urbanizing areas. The supplementary sample will be used to more precisely estimate agricultural land being converted to urban use. Computer edit routines are being developed, with special attention

given to large deviations of data values from those observed in 1982. Section staff also assisted in the development of remote data entry software to be used by state SCS offices. The 1982 NRI data files to be used in this data entry system were downloaded to an AT&T 3B2 minicomputer and transmitted to states on cassette tapes.

County base data worksheets were preprinted and sent to states for completion. County base data, used in NRI estimation, provide a base acreage for each county in the U.S and include data for urban built-up areas, federal land, and rural transportation (roadway and railroad) areas.

Work on estimation procedures for the 1987 NRI was initiated. Expansion weights for estimates of totals will be constructed using certain control variables from the larger sample of the 1982 NRI.

A special project for New Mexico involved the location and transfer of all resources inventory PSUs in the state to U.S. Geological Survey quadrangle sheets. These will be used in cooperation with the U.S. Forest Service in a study of resource inventory methodology.

Members of the Survey Section working on resource inventory projects during the year were Harold Baker, Doug Bearrood, Richard Dorsch, Dorothy Edwards, Carol Francisco, Wayne Fuller, Zhaofeng Huang, Art Kuhl, Sheri Lin, Jorge Morel, Heon Jin Park, Kathie Reinertson, Mark Reiser, Jeanne Sorenson, Harvey Terpstra, and Sue Verkade.

The staff made numerous trips in connection with data management and statistical estimation activities. Richard Dorsch traveled to Fort Collins, Colorado, August 3-5, 1986, with Jeffery Goebel of SCS National Headquarters to assist with the development of the remote 1985 NRI data entry software system. Harvey Terpstra went to Washington, D.C., in March 1987 to discuss long-range plans for the SCS soils database; to Fort Worth, Texas, in April to discuss the transfer of additional data files; and to Iowa City, Iowa, and Madison, Wisconsin, in May to investigate computer installations using a relational database management system. Mark Reiser visited the South National Technical Center in Fort Worth to work with staff on statistical problems relating to the 1982 National Resources Inventory. Roy Hickman and Art Kuhl traveled to the Stephenville, Texas, area on May 18-23 to observe 1987 NRI field data collection procedures employed by SCS county resource conservationists.

Spatial Statistics

Noel Cressie received further funding from the National Science Foundation for two years. This is to continue his research in spatial prediction.

There are a number of methods, including kriging, splines, the Kalman filter, and recursive prediction, which could be used. The various criteria that these methods optimize will be compared and the performance of each assessed. The nearest-neighbor approach and the Markov-random-field approach both emphasize parameter estimation, but the models could then be used for prediction.

During his term as an ASA/NSF/Census Fellow in 1985-1986, Cressie and his research associate N. H. Chan completed a spatial study of the incidence of Sudden Infant Deaths in the counties of North Carolina.

Census Undercount

Joint statistical agreements between ISU and the U.S. Bureau of the Census have supported Noel Cressie's research on undercount in the decennial census. Work that started while Cressie was an ASA/NSF/Census Fellow in 1985-86 has continued; an empirical Bayes approach to undercount adjustment has been developed. Currently under investigation is the effect of adjusting at different levels, e.g., the state level versus the county level.

Statistical Prediction

A grant from the U.S. Office of Naval Research supports research by David Harville in the area of statistical prediction. He is investigating the problem of predicting the value of a random variable w on the basis of n observable random variables $y_1, \ldots, y_n$, where the expected values of w, $y_1, \ldots, y_n$ depend linearly on unknown parameters $\beta_1, \ldots, \beta_p$.

Harville's main objective is the development of prediction procedures suitable for various cases where the covariance matrix V of $w, y_1, \ldots, y_n$ is unknown. Improved approximations are being sought for the variance $V[\hat{w} - w]$ of the prediction error θ. Different choices for the estimator $\hat{\theta}$ of θ are being compared using $V[\hat{w}(\hat{\theta}) - w]$ as a criterion.

Bayesian point predictors are also being studied, and prediction intervals are being devised for the value of w that do not depend on an assumption that $\hat{\theta}$ is the true value of θ.

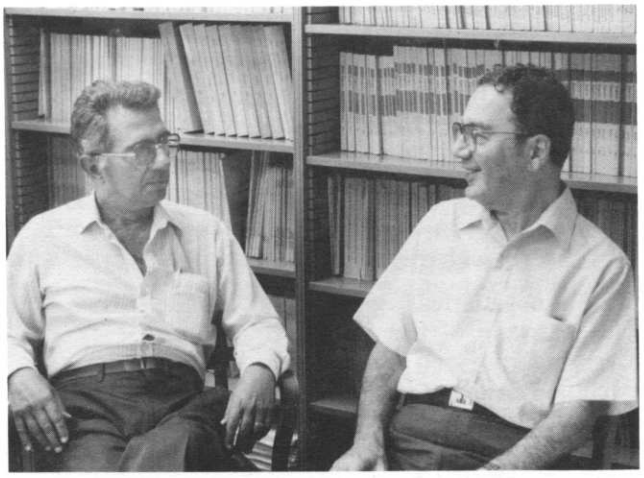
Bayesian Statistics

Recently Glen Meeden proved the admissibility of various point estimators in finite populations. The proof uses the stepwise Bayes technique and highlights the importance of a pseudo-posterior distribution, called the Polya posterior. The method was extended to set estimation as well. This work was supported in part by a grant from the National Science Foundation.

Research by Meeden on admissible credible sets for a committee of Bayesian experts was supported in part by a contract from the Boeing Military Airplane Company starting on March 1, 1987.

Order Statistics and Robust Inference

H. A. David, principal investigator on a grant project supported by the U.S. Army Research Office, has prepared a revised and expanded second edition of his 1963 Griffin monograph, *The Method of Paired*



J. Tiago de Oliveira, visiting professor from Portugal, confers with H. A. David (R).

Comparisons. In the intervening years, parametric approaches, especially those based on the Bradley-Terry model, have been greatly developed, allowing for much increased flexibility as well as multivariate generalizations. Techniques of mathematical programming have permitted analyses requiring milder model assumptions. These and other advances are described. The distinctive emphasis of the monograph continues to be on simple nonparametric procedures and on the analogy between paired comparisons and tournaments.

David has also developed a simple new method for ranking from unbalanced paired-comparison data (see abstract on p. 29).

B. K. Kale, visiting professor, and U. Gather (Aachen University of Technology) have investigated maximum likelihood estimation in k-outlier models. Their paper treats the indexing set (υ) of the outlier observations as a parameter and shows that unique MLEs of υ and other parameters of the model exist in many situations, provided that $\partial G/\partial F$ is monotone in some T(x). Here F denotes the target distribution function and G, the cdf of an outlier observation. These results are used to obtain a likelihood ratio test of no outliers against exactly k outliers. A procedure is given to determine k, the number of outliers in a supermodel consisting of a collection of k-outlier models for $k = 1, \ldots, n$.

Ishay Weissman, visiting professor, and L. de Haan (Erasmus University, Rotterdam) have prepared a paper entitled "The index of the outstanding observations among n independent ones."

Jose Tiago de Oliveira, visiting professor, completed a paper on the estimation of the dependence structure of bivariate extremes.

Sciences and Humanities Research Institute

SHRI funds help support the research of Yasuo Amemiya, Krishna Athreya, H. A. David, Mervyn Marasinghe, and Glen Meeden. Much of this work also received support from federal grants in 1986-87. The work of David and Meeden has been described in earlier sections of the annual report.

Krishna Athreya was on faculty improvement leave for the academic year to engage in research in India and in California on limit theorems in probability theory and statistics. During summer 1986 his research received support from a National Science Foundation grant. A new NSF grant project is supporting research on bootstrap asymptotics in statistics, stochastic processes, and limit theorems for branching and almost regenerative processes, beginning June 15, 1987. In June Athreya visited Göteborg University in Sweden, Aalborg University and the University of Copenhagen in Denmark, the Universities of Mainz and Darmstadt in West Germany, and the University of Rome in Italy to consult with faculty members and present talks on bootstrap methods, branching processes, and sampling.

Yasuo Amemiya's research on multivariate analysis concentrated on multivariate components of variance, factor analysis, and structural equation models. For the multivariate components of variance model, the powers of test procedures for the rank of the between-group covariance matrix under the alternative of incorrectly specified rank were studied. For factor analysis and structural equation analysis, Amemiya investigated, in collaboration with T. W. Anderson at Stanford University, the applicability of standard inference procedures for a large class of nonnormal factor vectors and error vectors.

Zhaofeng Huang and Amemiya proposed an adjusted maximum likelihood estimator for the unrestricted factor analysis. By means of a simulation, they showed the superiority of the adjusted estimator and studied the behavior of studentized statistics and the usefulness of goodness-of-fit test statistics in small samples.

Mervyn Marasinghe and Jim Symanowski completed work on outliers. A computer program to locate multiple outliers efficiently in regression model situations was designed as a portion of Symanowski's M.S. creative component.

Research by Marasinghe on interaction models for factorial experiments continued with Charles Farmer through summer 1986. (See Farmer's dissertation abstract on p. 35.) Part of this work will be presented at the 1987 American Statistical Association annual meeting.

Other Research

William Q. Meeker, Jr., has been working with Luis Escobar (AT&T Bell Laboratories) to develop methods that will work with censored data to assess the effects that departures from an assumed model will have on desired inferences.

Kenneth Koehler and Paul McGovern (Department of Psychology) are co-principal investigators on a project initiated this year with the support of a grant from the National Institute on Drug Abuse. They are investigating properties of bootstrap estimators for the parameters of limited failure population survival models when survival results may be

correlated. This procedure allows for both interval and right censoring. It is being used to analyze smoking cessation data collected from clinics where participants are treated in groups.

Fred Lorenz continues to do sociological research on community organizations. In an article appearing in an edited book, he reports that there has been a dramatic decline in the number of community planning agencies nationwide, owing primarily to the loss of federal support. The decline is most pronounced in rural areas where there are few alternatives to help local governments work with federal agencies. In an investigation of 62 central Iowa social service agencies, Lorenz found that predictable budget cuts lead to reductions in staff and activities but, under conditions of high uncertainty, managers respond with aggressive, creative strategies.

Carl Roberts is working with a colleague at the University of Illinois-Chicago Circle on a research project on trends in occupational mobility and achievement in the United States from 1952 to 1984. This involves white collar, blue collar, and farm groups classified by educational groups.

Roberts is in the beginning stages of comparative analysis of radio news from East and West German broadcasters.

Applying logistic regression to data from a linguistic content analysis of exorcism accounts, he and a colleague at the University of Notre Dame are exploring the decline of Christendom in the Middle Ages.

Research into God images using Ames, Iowa, data has ended, with results reported in a paper presented in April at the Midwest Sociological Society meeting. Roberts is now addressing the same theoretical questions to National Opinion Research Council data from 1984-85 for the U.S.

A research bibliography compiled jointly by Mack Shelley II and two colleagues in the Department of Sociology, on university-industry relationships in biotechnology research, will be published later in 1987. Related work by Shelley on the organizational and political consequences of biotechnology research emphasis is underway.

Shelley is working with a colleague in political science on the economic and quality-of-life factors in patterns of intercity migration. Other work on legislative elections and voting behavior is in process.

Robert Strahan's recent research has mainly focused on two topics: the annotated computer analyses associated with his faculty improvement leave, and examination of a simple, portable (electrical skin conductance) measure of emotional arousal.

Mervyn Marasinghe visited the Department of Mathematical Sciences, Montana State University, June 20-July 20, 1986, for research collaboration with Robert Boik. They extended results on detecting nonadditivity in two-way factorials to other linear models. Some new tests for three-way interaction are proposed in two papers to be presented at the 1987 American Statistical Association annual meeting. Marasinghe's visit at Montana State was supported in part by an ISU research grant.

Professional Activities

H. A. David is co-chair of the American Statistical Association Committee for Filming Distinguished Statisticians and vice-chair of the Committee on ASA Archives. Herbert T. David is chair of the Archives Committee of the Institute of Mathematical Statistics. Stephen B. Vardeman was appointed to the ASA Committee on Award for Outstanding Statistical Application for a three-year period beginning in 1987. He continues to serve as a member of the ASA Committee on Quality and Productivity.

William Q. Meeker completed a three-year term on the advisory board of the ASA Section on Physical and Engineering Sciences in 1986. For the Section on Statistical Education, W. Robert Stephenson is serving on the Committee to Prepare Guidelines for Undergraduate Programs in Statistics.

Stephenson is also director-at-large for Mu Sigma Rho national statistics honorary society.

Kenneth J. Koehler was president of the Iowa chapter of the American Statistical Association until April 1, 1987.

"When I teach statistical methods, especially to students in the physical sciences and engineering, I try to point to the debt science owes to a small agricultural field station in the United Kingdom. At Rothamsted the principles of experimental design and subsequent data analysis were worked out using studies as close to practical agriculture as you can get. . . . These principles are now accepted throughout the scientific world. Most of biometrical work today still rests on those prescriptions. . . ."

—D. F. Cox, from "The Hatch Act and Biometrics in 1987," presented at the spring meeting of the Biometric Society (ENAR and WNAR) in Dallas, Texas

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Wayne Fuller has been a member of the National Research Council's Panel on Decennial Census Methodology since 1984. In 1986 he became a member of Statistics Canada's Advisory Committee on Statistical Methods. He attended panel meetings in Washington, D.C., on October 2-3, 1986, and May 7-8, 1987, and advisory committee meetings in Ottawa, Ontario, Canada, on September 28-30, 1986, and April 27-29, 1987. He has served on the IMSL Advisory Board since 1981.

Mack Shelley continued to serve as the Iowa State University Official Representative to the Inter-University Consortium for Political and Social Research.

Papers Presented, Lectures, and Seminars

At the 1986 joint statistical meetings of the American Statistical Association, the Biometric Society (ENAR and WNAR), and the Institute of Mathematical Statistics in Chicago, Illinois, August 18-21:

Abdurachman, Edi, and **Herbert T. DAVID:** "Processes with delays";

AMEMIYA, Yasuo: "On the multivariate variance components model";

CRESSIE, Noel: "In search of generalized covariances for kriging";

Read, Timothy R. C., and **Noel CRESSIE:** "Mapping variables with unequal variance";

Crowder, Stephen V. (Corning Glass Works), and **Stephen B. VARDEMAN:** "Adaptive filtering for a process mean";

Francisco, Carol A. (Syntex Laboratories, Inc.), and **Wayne A. FULLER:** "Estimation of the distribution function with data from a complex survey";

Gan, Fah Fatt (National University of Singapore), and **Kenneth J. KOEHLER:** "Goodness-of-fit tests based on P-P probability plots";

GHOSH, Malay (Iowa State University and University of Florida), and **Glen D. MEEDEN:** "Empirical Bayes estimation in finite population sampling";

GROENEVELD, Richard A.: "Skewness properties of the Weibull and generalized Tukey lambda distributions";

Hong, Chong Sun, and **H. T. DAVID:** "Relative efficiency when the normal population mean is restricted to a grid";

Johnson, Jean, and **Dean ISAACSON:** "Conditions for strong ergodicity using intensity matrices";

" . . . in the United States, the initial support for biometrics came from agricultural research. The primary support for George Snedecor's work at Iowa State was the Agriculture and Home Economics Experiment Station, an organization formed by the Hatch Act. The biometrics profession today derives most of its support from the health sciences but its roots are in agriculture and the Hatch act played a decisive role in its evolution . . . "
—D. F. Cox, *ibid.*

Jeske, Daniel R. (Iowa State University and AT&T Bell Laboratories), and **David A. HARVILLE:** "Prediction, confidence, and empirical-Bayes intervals in linear models";

KOEHLER, Kenneth J.: "Applying the LPF survival model to smoking cessation data";

Escobar, Luis A., and **William Q. MEEKER, Jr.:** "Algorithm for the censored data Fisher information matrix for the smallest extreme value distribution";

Ostrouchov, George, and **William Q. MEEKER, Jr.:** "Accuracy of approximate confidence bounds computed from interval censored Weibull data";

Rogers, M. P. (Iowa State University and Indiana University Medical Center), and **H. A. DAVID:** "Selection using a dichotomized auxiliary variate";

SHELLEY, Mack C. II: "A log-linear analysis of special legislative elections";

STEPHENSON, W. Robert, and Michael D. Tveite: "Call me M.A.D.A.M.";

SUKHATME, Shashikala: "Power of some nonparametric tests";

Tveite, Michael D. (Process Management Institute), **V. A. SPOSITO,** and **W. Robert STEPHENSON:** "Likelihood ratio tests in L_1 regression."

" . . . Hatch Act sources continue to support the biometrics profession but the proportion of total support contributed by this source . . . continues to decline . . . However, the source remains vital to the profession. Certainly it would be a different profession had it not been for the Hatch Act and the vision of people like George Snedecor and Gertrude Cox in seeing the mutual benefits that would flow from the association of the profession with the system of Experiment Stations . . . "
—D. F. Cox, *ibid.*

At the spring meeting of the Biometric Society (ENAR and WNAR), held jointly with American Statistical Association sections and the Institute of Mathematical Statistics in Dallas, Texas, March 22-25, 1987:

COX, David F.: "The Hatch Act and biometrics in 1987";

Zimmerman, Dale L. (University of Iowa), and **David A. HARVILLE:** "A generalized least squares approach to the analysis of spatial experiments."

At the Midwest Sociological Society meetings in Chicago, Illinois, April 15-18, 1987:

LORENZ, Frederick O., Paul Lasley, and Rand Conger: "The structure of perceived stress";

Muhwezi, Dan, and **Frederick O. LORENZ:** "Fiscal stress in small cities: Antecedents and responses";

ROBERTS, Carl W.: "Imagining God: Who is created in whose image?" and "Syntax on content analysis: "A comparison of the 1926 and 1933 prefaces to the Nazi party platform."

At other locations:

AMEMIYA, Yasuo: "Estimation for the nonlinear functional relationship model," seminar for the Division of Statistics, University of California-Davis, January 29, 1987.

Andrews, Douglas: "Travel and language study in the USSR," presentation for the International Forum, Iowa State University, October 30, 1986.

ATHREYA, Krishna: "Bootstrap asymptotics II and III," lectures at the Department of Mathematics, Manipur University, Imphal, India, July 3 and 8, 1986.

"Bootstrap asymptotics," at the First World Congress of the Bernoulli Society of Mathematical Statistics and Probability, in Tashkent, USSR, on September 12; also seminars under the

same title, as follows: August 22 at the Department of Mathematics, National University of Singapore; February 26, 1987, at the Department of Mathematics, University of Utah; March 4 as the Neyman Seminar, Department of Statistics, University of California-Berkeley; April 14, for the Division of Statistics, Department of Mathematics, University of California-Santa Barbara; April 15, for the Department of Mathematics, University of California-San Diego; April 17, for the Department of Statistics, University of California-Riverside; and May 20, for the Division of Statistics, University of California-Davis.

"Hitting times of small sets for Markov chains," seminar, Stat-Math Division, Indian Statistical Institute, Calcutta, September 3, 1986.

"On the maximum sequence in a critical branching process" and "Regeneration methods for Markov chains," seminars on October 24 and 31 for the Indian Statistical Institute Bangalore Centre.

"On the maximum sequence in a critical branching process," Probability Seminar, Department of Statistics, University of California-Berkeley, February 6, 1987; also as seminars for the Department of Mathematics, University of Utah, February 27 and for the Department of Mathematics, University of Mainz, West Germany, June 25.

"Branching processes with sibling dependence," Official Opponent Presentation at P. Broberg's Ph.D. thesis defense at Göteborg University, Sweden, June 5.

"Bootstrap asymptotics" and "On the maximum sequence in a critical branching process," seminars at the Chalmers Institute of Technology, Göteborg University, June 8 and 10.

"Bayesian approach to finite population sampling," June 11, at the Conference on Sampling sponsored by the Swedish Statistical Association and held in Källe, Sweden; also as seminars for the Department of Mathematics, Aalborg University, Denmark, June 16, and the Department of Mathematics, University of Mainz, West Germany, June 25.

"Bootstrap asymptotics," seminar for the Department of Mathematics, Darmstadt University, West Germany, on June 26.

BAILEY, Theodore B.: "Performance of superior genotypes using pedigree selection," for a poster session at the Second International Conference on Quantitative Genetics, June 2 at Raleigh, North Carolina.

Carriquiry, Alicia: "Mixed model methodology in animal breeding," seminar for the Animal Breeding and Biometrics Groups, Ruakura Animal Research Centre, Hamilton, New Zealand, February 27.

CRESSIE, Noel A. C.: "A graphical procedure for determining nonstationarity in time series and spatial processes," seminar, Washington Statistical Society, Washington, D.C., July 17, 1986.

"In search of generalized covariances for kriging," seminar, Department of Statistics, Kansas State University, September 26.

"Empirical Bayes estimation of undercount: The art of compromise," seminar, U.S. Bureau of the Census, Washington, D.C., October 8.

"Improving upon the Neyman-Pearson approach to testing hypotheses," October 12, at the Northeastern Regional Conference on Microeconometrics, held at the University of Western Ontario, London, Ontario, Canada.

"The VPRT: Optimal sequential testing," seminar for the Medical Research Statistics group, Mayo Clinic, Rochester, Minnesota, March 3, 1987.

"A graphical procedure for determining nonstationarity in time series," seminar, School of Business Administration, University of Michigan, March 20.

"Mapping variables," at the National Computer Graphics Association's conference and exposition, Computer Graphics '87, Philadelphia, Pennsylvania, March 24.

"Spatial prediction and ordinary kriging," at the MGUS-87 Conference: Emerging Concepts (held by the Mathematical Geologists of the United States), Redwood City, California, April 14.

"Robustness of one- and two-sample t-statistics," seminar for Hewlett Packard Company, Palo Alto, California, April 15.

"Spatial prediction," May 14, at the American Statistical Association/Environmental Protection Agency meeting on Sampling and Site Selection in Environmental Studies, held in Washington, D.C.

DAVID, H. A.: "Closed adaptive sequential paired comparison selection procedures," by David and **D. M. Andrews,** at the 13th International Biometric Conference, Seattle, Washington, July 29, 1986.

"Order statistics," lecture for the Department of Computer Science and Experimental Statistics, University of Rhode Island, November 3.

"Some recent developments in the method of paired comparisons," presentation to Procter & Gamble, Inc., Cincinnati, Ohio, March 10, 1987.

"Ranking and selection from paired-comparison data," lecture in the Department of Statistics and Actuarial Science, University of Iowa, April 30.

DAVID, Herbert T.: "Inspecting value into Bernoulli lots, and fit into assemblies," by David, **Juan Ramírez-Cid,** and **Stephen VARDEMAN,** at the IBM Corporate Technical Institutes Statistics Symposium—Theory and Practice: Bridging the Gap, July 17, 1986, in Thornwood, New York.

"Randomness," seminar, Department of Industrial Engineering, Iowa State University, March 18, 1987.

"The statistical point of view," seminar, Department of Architecture, Iowa State University, April 6.

"Problems in multiple tolerancing," by David and Michael J. McCann, at the Fourth Annual Quality and Productivity Research Conference, sponsored by Ford Motor Company, AT&T, Bell Communications, and the University of Wisconsin-Madison Center for Quality & Productivity Improvement, June 3, Rochester, Michigan.

"Module reliability—forwards and backwards," "Processes with delays," and "Problems in multiple tolerancing"—colloquia for the Statistical Engineering Division, National Bureau of Standards, Washington, D.C., presented on June 9, 25, and 30, respectively.

FULLER, Wayne A.: "Small area estimation as a measurement error problem," August 12, 1986, at the Conference on Small Area Estimation sponsored by the Central Norwegian Bureau of Statistics, Oslo, Norway.

"Response error and second-order statistics," seminar, U.S. Bureau of Labor Statistics, Washington, D.C., October 6.

Discussant, session on Estimation of Cross-sectional and Change Parameters in Panel Surveys, at the ASA International Symposium on Panel Surveys, Washington, D.C., November 21.

"Nonstationary autoregressive time series" and "Measurement error models," seminars presented at Colorado State University on March 30, 1987, and at Arizona State University on April 1 and 2.

HARVILLE, David A.: "Computational aspects of likelihood-based inference for variance components," by Harville and **Terrance P. Callanan** (Eastman Kodak Company), presented at the International Symposium on Advances in Statistical Methods for Genetic Improvement of Livestock, February 18, 1987, in Armidale, Australia; also Animal Breeding Seminar, Iowa State University, February 2.

"BLUP (best linear unbiased prediction) and beyond," presented at the International Symposium on Advances in Statistical Methods for Genetic Improvement of Livestock, February 18, in Armidale, Australia; also Animal Breeding Seminar, Iowa State University, February 9.

HINZ, Paul: two lectures on the topic of graduate study and careers in statistics, Department of Mathematics, Luther College, February 20.

HOTCHKISS, Donald K.: "Basic statistics for sensory evaluation," for the Bernice K. Watt Symposium, Department of Foods and Nutrition, Iowa State University, April 23, 1987.

Jeske, Daniel R. (Iowa State University and AT&T Bell Laboratories, Holmdel, New Jersey), and **David A. HARVILLE:** "Prediction-interval procedures and (fixed-effects) confidence-interval procedures for mixed linear models," at the Conference on the Analysis of the Unbalanced Mixed Model, sponsored by the University of Florida and the Office of Naval Research, April 8.

KEMPTHORNE, Oscar: "Comparative experiments and randomization," at Statistical Design: Theory and Practice, a Conference in Honor of Walter T. Federer, July 17, 1986, at Cornell University.

"What is applied statistics?" at a Conference in Honor of the Retirement of Professor Virgil L. Anderson, November 14, at Purdue University.

"Relationships between mathematics and statistics," at the annual meeting of the Iowa chapters of the Mathematics Association of America, the American Statistical Association, and the Society of Industrial and Applied Mathematicians, April 25, 1987, in Cedar Falls, Iowa.

KOEHLER, Kenneth J.: "Models for proportions with non-multinomial variation," seminar, Department of Statistics and Actuarial Science, University of Iowa, November 13, 1986.

"A graphical aid for selecting a distribution function," at the annual meeting of the Iowa chapters of the Mathematics Association of America, the American Statistical Association, and the Society of Industrial and Applied Mathematicians, April 25, 1987, in Cedar Falls, Iowa.

Lasack, Paula: "Analyzing biological data: A look at another dimension," Entomology Seminar, Iowa State University, April 27.

LORENZ, Frederick O.: "The impact of sex roles, ethnic integration, and marital satisfaction on the psychological well-being of Chicanas," at the Southwestern Sociological Association meetings in Dallas, Texas, April 22.

MEEDEN, Glen: "Where is the center of a population?"—seminar for the Department of Mathematics, Grinnell College, November 19, 1986.

"Using the Polya posterior in finite population sampling for point and set estimation problems," seminar for the Department of Mathematics and Computer Science, University of Maryland-Baltimore County, April 1987.

"Admissible credible sets for a committee of Bayesian experts," at the Third Valencia International Meeting on Bayesian Statistics, Altea, Spain, held on June 1-5.

MEEKER, William Q., Jr.: "Software for life data analysis," at the biannual meeting of the Pacific Northwest Statistics Group, Victoria, British Columbia, Canada, April 10, 1987.

"STAR: Analysis and presentation of reliability data," by George D. Buswell, P. Agarwala, S. Fan, C. L. Gibson, Meeker, and D. H. Myers, presented on May 5 at the American Society for Quality Control's 41st Annual Quality Congress—Quality: The Universal Equation for Excellence, held in Minneapolis, Minnesota.

REISER, Mark R.: "Direction-of-wording effects in social life feeling questionnaires," seminar at the U.S. Bureau of Labor Statistics, Washington, D.C., April 3.

"A comparison of latent structural models for psychiatric questionnaires," seminar for the Department of Mental Hygiene, School of Public Health, Johns Hopkins University, April 8.

SACKS, Jerome M.: "Estimated prevalence of *Mycobacterium paratuberculosis* infection in cattle culled in the United States," by D. L. Whipple, R. S. Merkal, Sacks, and R. G. Snyder, presented at the annual meeting of the U.S. Animal Health Association, Ithaca, New York, in October 1986.

SHELLEY, Mack C. II: "The ICPSR: A data archive for social science research," Department of Political Science Professional Seminar, Iowa State University, October 8, 1986.

STEPHENSON, W. Robert: "Iowa State University/Industry Affiliate Program," at the Second International Conference on Teaching Statistics, held in Victoria, British Columbia, Canada, August 11-15, 1986.

"What statisticians do," lectures for the departments of Mathematics at St. Olaf College and Macalester College, October 16 and 17.

STRAHAN, Robert: "A takes-only-seconds portable measure of arousal" and "Second-chance course examinations," at the annual meeting of the American Psychological Association on August 22 and 23, 1986, respectively, in Washington, D.C.

"Second-chance course examinations: An annotated computer program," at the annual meeting of the Iowa Educational Research and Evaluation Association, November 6 in Ames.

SUKHATME, Shashikala: "Some applications of perturbation theory," seminar for the Department of Mathematics and Statistics, University of Pittsburgh, May 1, 1987.

VARDEMAN, Stephen B.: "Avenues of university involvement in statistics for quality and productivity improvement," October 29, 1986, at a Symposium on Education in Statistical Quality and Productivity Improvement for Michigan Industry, held in East Lansing, Michigan, by Michigan State University in cooperation with General Motors.

"A state space model approach to an old optimal control problem of Box and Jenkins," colloquium talk for the Department of Statistics, Virginia Polytechnic Institute and State University, March 5, 1987.

"The discipline of statistics in American industry and technology during the remainder of the 20th century," as a Balomenos Lecture on Directions in Mathematics: Educating Scientists and Engineers, Department of Mathematics, University of New Hampshire, April 2.

"Recent trends in industrial and engineering statistics," seminar for the Department of Mechanical Engineering, Iowa State University, April 23.

Other Meetings

Alicia Carriquiry attended the Third World Congress on Genetics Applied to Livestock, held in Lincoln, Nebraska, in August 1986. She also went to the International Symposium on Advances in Statistical Methods for Genetic Improvement of Livestock, held in Armidale, Australia, February 16-20, 1987.

Glen Meeden attended the 33rd meeting of the National Bureau of Econometric Research Seminar on Bayesian Inference in Econometrics, held in Riverside, California, in October.

Noel Cressie and Kenneth J. Koehler attended the Iowa chaper meeting of the American Statistical Association held at the University of Iowa on October 30.

Avonelle Hefflefinger went to the 4th annual all-Iowa conference for women in higher education administration, The Way Up IV: A Call for Leadership, November 11 in Des Moines, Iowa. The conference was sponsored by the Iowa Coordinating Council for Post-High School Education, the Iowa Commission on the Status of Women, and the American Council on Education—National Identification Program.

Wayne Fuller and John Eltinge attended the ASA International Symposium on Panel Surveys November 19-22 in Washington, D.C.

David F. Cox and Bud Meador attended SUGI 12, the Twelfth Annual Conference of SAS Users Group International, held in Dallas, Texas, on February 8-11, 1987.

George Battese and John Eltinge went to the Third Annual Research Conference sponsored by the U.S. Bureau of the Census and held in Baltimore, Maryland, March 28-April 1.

Oscar Kempthorne and David Harville attended the Conference on the Analysis of the Unbalanced Mixed Model held at the University of Florida April 6-10 and cosponsored by the U.S. Office of Naval Research.

Jauvanta Walker attended the 1987 Communications Conference and North Central Regional Meeting of Women in Communications, Inc., in Madison, Wisconsin, April 9-11.

Jerome Sacks took part in the Ninth Annual Midwest Biopharmaceutical Statistics Workshop held at Ball State University on May 27-29. He also visited the Mayo Clinic biostatistics unit in Rochester, Minnesota, in May.

Edward Pollak attended the Second International Conference on Quantitative Genetics, organized at North Carolina State University and held on May 31-June 5. W. Robert Stephenson and Stephen Vardeman went to the Quality and Productivity Research Conference held on June 2-5 in Rochester, Michigan.

Publications and Dissertation Abstracts

In addition to publishing results of their own research in 1986-87, many faculty members held editorial positions for a variety of journals.

William Q. Meeker, Jr., completed his year as editor-elect of *Technometrics* and began to serve a three-year term as editor. Denise Riker is editorial assistant. Meeker remains on the editorial board of *Selected Tables in Mathematical Statistics.*

William J. Kennedy continued as editor of *The American Statistician,* with Darlene Wicks as editorial assistant. Wayne Fuller, Glen Meeden, Vincent Sposito, and Stephen Vardeman continued as associate editors; Yasuo Amemiya began similar service on January 1, 1987. Kennedy is also on the international editorial board of *Communications in Statistics—Simulation and Computation* and is coeditor of its Algorithms section.

Wayne Fuller became an associate editor of *Survey Methodology* in 1986 and continued as an associate editor of the *Journal of Business and Economic Statistics.*

Oscar Kempthorne is an associate editor of the *Journal of Statistical Planning and Inference* and a member of its executive committee. He is also on the editorial advisory board of the *Journal of Statistical Computation and Simulation.*

Noel Cressie is an associate editor of the *Journal of the American Statistical Association* Theory and Methods Section and is on the editorial board of *Chemometrics and Intelligent Laboratory Systems.*

Stephen Vardeman continues as an associate editor of *Technometrics* and Paul Hinz, of the *Iowa State Journal of Research.*

Krishna Athreya is an associate editor of *Probability Theory and Related Fields* and serves on the editorial board of *Statistics & Probability Letters.*

Edward Pollak continues to serve on the editorial board of *Mathematical Biosciences.*

Mark Reiser is a member of the editorial board for *Sociological Methods & Research,* and Leroy Wolins is a member of the board of editors for *Educational and Psychological Measurement.*

The preprint series initiated by the Statistical Laboratory in 1986 now contains 60 titles. Two sets of abstracts, each containing information on 30 technical reports, are available on request. Any preprint may be requested by number directly from the author. The next list (beginning with #87-1) is scheduled for distribution early in the 1987 fall semester.

The Department of Statistics has decided to undertake the revision of the Snedecor-Cochran book on *Statistical Methods* for the Iowa State University Press. This will be the eighth edition of George W. Snedecor's pioneering book, which has been translated into a number of languages and has had a world-wide influence on the use of statistics in agricultural research and development. A contract was signed with the press in January 1987.

Books

COX, C. Philip. *A Handbook of Introductory Statistical Methods.* John Wiley & Sons, Inc. (New York) 1987. xxiii + 272 pp.

This compact volume was developed to complement instruction in a first course on statistical methods for graduate students who expect to use such methods in their own research. It is also appropriate as a reference source, on commonly used statistical analysis procedures and principles, for scientists working in quantitative research areas. The book is published as a volume in the Wiley Series in Probability and Mathematical Statistics.

Topics are grouped under the following headings: Some Basic Concepts and Procedures; Comparing Two Groups; Some Discrete, Categorized, Data Procedures; Linear Regression: Fitting Straight Lines to (x,y) Data; Linear Correlation: Measuring Relationship; Completely Randomized Experiments: Two or More Groups; Contrasts for Examining Linear Combinations of Group Means; Multiple Comparisons; Experiments Using Randomized Block and Latin Square Designs; Introduction to Matrix Operations; Multiple Regression: Describing Data in Terms of Several Variables (Plus Chance); and Multiple Correlation. One interesting addition is a photograph of a pyrgus, a dice box dating from approximately 300-400 A.D. A section on Notes and Notations, a list of references, and some commonly used statistical tables are also included.

FULLER, Wayne A. *Measurement Error Models.* John Wiley & Sons, Inc. (New York) 1987. xxiii + 440 pp.

This book is an outgrowth of research on measurement error, also called response error, in data collected from human respondents. It is the first book-length treatment of estimation methods that explicitly recognize the presence of measurement error. Included are regression models with errors in the variables, latent variable models, and factor models. Real-data examples from a variety of areas of application are used.

Recent results for nonlinear models and for models with unequal variances are presented. The book also covers the estimation of true values for the fixed model and prediction of true values under the random model. Model checks and the analysis of residuals form a part of the treatment.

The book is intended as a text for a graduate course concentrating on statistical analyses in the presence of measurement error and as an auxiliary text in courses on regression analysis. The treatment assumes a background in ordinary linear regression methods and an understanding of large sample theory. A number of sources of appropriate software are mentioned. Available software includes the program EV CARP for the personal computer, developed at Iowa State (see p. 17). The book is published in the Wiley Series in Probability and Mathematical Statistics.

ISAACSON, Dean L., and Richard W. Madsen. *Markov Chains: Theory and Applications.* Robert E. Krieger Publishing (Melbourne, Florida) 1985. x + 256 pp.

This is a reprint of the original 1976 edition published in the Wiley Series in Probability and Mathematical Statistics.

Krause, Robert A., Dinker I. Patel, and **Mack C. SHELLEY II.** *Transportation Policy in the States: Current and Future Trends.* The Center for Transportation (CENTRANS), Council of State Governments (Lexington, Kentucky) 1987. viii + 298 pp.

Research into what transportation policy information state policymakers need, as well as how they use this information, is an area where little investigation has been done. This publication provides a resource or database book to identify and analyze transportation issues and policy issue information needs facing the 50 states and United States commonwealths and territories.

Data were collected through a questionnaire sent in 1986 to a cross-section of key state transportation policymakers in all the states and territories of the U.S. The questionnaire included two sets of questions, one set to determine the degree to which respondents utilized transportation-specific information, the other set to elicit essay-type information on short-term (1987) and long-term transportation problems.

Tabulation was limited to data from the 270 questionnaires received within a shut-off window of approximately one month, a 21 percent response rate. These data, including regional comparisons, are summarized in numerous tables and charts.

Schmidt, Steffen W., **Mack C. SHELLEY, II,** and Barbara A. Bardes. *American Government and Politics Today.* West (St. Paul, Minnesota) 1987. xxxiii + 713 pp.

This second edition provides an update through early 1987 on United States political customs, the Constitution, federalism, civil liberties, minority rights, emerging issues (regarding women, the elderly, the handicapped, juveniles, and gays), public opinion, political parties, the media, campaigns and

elections, interest groups, the presidency, Congress, the bureaucracy, the judiciary, political economy, domestic policy, foreign and defense policy, and state and local government.

Special features of this edition are: more extensive use of public opinion poll data, "critical thinking" sections discussing theoretical points buttressed by recent research results, a new appendix including selected numbers of *The Federalist Papers,* and more full-color graphs and charts. An additional innovation is a set of enrichment lectures supplemented by full-color transparency acetates.

Published Research

AMEMIYA, Yasuo, Wayne A. FULLER, and Sastry G. Pantula. The asymptotic distributions of some estimators for a factor analysis model. *Journal of Multivariate Analysis* 22:1 (1987) 51-64.

The limiting behavior of the estimators of the parameters of the factor analysis model is studied under the errors-in-variables parameterization. A computationally efficient expression is given for the covariance matrix of the limiting distribution of the estimators. The limiting distribution of the vector containing the estimated coefficients and the estimated error variances is shown to be valid for a broad class of assumptions about the true factors.

Anderson, Kevin K. (IBM T. J. Watson Research Center), and **Krishna B. ATHREYA.** A renewal theorem in the infinite mean case. *The Annals of Probability* 15:1 (1987) 388-393.

Let $F(\cdot)$ be a c.d.f. on $[0, \infty)$ such that $1 - F(x)$ is regularly varying with exponent $-\alpha$, $\frac{1}{2} < \alpha \leq 1$. Let $Q(\cdot):R^+ \to R^+$ be nonincreasing and regularly varying with exponent $-\beta$, $0 \leq \beta < 1$. Then as $t \to \infty$, $(U^*Q)(t) \equiv \int_{[0,t]} Q(t-u)\, U(du)$ is asymptotic to $c(\alpha,\beta)$ $(\int_0^t Q(u)du)(\int_0^t (1 - F(u))du)^{-1}$, where $U(\cdot)$ is the renewal function associated with $f(\cdot)$ and $c(\alpha,\beta)$ is a suitable constant.

This is an improved version of a theorem due to Teugels, whose proof appears to be incomplete. Applications of the result to the second order behavior of $U(t)$ in some special cases are also given.

ATHREYA, K. B. Polya urn schemes in Bayesian approach to finite population sampling—A limit theorem. *Mathematical Sciences Research Institute Technical Report 05608-87,* Berkeley, California. 1987. 11 pp.

If $\bar{X}_p$, $\bar{X}_s$ represent the population mean and the sample mean, respectively, then under a posterior distribution on the population corresponding to that of Polya's urn scheme, whose initial composition is that of the sample, the distribution of $(\bar{X}_p - \bar{X}_s)$ is asymptotically normal.

ATHREYA, Krishna B., and Sastry G. Pantula. Mixing properties of Harris chains and autoregressive processes. *Journal of Applied Probability* 23:4 (1986) 880-892.

In this paper, strong mixing properties are proved for Markov chains and some autoregressive time series, restricted to the case of iid innovation. First, the strong mixing property is established for a wide class of Harris-recurrent Markov chains. With the use of that result, a set of necessary and sufficient conditions is derived to guarantee the strong mixing property for autoregressive processes.

ATHREYA, K. B. Bootstrap of the mean in the infinite variance case. *The Annals of Statistics* 15:2 (1987) 724-731.

Let $X_1, X_2, \ldots, X_n$ be independent identically distributed random variables with $EX_1^2 = \infty$ but X_1 belonging to the domain of attraction of a stable law. It is known that the sample mean $\bar{X}_n$ appropriately normalized converges to a stable law. It is shown here that the bootstrap version of the normalized mean has a random distribution (given the sample) whose limit is also a random distribution, implying that the naive bootstrap could fail in the heavy tailed case. Thus, constructing confidence limits on the basis of a Monte Carlo simulation of the bootstrap could yield misleading results of order α_1, $0 < \alpha \leq 2$.

Jankowiak, R., G. J. Small, and **K. B. ATHREYA.** Derivation of the density of states and distribution functions for two-level systems in glasses. *Journal of Physical Chemistry* 90 (1986) 3896-3898.

A formalism for calculating the density of states function for tunneling systems in amorphous materials is described. Gaussian distribution functions for the asymmetry and the tunneling parameter are employed. It is shown that, over a broad energy range ($E << h\omega_0$), the density of states function is an increasing function of energy proportional to $E^{\tilde{\mu}_{eff}}$ with $0.3 \lesssim \tilde{\mu}_{eff} \lesssim 0.5$.

Chang, Stephen F. (ISU and California State College-Bakersfield), and **William J. KENNEDY.** Error-free computer solution of certain systems of linear equations. *Journal of Computational and Applied Mathematics* 18:3 (1987) 279-287.

A procedure is proposed that generates the exact solution for the system $Ax = \mathbf{b}$, where A is an integral nonsingular matrix and $\mathbf{b}$ is an integral vector, by improving the initial floating-point approximation to the solution. This procedure, based on an easily programmed method proposed by O. Aberth [*Journal of Computational and Applied Mathematics* 4 (1978) 285-288], first computes the approximate floating-point solution x^* by using an available linear equation solving algorithm. Then it extracts the exact solution x from x^* if the error in the approxima-

tion x* is sufficiently small. An a posteriori upper bound for the error of x* is derived when Gaussian Elimination with partial pivoting is used. Also, a computable upper bound for |det(A)|, which is an alternative to using Hadamard's inequality, is obtained as a byproduct of the Gaussian Elimination process.

Chua, Tin Chiu (University of South Dakota and Iowa State University), and **Wayne A. FULLER.** A model for multinomial response error applied to labor flows. *Journal of the American Statistical Association* 82:397 (1987) 46-51.

A model is developed for the response error associated with reported categorical data in a single multinomial classification. This model is used to construct estimators for the interior cells of a two-way table with marginals subject to independent response error. The estimation procedure is applied to the month-to-month table of employment status obtained from the U.S. Current Population Survey, using data obtained for 1978-1980.

COX, C. Philip, and **Richard A. GROENEVELD.** Analytic results on the difference between the G^2 and χ^2 test statistics in one degree of freedom cases. *The Statistician* 35:4 (1986) 417-420.

The Pearson chi-squared (χ^2) and likelihood ratio (G^2) test statistics, for 2×2 contingency table analyses, are compared. For canonically arranged tables, circumstances are defined for which it is shown that the sign of $(G^2 - \chi^2)$ is determined by the sign of the difference, $(O_{11} - E_{11})$, between the observed and expected numbers in the upper left cell. An analogous result for the tests of the null hypothesis H_0: $p = p_0$ for a proportion p, against a two-sided alternative, is also given. Some statistical implications of these analytic results are considered.

CRESSIE, Noel. Kriging nonstationary data. *Journal of the American Statistical Association* 81:395 (1986) 625-634.

Consider spatial data modeled to have come from a random function with a nonstationary mean. The method of spatial prediction known as kriging exploits second-order spatial correlation structure to obtain minimum-variance unbiased predictions of certain average values of the random function. But to do so, one must assume either that the mean function (the drift) is known up to an additive constant or that the second-order structure (the variogram) is known exactly. Knowledge of the drift allows the (stationary) variogram to be estimated and leads to ordinary kriging. Knowledge of the variogram allows the drift to be estimated and leads to universal kriging. More usually, neither is known.

This article shows how median polish of gridded spatial data provides a resistant and relatively bias-free way of kriging in the presence of drift, yet yields results as good as the mathematically optimal (but operationally difficult) universal kriging. Comparisons are performed on two data sets derived from ore-exploration drilling.

CRESSIE, Noel. Contributed discussion of the paper by Cary Isaki, Gregg Diffendal, and Linda Schultz: Statistical synthetic estimates of undercount for small areas. *Proceedings, Bureau of the Census Second Annual Research Conference,* held March 23-26, 1986, in Reston, Virginia. Pp. 580-583. 1986.

CRESSIE, N. Using the scan statistic to test for uniformity. Pp. 87-100 in *Goodness-of-Fit* (Colloquia Mathematica Societatis Janos Bolyai, Vol. 45), edited by P. Revesz, K. Sarkadi, and P. K. Sen (Proceedings of the International Colloquium on Goodness of Fit, Debrecen, Hungary, 1984). North-Holland Publishing Company (Amsterdam). 1987.

The problem of "bump hunting," i.e., finding a rectangular signal in the presence of background noise, is an important activity of many experimental physicists. Suppose it is desired to test whether points in an interval are uniformly distributed, versus whether they come from a clustering (or bump) alternative. Take a fixed scan width and slide a window across the points, noting how many points are in the window as a function of its location. Then the scan statistic is the maximum, over window location, of the number of points in the window. To test the uniformity hypothesis against the clustering alternative, it can be shown that the generalized likelihood ratio test yields the scan statistic. This article discusses properties of the statistic, and gives directions for further research.

CRESSIE, Noel. A nonparametric view of generalized covariances for kriging. *Mathematical Geology* 19:5 (1987) 425-449.

Fitting trend and error covariance structure iteratively leads to bias in the estimated error variogram. Use of generalized increments overcomes this bias. Certain generalized increments yield difference equations in the variogram that permit graphical checking of the model. These equations extend to the case where errors are intrinsic random functions of order k, $k = 1,2,\ldots$, and an unbiased nonparametric graphical approach for investigating the generalized covariance function is developed. Hence, parametric models for the generalized covariance produced by **BLUEPACK-3D** or other methods may be assessed. Methods are illustrated on a set of coal ash data and a set of soil pH data.

CRESSIE, N. A. C., and **R. Guo.** Mapping variables. Pp. 521-530 in Volume III, *Proceedings of NCGA's Computer Graphics '87* (Eighth Annual Conference and Exposition of the National Computer Graphics Association, held in Philadelphia, Pennsylvania, March 22-26, 1987). 1987.

Usually a variable associated with regions is mapped by a graded color code (or gray scale) directly onto the two-dimensional outline of the regions. Many such variables however are proportions over a base that varies from region to region, and hence those with a larger base have a smaller variance (e.g., percent unemployed in each of the 50 states in the USA). How, then, can one be sure that an unusually large value of the variable in a unit with a small base is not simply due to large *random* fluctuations? By working with a cancer-incidence data set (the base being the population-years-at-risk), we describe some statistical tools that enable variables with unequal variance to be displayed sensibly on a map.

CRESSIE, N. A. C., and R. Horton. A robust-resistant spatial analysis of soil water infiltration. *Water Resources Research* 23:5 (1987) 911-917.

Data taken at adjacent spatial locations often exhibit correlation that must be taken into account in their analysis. Geostatistical methods, originally developed for the mining industry, have proven to be adaptable to hydrological problems. This paper concentrates on estimating the spatial correlations between soil water infiltration observations, with special emphasis on resistant methods to remove nonstationarity. After this removal, robust semivariogram estimators are used to examine the spatial dependencies for various tillage treatments. There is some indication that infiltration characteristics inherit different types of spatial dependency, depending on the tillage treatment applied.

CRESSIE, N. A. C., R. T. Withers, and N. P. Craig. The statistical analysis of somatotype data. *Yearbook of Physical Anthropology* 29 (1986) 197-208.

One method of describing human morphology is somatotyping. The literature contains examples of one-way ANOVAs being conducted on somatotype attitudinal distance (SAD) values to determine whether there are statistically significant differences between group somatotype means. The problems with this strategy concern premature collapsing of the three component somatotype vectors into a scalar SAD value together with use of inappropriate degrees of freedom for the F-ratio.

A theoretical rationale is presented for remedying the latter defect. However, a one-way MANOVA, which uses Wilks's lambda as the test statistic, is the most powerful method of determining whether there are statistically significant differences between the somatotype means for two or more groups.

If the null hypothesis is rejected, then for more than two groups, pairwise comparisons should be conducted by using Hotelling's T^2 with a Bonferroni adjusted alpha level. The one-by-one and joint contributions of the somatotype components to each significant pairwise difference can furthermore be determined by univariate F-ratios, discriminant function analyses, and forward stepwise discriminant analyses.

Hamlett, J. M., R. Horton, and **N. A. C. CRESSIE.** Resistant and exploratory techniques for use in semivariogram analyses. *Soil Science Society of America Journal* 50:4 (1986) 868-875.

Journal Paper No. J-11759 of the Iowa Agriculture and Home Economics Experiment Station, Projects 2556 and 2715.

"Traditional" statistical analyses based on the assumption of independent observations are being replaced by spatial analyses that take account of correlations between neighboring observations. Geostatistics is one approach with potential applications in soils research.

This paper uses exploratory data analysis techniques in a novel way, relying on resistant measures, graphical tools, and robustness ideas, to help "model" the spatial structure of data. Data on soil-water pressure potential, collected during the 1983 crop season in central Iowa, were analyzed by straightforward techniques that assured that the data met the necessary implicit assumptions of stationarity (of the mean *and* the variance) and at least symmetry. Stem-and-leaf plots and plots of mean vs. variance (or for a more resistant analysis, median vs. interquartile range squared) were used to assess the variance stationarity and data distributions. A nonparametric approach of median-based techniques was used to remove drift along both grid directions. Then the spatial structure was exposed through computing and interpreting semivariograms of the modified data.

DAVID, H. A. Inequalities for ordered sums. *Annals of the Institute of Statistical Mathematics* 38:3, Part A (1986) 551-555.

Let $x_i = y_i + z_i$, $i = 1, \ldots, n$, and write $x_{(1)} \leq \ldots \leq x_{(n)}$, with corresponding notation for the ordered y_i and z_i. It is shown that $\max_{i=1,\ldots,r} (y_{(i)} + z_{(r+1-i)}) \leq x_{(r)} \leq \min_{j=1,\ldots,n+1-r} (y_{(n+1-j)} + z_{(r-1+j)})$. Inequalities are also obtained for convex (or concave) functions of the $x_{(i)}$ [cf. N. L. Smith and Y. L. Tong, *Annals of the Institute of Statistical Mathematics* 35 (1983) 255-265]. The results lead immediately to bounds for the expected values of order statistics in nonstandard situations in terms of simpler expectations.

DAVID, H. A. Ranking from unbalanced paired-comparison data. *Biometrika* 74:2 (1987) 432-436.

It is proposed that for ranking objects or players in an incomplete paired-comparison experiment or tournament with at most one comparison per pair, the score of a player, C, be the total number of (a) wins of players defeated by C minus losses of players to whom C lost, plus (b) C's wins minus C's losses. A tied match counts as half a win plus half a loss. More general tournaments can be treated similarly.

DAVID, H. A., and **D. M. Andrews.** Closed adaptive sequential paired-comparison selection procedures. *Journal of Statistical Computation and Simulation* 27:2 (1987) 127-141.

Bechhofer and Kulkarni (1982) introduced closed adaptive sequential procedures as a new method for selecting the best of t (≤ 2) Bernoulli populations. We modify their approach to obtain two procedures for selecting the best of t objects in a curtailed Round Robin-type paired-comparison experiment. Objects are paired sequentially, and the experiment is stopped as soon as one object has achieved a number of preferences that no other object can equal (weak curtailment) or surpass (strong curtailment) if the tournament were run to completion. Ties for first place are broken at random.

Weak curtailment clearly selects the same object as the complete Round Robin, with generally substantially fewer comparisons. Strong curtailment effects a further appreciable reduction in the average number of comparisons needed. It is shown that the probabilities of selecting a particular object are the same for weak and strong curtailment if the Bradley-Terry model holds, but generally not otherwise.

Some comparisons are made with Knockout tournaments. Extensions to the selection of more than one object are also discussed.

FULLER, Wayne A. Least squares estimation for the errors-in-variables model. In *Methods of Operations Research 53* (Proceedings of the Symposium on Operations Research organized by the Gesellschaft für Mathematik, Ökonomie und Operations Research and the University of Munich, held August 26-28, 1985), edited by Martin J. Beckmann, Karl-Walter Gaede, Klaus Ritter, and Hans Schneeweiss. Verlag Anton Hain. 16 pp. 1986.

Estimation for the parameters of a simple errors-in-variables model is outlined. Differences between the properties of least squares estimators for the usual regression model and for the errors-in-variables model are discussed. Residuals are defined for the errors-in-variables analysis, and residual plots suitable for model checking are suggested. An example in which measurement error is important is presented.

FULLER, Wayne A. Small area estimation as a measurement error problem. Pp. 7-21 in *Proceedings of the Conference on Survey Research Methods in Agriculture* held in Leesburg, Virginia, June 15-18, 1986. American Statistical Association and National Agricultural Statistics Service, U.S. Department of Agriculture. 1987.

A model based upon measurement error concepts is utilized for small area estimation. The formulation permits the small areas to be treated as fixed or random. Conditionally unbiased estimators and components of variance estimators can be derived with alternative specifications for the basic model.

FULLER, Wayne A. Estimators of the factor model for survey data. Pp. 265-284 in *Applied Probability, Stochastic Processes, and Sampling Theory,* edited by I. B. MacNeill and G. J. Umphrey. D. Reidel Publishing Company (Dordrecht, the Netherlands) 1987.

Limited properties of estimators of the parameters of the factor model computed from an estimated covariance matrix are presented. It is shown that construction of the estimators and of the estimated covariance matrix of the estimators is computationally feasible for data collected in surveys of complex design.

FULLER, W. A., and **R. M. Harter.** The multivariate components of variance model for small area estimation. Pp. 103-123 in *Small Area Statistics—An International Symposium,* edited by R. Platek, J. N. K. Rao, C. E. Särndal, and M. P. Singh. John Wiley & Sons (New York) 1987.

The multivariate regression model with components-of-variance error structure is considered. Predictors for small area means are given as the estimated regression mean plus the predictor of the random component associated with the area. Nearly minimum mean square error predictors and nearly unbiased estimators of the prediction mean square error are constructed, employing expansions in the reciprocals of the degrees of freedom. Models with unequal numbers of observations and estimators for finite populations are considered. Results of a Monte Carlo study are presented.

GHOSH, J. K. (Indian Statistical Institute and Iowa State University), and C. K. Mustafi. A note on the residual median process. *The Canadian Journal of Statistics* 14:3 (1986) 251-255.

The residual median process, defined as the median of those observations that are greater than a number t, is considered. Using appropriate limit theorems, it is shown that the stochastic process converges in law to a Gaussian process defined in terms of a Brownian bridge.

GROENEVELD, R. A. Skewness for the Weibull family. *Statistica Neerlandica* 40:3 (1986) 135-140.

The skewness of the Weibull family of distributions is discussed for all values of the shape parameter. This class includes unimodal probability densities for which the coefficient of skewness μ_3/σ^3 is positive, but the order of the mean, median, and mode is $\mu < m < M$. For values of the shape parameter used in practice, the distributions are skewed to the right by a well-accepted definition of skewness.

Dombeck, Michael. P., Bruce W. Menzel, and **Paul N. HINZ.** Natural muskellunge reproduction in midwestern lakes. Pp. 122-134 in *Managing Muskies—American Fisheries Society Special Publication 15* (1986).

Journal Paper No. J-11373 of the Iowa Agriculture and Home Economics Experiment Station, Project 2236.

This study had the objective of statistically identifying ecological variables that may influence natural reproduction of muskellunge in lakes and to develop a procedure for estimating muskellunge reproductive potential in individual lakes by using readily accessible ecological data. Nine variables accounted for 57 percent of the variability in reproduction. A discriminant analysis was used to suggest lake-stocking and habitat-improvement strategies that may be useful for creating or maintaining self-sustaining muskellunge populations.

Keller-McNulty, Sallie (Iowa State University and Kansas State University), and **W. J. KENNEDY.** Error-free computation of the Moore-Penrose inverse with application to linear least squares analysis. *Journal of Statistical Computation and Simulation* 27:1 (1987) 45-64.

The paper develops a numerical method (and associated algorithm) that allows error-free computation of the Moore-Penrose inverse of a matrix having rational elements. Multiple modulus residue arithmetic is used to avoid error that is inherent in floating-point arithmetic. The method is an improved form of one originally presented by W. T. Stallings and T. L. Boullion [*SIAM Review* 14 (1972) 152-163].

KEMPTHORNE, Oscar. Comparative experiments and randomization. Pp. 43-88 in *Statistical Design: Theory and Practice*—Proceedings of a Conference in Honor of Walter T. Federer, edited by Charles E. McCulloch, Steven J. Schwager, George Casella, and Shayle R. Searle. Cornell University (Ithaca, New York). 1986.

Journal Paper No. J-12358 of the Iowa Agriculture and Home Economics Experiment Station, Project 890.

How is one to determine whether a particular intervention alters the progress of a disease? The prescription of R. A. Fisher is to use randomization. What is randomization? What data analyses are appropriate? How is analysis related to design? In particular, how should it be related to the randomization procedure that was used? Is the use of Gauss-Markov linear model theory justified by randomization? Are the standard "classical" randomized designs satisfactory?

In considering the questions above, the author first discusses Fisher's exposition. The view is given that analysis should be related to tests of significance and that tests of significance should be based on the frame of reference that is induced by the actual randomization procedure that was used in the planning of the experiment; that is, analysis of the resultant data should be based on randomization tests of significance of null and alternative models of treatment effects. Such a view is totally antithetic to Bayesian thinking, as is discussed.

Suggestions are made on the choice of design, which is related totally, in the view of the author, to the choice of randomization that is made—which is, of course, of an "informal" Bayesian nature. Implementation of these suggestions requires extensive use of high-speed computation in both design and analysis. However, it does not depend on the usual parametric modeling of "error," or any limit theory. Furthermore, it does not require untestable and unrealistic assumptions.

KEMPTHORNE, Oscar. Where are the Americans? A comment. *The Institute of Mathematical Statistics Bulletin* 15:5 (1986) 242-245.

KEMPTHORNE, Oscar, and R. R. Allmaras. Errors and variability of observations. Pp. 1-31 in *Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods*—Agronomy Monograph No. 9 (2nd edition). Arnold Klute, editor. American Society of Agronomy, Inc., and Soil Science Society of America, Inc. (Madison). 1986.

Journal Paper No. J-11311 of the Iowa Agriculture and Home Economics Experiment Station, Project 890.

The objective of this chapter is to describe the basic ideas of statistics that are relevant to errors of observations and numbers derived from those observations in experiment-based investigations involving the quantification of one or more attributes. Topics covered are the classification of measurement errors, the scientific validity of measurements, characterization of variability, the estimation of precision, the precision of derived observations, the roles of bias and precision, how to study errors of observation, the role of errors of observation in the study of relationships, and a note on terminology. Finally there is a brief discussion of statistical problems experimenters will meet and techniques that may be useful. Appropriate references are included.

KOEHLER, Kenneth J., and **Jeffrey R. Wilson** (Arizona State University). Chi-square tests for comparing vectors of proportions for several cluster samples. *Communications in Statistics—Theory and Methods* 15:10 (1986) 2977-2990.

Test statistics are developed for comparing vectors of proportions obtained from several independent two-stage cluster samples. It is assumed that clusters are selected with probability proportional to size for each sample. Wald's general method of constructing quadratic forms is used to obtain a large sample chi-square test. More easily evaluated chi-square tests are derived from the Dirichlet-multinomial model. Corresponding goodness-of-fit tests for the Dirichlet-multinomial model are also derived.

LORENZ, Frederick O., Charles L. Mulford, Betty L. Wells, and Daisy Kabagarama. How social service agencies react to uncertainty: Budget cuts need not curb creativity. *Sociology and Social Research* 71:1 (1986) 29-30.

Both staff cuts and creative strategies of adaptation are possible when agencies face budget shifts and uncertainty. Faced with budget cuts, many agencies in central Iowa responded by cutting staffs. However, when faced with high uncertainty, many agencies whose budgets have been cut or frozen respond with aggressive, creative strategies.

MARASINGHE, Mervyn G. A note on methods for computing Tukey's and Mandel's interaction sums of squares. *Communications in Statistics—Simulation and Computation* 15:3 (1986) 649-654.

Algorithms, which are generalizations of well-known single-pass algorithms for computing sample variances and covariances, are proposed for certain nonstandard analysis of variance computations and are compared in a numerical study.

MEEDEN, Glen. Estimation when using a statistic that is not sufficient. *The American Statistician* 41:2 (1987) 135-136.

Recently E. L. Lehmann [*Journal of the American Statistical Association* 78 (1983) 624-627] discussed several examples of absurd UMVU estimators. He argued that these estimators arose because the amount of information available was inadequate for the estimation problem at hand. Here it is argued that such absurd UMVU estimators result more from the property of unbiasedness than from inadequate information.

Ghosh, Malay, and **Glen MEEDEN.** Empirical Bayes estimation in finite population sampling. *Journal of the American Statistical Association* 81:4 (1986) 1058-1062.

The paper introduces a new empirical Bayes approach in model-based finite population sampling theory. Empirical Bayes estimators of the population mean are given, and these estimators are compared with the classical estimators with respect to their Bayes risks.

Mazloum, Reda, and **Glen MEEDEN.** Using the stepwise Bayes technique to choose between experiments. *The Annals of Statistics* 15:1 (1987) 269-277.

In Meeden and Ghosh [*The Annals of Statistics* 11 (1983) 296-305] a theory was developed for choosing, possibly at random, from a group of experiments the one to be observed. Here we consider the problem when the class of possible designs is restricted to a subclass of all designs. A theorem that identifies some admissible decision procedures and generalizes the early work is proved. Some applications to finite population sampling are discussed.

MEEKER, William Q., Jr. Planning life tests in which units are inspected for failure. *IEEE Transactions on Reliability* R-35:5 (1986) 571-578.

In some life tests, exact failure times cannot be observed. Instead failures are detected upon inspection. Equally spaced inspection times can be statistically inefficient, especially when a product has a decreasing failure rate. In such cases, equal spacing in log time provides an attractive alternative. This paper gives guidelines for choosing statistically efficient inspection times and the approximate sample size that achieves a specified degree of precision for estimating a particular quantile of a Weibull time-to-failure distribution. This information can be used to plan more efficient life tests.

MEEKER, William Q., Jr. Limited failure population life tests: Application to integrated circuit reliability. *Technometrics* 29:1 (1987) 51-65.

The purpose of this article is to outline methods for analyzing life test data from life tests for "limited-failure" populations. Solid-state electronic components, such as integrated circuits, often fail because of manufacturing defects. Typically, a small proportion of the components has one or more defects that cannot be detected in a simple inspection but that will eventually cause the component to fail. If a component has no such defects, the probability that it will fail under carefully controlled conditions is virtually 0. By assuming a time-to-failure distribution for the units susceptible to failure from manufacturing defects, laboratory life tests of limited duration can be used to estimate the proportion of units that have such defects and the parameters of the assumed time-to-failure distribution of the defective subpopulation. Applications are described, and a numerical example is included.

Agarwala, P., G. D. Buswell, S. C. Fan, C. L. Gibson, **W. Q. MEEKER,** and D. H. Myers. STAR: Software for the analysis and presentation of reliability data. *Transactions of the 1987 ASQC Quality Congress* held in Minneapolis, Minnesota, May 4-6, 1987. (1987.) Pp. 264-269.

STAR is a UNIX™-based software package developed to help both statisticians and nonstatisticians quickly and efficiently analyze censored time-to-failure data and effectively present their results. STAR can be used either interactively or in batch. In the interactive mode, STAR users can optionally be guided through their analysis. This is possible because STAR has a strategy for the analysis of reliability data embedded within it. This strategy packages reliability analysis methods in a logical order that makes it easy for the novice user to perform an analysis and have confidence in the results.

Some of the capabilities of STAR include: high

quality tables and color graphics; parametric and nonparametric analysis of arbitrarily censored and truncated data; probability plotting; pointwise and simultaneous confidence limits on all estimates; maximum likelihood estimation of parametric models; Cox proportional hazards modeling; regression modeling; special modules for accelerated life testing; failure probability, failure rate, and quantile estimates.

Escobar, Luis A., and **William Q. MEEKER, Jr.** Algorithm AS 218: Elements of the Fisher information matrix for the smallest extreme value distribution and censored data. *Applied Statistics* 35:1 (1986) 80-86.

This paper presents an efficient and accurate algorithm to compute the Fisher Information Matrix for censored data from a smallest extreme value distribution with pdf $g((\gamma - \mu)/\sigma)$, where μ and σ are the location and scale parameters, respectively. The algorithm allows for censoring on the right, the left, or both sides, and it provides the elements of the Fisher Information Matrix for single time (Type I) censored data, failure (Type II) censored data, and multiple time or progressive failure censored data.

This algorithm can be used to compute asymptotic variances and covariances of maximum likelihood estimators of parameters and of functions of the parameters, which are useful in comparing alternative test plans, determining sample sizes for censored life tests, and to determine coefficients for optimal asymptotic estimation of μ and σ using linear combinations of order statistics.

Fischer, Martin L., and **Karen Moore** (A. C. Nielsen Company). An improved credit scoring function for the St. Paul Bank for Cooperatives. *Journal of Agricultural Cooperation* 1 (1986) 11-21.

A new credit scoring function for classifying Bank for Cooperatives loans (pricing loans based on credit risk), screening loan applications, and diagnosing credit weaknesses was estimated using stepwise logistic regression analysis. Both dichotomous and polychotomous versions were estimated and found to be more accurate than the old function used prior to 1986.

The dichotomous model was preferred for the uses mentioned because it is nearly as accurate as the polychotomous model, and much simpler to use and understand. The model was tested for validity for different types of cooperatives. When the test sample and estimating samples were combined, the dichotomous model correctly classified 92 percent of the 708 cooperatives in a 2-class system and 70 percent in a 4-class system.

Nkansah, Paul T. (Iowa State University and Atlanta University), and **H. T. DAVID.** Network median problems with continuously distributed demand. *Transportation Science* 20:3 (1986) 213-219.

The network p-median (supply point location) problem has been generalized to the case where demand is continuously distributed. For $p = 1$ and uniformly distributed demand, and with the objective of minimizing distance, the interior points of an "edge" may be omitted from the search for an optimal supply point when that edge belongs to a "circuit." Analogous conditions apply when demand is distributed in other than uniform fashion, and/or the objective is to minimize various forms of travel cost. In the case of $p \geq 2$, with uniformly distributed demand and with the objective of minimizing distance, p-tuples of supply points, whose components are, respectively, interior points of p "mutually distant" edges, can be omitted from the search for p optimal supply points.

ROBERTS, Carl W. Tracing formative influences on event recall: A test of Mannheim's sensitivity hypothesis. *Social Forces* 65:1 (1986) 74-86.

Evidence is presented in support of Karl Mannheim's theory that people are more sensitive to events that occur during their formative years than to those that occur later in the life course. Accordingly, a cohort analysis is performed on recall data from a questionnaire survey of Wilson scholars. Methodological problems in the analysis of cohort tables are considered, inspiring discussions of data transformations, stagewise regression, nonlinear regression techniques, and goodness-of-fit tests.

Cutlip, Randall C., Howard D. Lehmkuhl, Kim A. Brogden, and **Jerome M. SACKS.** Breed susceptibility to ovine progressive pneumonia (maedi/visna) virus. *Veterinary Microbiology* 12 (1986) 283-288.

In this retrospective study of breed differences in susceptibility to disease caused by ovine progressive pneumonia (OPP) virus, 29 Border Leicester sheep were compared with 46 Columbia sheep. As judged by frequency and severity of clinical signs and lesions attributable to the infection, Border Leicester sheep were markedly more susceptible than Columbia sheep, and experimentally infected sheep were slightly more susceptible than naturally infected sheep. Differences in susceptibility to infection by the virus were not determined.

Merkal, R. S., D. L. Whipple, **J. M. SACKS,** and G. R. Snyder. Prevalence of *Mycobacterium paratuberculosis* in ileocecal lymph nodes of cattle culled in the United States. *Journal of the American Veterinary Medical Association* 190:6 (1987) 676-680.

Infection with *Mycobacterium paratuberculosis* (paratuberculosis) has been recognized as a worldwide problem of ruminants for years. The study reported here was made to estimate the prevalence of paratuberculosis in clinically normal cattle culled in the United States.

During 1983 and 1984, ileocecal lymph node specimens were obtained from clinically normal cattle at 76 U.S. Department of Agriculture-inspected cull cattle slaughterhouses in 32 states and Puerto Rico. *Mycobacterium paratuberculosis* was isolated from the lymph nodes of 119 of 7,540 cattle. The prevalence rates of bovine paratuberculosis were 1.6 percent overall, 2.9 percent in dairy culls, and 0.8 percent in beef culls. No statistically significant differences were observed between male and female prevalence rates.

Pirtle, Eugene C., **Jerome M. SACKS,** and Ronald J. Nachman. Antiviral effectiveness of butylated hydroxytoluene against pseudorabies (Aujeszky's disease) virus in cell culture, mice, and swine. *American Journal of Veterinary Research* 47:9 (1986) 1892-1895.

Butylated hydroxytoluene (BHT) was evaluated for antiviral effectiveness on pseudorabies virus (PRV) in cell culture, mice, and swine. When relatively small amounts of BHT were mixed with PRV and incubated at 37 C for 30 or 60 minutes before inoculation into cell cultures, the cell cultures did not become infected with virus. The PRV was not infectious when the virus was treated with BHT and then inoculated intraperitoneally into mice, but was infectious when BHT and PRV were inoculated simultaneously or when BHT was inoculated either 30 or 60 minutes before PRV. Swine fed BHT-medicated feed for 10 days before they were intranasally exposed with virulent PRV did not have overt signs of pseudorabies, had a lower concentration of PRV in nasal mucus than control swine did, and had acceptable blood enzyme and cholesterol concentrations during the experiment. The BHT was detected in tissues of two swine after they were fed BHT-medicated feed for 10 days, and higher concentrations of BHT were detected in tissues of three swine given BHT feed for 29 days.

Whipple, D. L., R. S. Merkal, **J. M. Sacks,** and G. R. Snyder. Estimated prevalence of *Mycobacterium paratuberculosis* infection in cattle culled in the United States. *Proceedings of the Annual Meeting of the U.S. Animal Health Association* 90 (1986) 400-421.

This material is essentially described in the publication by Merkal, Whipple, Sacks, and Snyder already summarized.

Tsokou, Stavroula, **Mack C. SHELLEY II,** and Betty A. Dobratz. Some correlates of partisan preference in Greece, 1980: A discriminant analysis. *European Journal of Political Research* 14 (1986) 441-463.

The factors underlying patterns of partisan preference in Greece have been the subject of fairly little systematic analysis. This article uses data from a 1980 Euro-Barometer survey, the first to include a Greek sample, to outline the structure of the Greek partisan universe. A number of demographic variables—age, family income, education, occupation, sex, size of community, and household status—together with attitudinal variables regarding both foreign and domestic policy issues are tested as predictors of party identification. The multivariate statistical technique of discriminant analysis is used to measure the relative importance of these predictor variables in influencing the direction of party preferences. The findings show that attitudinal factors for the most part are more important than demographic traits. A stepwise discriminant analysis provides a rank ordering of the strongest explanatory variables. The impact of recent political and historical developments on the party system in Greece is discussed.

VARDEMAN, Stephen B. The legitimate role of inspection in modern SQC. *The American Statistician* 40:4 (1986) 325-328.

For many years there has been much discussion regarding the appropriateness of "inspection" and "acceptance sampling" as tools for quality and productivity. This expository article collects and attempts to put into perspective some of the main points of controversy regarding those techniques.

VARDEMAN, Stephen B. Comment on "Reconciling Bayesian and frequentist evidence in the one-sided testing problem" by George Casella and Roger L. Berger and "Testing a point null hypothesis: The irreconcilibility of P-values and evidence" by James O. Berger and Thomas Sellke. *Journal of the American Statistical Association* 82:1 (1987) 130-131.

VARDEMAN, Stephen, and John A. Cornell. A partial inventory of statistical literature on quality and productivity through 1985. *Journal of Quality Technology* 19:2 (1987) 90-97.

In 1984 the American Statistical Association established a Committee on Quality and Productivity. The Publications Subcommittee of that group adopted as one of its tasks the inventory of existing statistical literature on quality and productivity. This article is a partially annotated bibliography produced as a result of that effort.

Book Reviews, Etcetera

CRESSIE, Noel. *Spatial Data Analysis by Example—Volume I: Point Pattern and Quantitative Data,* by Graham Upton and Bernard Fingleton. Chichester, U.K.: John Wiley, 1985, xi + 410 pp., $56.00. Reviewed in *Technometrics* 29:1 (1987) 114-116.

Bendre, S. M., and **B. K. KALE** (University of Waterloo, Ontario, Canada). Correction: Masking effect on tests for outliers in exponential samples.

Journal of the American Statistical Association 81:396 (1986) 1132.

LORENZ, Frederick. *Applied Linear Statistical Models* (2nd edition) by John Neter, William Wasserman, and Michael H. Kutner. Homewood, IL: Richard D. Irwin, 1985. xx + 1127 pp. $43.95. Reviewed in *Journal of the American Statistical Association* 81:396 (1986) 1126-1127.

MEEDEN, Glen. *Testing Statistical Hypotheses: Worked Solutions*. W. C. M. Kallenberg, J. Beirlant, P. Van Blokland, J. J. Dik, P. J. M. M. Does, A. J. Van Es, R. D. Gill, P. L. J. Janssen, P. J. Kallenberg, C. A. J. Klaassen, E. Opperdoes, C. Van Tutten, B. F. Schriever, M. Vandemaele, and C. J. Warmer. Amsterdam: Mathematisch Centrum, 1984. iii + 310 pp. Dfl. 45.10. Reviewed in *Journal of the American Statistical Association* 81:395 (1986) 860.

MEEKER, William Q., Jr. *Applied Statistics Algorithms,* edited by P. Griffiths and I. D. Hill, Chichester, U.K.: Ellis Horwood, 1985, 307 pp., $54.95. Reviewed in *Technometrics* 28:3 (1986) 278-279.

Relaxing at the Spring Breakfast, L to R: Fred Hulting, Jonathan Biele, Victor Brescia, and Martin Grondona.

Thesis Abstracts

Abdurachman, Edi. Processes with delays. Ph.D. thesis, Iowa State University Library. December 1986.

A semi-Markov process X(t) may be viewed as constructed from a two-dimensional process $\{J_n,W_n\}$ with

$$X(t) = J_{N(t)} \qquad (1a)$$

where $$N(t) = \sup\{n: \Sigma_{i=1}^{n} W_i \leq t\}. \qquad (1b)$$

Here $\{J_n\}$ is a discrete-state Markov chain describing the succession of visited states, and $\{W_n\}$ is a process describing the succession of times spent in these states, with the W_n independent conditionally on realizations of $\{J_n\}$.

The limiting state distribution of a semi-Markov process is attractively structured in terms of the limiting distribution of $\{J_n\}$ and the expectations of the residence times W_n.

In this dissertation certain generalizations of semi-Markov processes (here called "Delay processes") are constructed as in (1), but with $\{J_n\}$ not necessarily a Markov chain and the W_n not necessarily conditionally independent, by expanding on a certain previously suggested elementary ergodic argument.

The above-mentioned attractive limiting structure can essentially be maintained for Delay processes if attention is focused on "essentially finite" state spaces in the sense of requiring a finite expected number of distinct visited states, and if distributional convergence is demanded in only the Cesaro sense.

Two examples of Delay processes are given, for the first of which $\{J_n\}$ is not Markov of any order, with a state space containing only two points; for the second example, which treats an "inventory position process" in the "lost sales case," $\{J_n\}$ is not an ergodic Markov chain and the W_n are not conditionally independent.

Finally, a sense is also given in which a Delay process is "close enough" to a semi-Markov process for ordinary, as opposed to Cesaro, convergence to apply.

Farmer, Charles Milton. A study of nonadditivity in factorial experiments. Ph.D. thesis, Iowa State University Library. December 1986.

Suppose that d experimental treatments, each at a number of levels, are applied to a group of subjects in such a way that each treatment combination is assigned to one, and only one, subject. This is the makeup of a factorial experiment. If the assignment of treatment combinations to subjects is random, standard techniques have long been available for examining the effects of differing levels within a treatment. In this thesis we seek a technique for examining the effects of differing combinations of levels between treatments.

For the simplest case, that of two treatments (or factors), we describe a number of techniques: some based on mathematical models, and some based on the rank of a matrix. We extend these techniques to the case where not all levels of one of the treatments are used, but only a random sample of levels. We also supply a procedure for choosing the appropriate technique.

When more than one response variable is measured on each subject, the problem becomes a bit more complicated, since these variables may well be correlated. However, we are still able to provide a partial solution to the above problem.

The case of three treatments, which, when solved, should suggest a general technique, is also examined here. Although by no means a complete solution, the

techniques described present a solid basis for further study.

Loubert, Sharon Kay. Inference procedures for the piecewise exponential model when the data are arbitrarily censored. Ph.D. thesis, Iowa State University Library. December 1986.

Lifetime data are often subject to complicated censoring mechanisms. In particular, point inspection schedules result in observations for which the exact failure times are known only to fall in an interval. Furthermore, overlapping intervals occur when more than one inspection schedule is employed.

While well-known parametric and nonparametric inference procedures exist, the piecewise exponential (PEX) model provides a flexible alternative. The PEX model is characterized by a piecewise-constant hazard function with specified jump points. The jump points may be determined as a function of the data, giving the model a nonparametric interpretation, or according to physical considerations related to the process but independent of the data. Assumptions concerning the shape of the hazard function can be incorporated into the model.

The EM algorithm provides a useful method of estimation, particularly as the number of hazard jump points increases. Its convergence is guaranteed even when the MLE lies on the boundary of the parameter space.

A version of the EM algorithm is used to construct approximate confidence intervals based on inverting the likelihood ratio test statistic. Asymptotic properties of the PEX estimator are given for certain censoring mechanisms. A Monte Carlo study was done to investigate the effect of a constrained hazard function and of the choice of jump points on the resulting estimate of the survival function. The performance of the likelihood-ratio-based confidence intervals is also evaluated.

Stephen Mitchell Miller. The limiting behavior of residuals from measurement error regressions. Ph.D. thesis, Iowa State University Library. December 1986.

Multivariate measurement error regression models with normal errors are investigated, and residuals, analogous to those of ordinary least squares, are defined. The limiting behavior of test statistics based on the residuals is determined.

The residuals, properly standardized, are represented as a linear combination of two independent random vectors. This representation is used to show that the empirical process based on the standardized residuals converges to a unique Gaussian process, where the limit process is that of a normal sample standardized with estimated mean and variance. It is shown that many goodness-of-fit tests for normality based on the standardized residuals have the same limiting distribution as that of tests based on a sample of iid normal random vectors.

Tests for outliers, for autocorrelation, and for homogeneity of variance are investigated. A test for autocorrelation is constructed by regressing the residuals on their lagged values and testing for zero coefficients. A test for homogeneity of variance is constructed by regressing the squared residuals on estimated values of the true independent variables and testing for zero coefficients. It is shown that the regression t-statistics and F-statistics for the autocorrelation test and for the homogeneity test converge to N(0,1) and chi-square random variables, respectively.

Monte Carlo studies are conducted to examine the adequacy of the asymptotic approximations in small samples. The large sample approximations are judged adequate even for models with only twenty degrees of freedom.

Neerchal Kashiviswanath Nagaraj. Estimation of stochastic difference equations with nonlinear restrictions. Ph.D. thesis, Iowa State University Library. December 1986.

Let the parameters of the stochastic difference equation

$$Y_t = \Sigma_{t=1}^{q} \alpha_i \psi_{ti} + \Sigma_{j=1}^{p} \gamma_j Y_{t-j} + e_t \qquad (1)$$

satisfy

$$\mathbf{f}(\eta) = \mathbf{0}, \qquad (2)$$

where $\mathbf{f}(\eta)$ is a continuous, twice differentiable function of η that takes values in r-dimensional Euclidean space, $r \leq q + p$, and $\eta = (\alpha_1, \ldots, \alpha_q, \gamma_1, \gamma_2, \ldots, \gamma_p)'$. It is assumed that $\{\psi_{ti}, i = 1,2, \ldots, q\}$ are independent of the error process $\{e_t\}$. The model described by (1) and (2) contains a wide class of regression models used in practice. One example is the ordinary regression model with errors that follow a stationary or a nonstationary autoregression.

Asymptotic properties of the least squares estimator of η constructed subject to the restrictions (2) are derived. In the derivation, the sums of squares for different ψ_{ti} are permitted to increase at different rates as the sample size increases. The asymptotic results justify use of the usual regression statistics for inference about the parameter vector η. Models where the theory is applicable are discussed.

The results of a Monte Carlo experiment comparing several estimation procedures are reported. The model for the experiment is a regression model with two regressors, one a random walk and one a sequence of normal independent random variables. The error process is a first-order autoregressive process. Therefore $\eta' = (\alpha_1, \alpha_2, \gamma_1) = (\underline{\alpha}', \gamma_1)$.

The empirical variance of the nonlinear least squares estimator of $\underline{\alpha}$ and the empirical variance of the generalized least squares estimator of $\underline{\alpha}$ based on the true value of the first-order autocorrelation coefficent γ_1 are compared. The ratio of the empirical variance of the nonlinear least squares estimator of $\underline{\alpha}$ to that of the generalized least squares estimator of $\underline{\alpha}$ varies from 0.98 to 1.48 for samples of size 25 and from 0.98 to 1.26 for samples of size 100. The empirical percentiles of the "t-statistics" are compared to the percentiles of the corresponding limiting distributions. The study indicates that, if the parameter

of the error process is very close to the stationarity boundary, a larger sample size is required for the approximations to work well than if the parameter is close to zero.

Schnell, Daniel James. Estimators for the nonlinear errors-in-variables model. Ph.D. thesis, Iowa State University Library. May 1987.

Let an observed random vector $\mathbf{Z}_t$ be represented as $\mathbf{Z}_t = \mathbf{z}_t^0 + \underset{\sim}{\varepsilon}_t$, where $\mathbf{z}_t^0$ is a fixed unobservable true value and $\underset{\sim}{\varepsilon}_t$ is a stochastic measurement error. According to the nonlinear functional measurement error model, the true values $\mathbf{z}_t^0$ are assumed to satisfy the nonlinear relation $f(\mathbf{z}_t^0; \underset{\sim}{\beta}^0) = 0$, where $\underset{\sim}{\beta}^0$ is a fixed but unknown vector of parameters. The measurement errors are assumed to be independently distributed with zero mean and covariance matrix $\underset{\sim}{\Sigma}_{\varepsilon\varepsilon} = \sigma^2 \underset{\sim}{T}_{\varepsilon\varepsilon}$, where σ^2 is a positive scalar and $\underset{\sim}{T}_{\varepsilon\varepsilon}$ is a fixed positive definite matrix.

Under the model, maximum likelihood estimators of $\underset{\sim}{\beta}^0$ and $\{\mathbf{z}_t^0\}$ can be constructed for a given value of $\underset{\sim}{T}_{\varepsilon\varepsilon}$. Properties of estimators of $\underset{\sim}{\beta}^0$ and $\{\mathbf{z}_t^0\}$ are presented for correctly specified $\underset{\sim}{T}_{\varepsilon\varepsilon}$ and for $\underset{\sim}{T}_{\varepsilon\varepsilon}$ misspecified.

A weighted least squares estimator for $\underset{\sim}{T}_{\varepsilon\varepsilon}$, which uses the model residuals, is presented. The estimator of $\underset{\sim}{T}_{\varepsilon\varepsilon}$ is shown to be consistent and asymptotically normally distributed for a sequence in which the sample size becomes larger and σ^2 becomes smaller as the index of the sequence increases. A test of specification for $\underset{\sim}{T}_{\varepsilon\varepsilon}$ is constructed using the least squares estimator of $\underset{\sim}{T}_{\varepsilon\varepsilon}$. The limiting behavior of the test statistic is derived, and the test is investigated in a Monte Carlo study.

A second estimator of $\underset{\sim}{t}_{\varepsilon\varepsilon}$ is derived by the method of maximum likelihood, assuming normally distributed measurement errors. The maximum likelihood estimator is shown to be consistent, and its limiting distribution is derived. A likelihood ratio test for correct specification of $\underset{\sim}{T}_{\varepsilon\varepsilon}$ is introduced, and its limiting behavior is discussed.

Zimmerman, Dale Lee. A random field approach to spatial experiments. Ph.D. thesis, Iowa State University Library. December 1986.

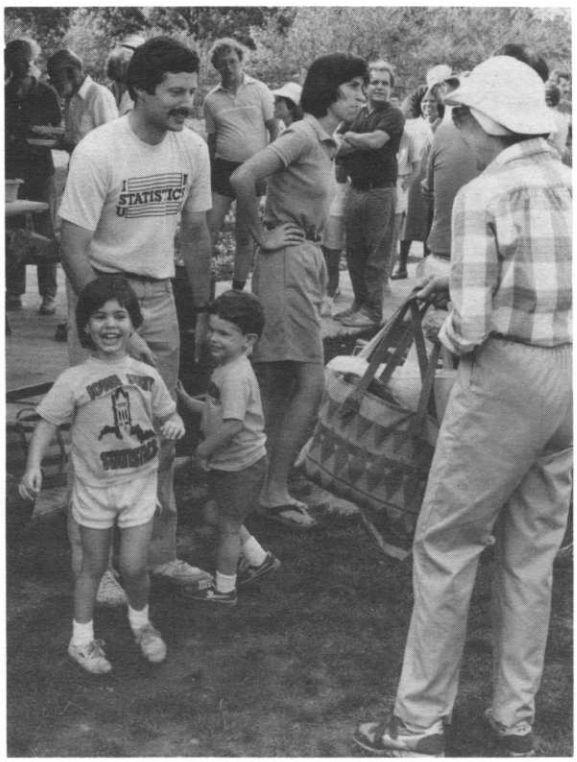
A spatial experiment is a comparative experiment in which the experimental units are distributed throughout a region in d-dimensional Euclidean space. The classical analysis of variance of such an experiment ignores spatial correlation among the responses. An alternative approach to the analysis of spatial experiments is proposed that does not ignore spatial correlation. In this approach, the outcome of a spatial experiment is regarded as a single realization of a collection of random variables indexed by points in d-dimensional Euclidean space. Such a collection of random variables is called a random field.

In conjunction with this approach, we adopt the linear model $\underset{\sim}{y} = X\underset{\sim}{\beta} + \underset{\sim}{e}$, where $\underset{\sim}{y}$ is an $n \times 1$ random vector whose elements are observable members of a d-dimensional random field $\mathcal{F}_Y = \{Y_{\underset{\sim}{s}}: \underset{\sim}{s} \in \mathbb{R}^d\}$, $\underset{\sim}{e}$ is an $n \times 1$ random vector whose elements are unobservable members of a random field $\mathcal{F}_Z = \{Z_{\underset{\sim}{s}}: \underset{\sim}{s} \in \mathbb{R}^d\}$ satisfying $E\{Z_{\underset{\sim}{s}}\} = 0$ for all $\underset{\sim}{s} \in \mathbb{R}^d$, X is an $n \times p$ matrix whose elements are functions of $\underset{\sim}{s}$, and $\underset{\sim}{\beta}$ is a $p \times 1$ vector of unknown parameters.

The elements of the covariance matrix V of $\underset{\sim}{e}$ are given by evaluating a generally nonlinear function $C(\cdot,\cdot;\underset{\sim}{\theta})$ of 2d variables, where $\underset{\sim}{\theta}$ is an $m \times 1$ vector of unknown parameters, at the sites where $\mathcal{F}_Y$ is observed. This function is called the covariogram of $\mathcal{F}_Y$. We refer to this model as the random field linear model (RFLM).

The estimation of the RFLM parameters $\underset{\sim}{\beta}$ and $\underset{\sim}{\theta}$ by maximum likelihood approaches is studied extensively. The estimation procedures are generally quite burdensome computationally; however, certain features of the RFLM can, in many cases, be exploited to reduce the amount of computation. The required amount of computation is primarily related to the structure of V. This, in turn, is greatly affected by the spatial configuration of the sites at which $\mathcal{F}_Y$ is observed and by properties of the covariogram of $\mathcal{F}_Y$. Also investigated are conditions under which the estimators of $\underset{\sim}{\beta}$ and $\underset{\sim}{\theta}$ are consistent and asymptotically normal.

Estimation of treatment contrasts in a spatial experiment is of major interest. Results from "pseudo-experiments" based on uniformity trial data suggest that the random field approach is superior to the classical analysis of variance and to several recently proposed "nearest-neighbor" methods.



Ken Koehler's daughter sports this year's T-shirt while Ken wears an older model. The design for the new shirt, based on a current campus logo, was suggested by Steve Crowder. Iowa STAT-ers and the undergraduate Statistics Club ordered and sold T-shirts to help support their activities.

Department of Statistics

In the spring the State Board of Regents approved a program leading to the degree of Master of Science in Operations Research as a joint offering by the departments of Statistics and Industrial Engineering. This is the culmination of years of cooperation between the two departments that has already led to a number of graduate degree programs in operations research completed through joint major programs in statistics and industrial engineering or engineering valuation.

The Department of Statistics continues to offer courses leading to the degrees Bachelor of Science, Master of Science, and Doctor of Philosophy with major in statistics. These degrees are conferred by the College of Sciences and Humanities and the Graduate College. In addition, the department administers the undergraduate curriculum in biometry leading to a B.S. degree conferred by the College of Agriculture. The curriculum has two options: biostatistics and information management.

Degree candidates in statistics or biometry may choose to receive the degree jointly with another department. Computer science is most often chosen at the undergraduate level for a co-major. A joint major is not a frequent choice at the graduate level but does represent a way to add depth in areas of application.

An M.S. candidate in statistics may choose either a thesis or a nonthesis option. The latter requires completion of four additional credits, including a creative component representing at least two credits of independent work. The doctoral program is research-oriented and requires completion of a dissertation based on independent, creative work.

Graduate students may specialize in probability, general theory, general methods, linear models, experimental design and analysis, survey design and analysis, statistical computing, operations research, or an area of application such as biostatistics, genetic statistics, psychometrics, econometric statistics, or industrial and engineering statistics. More information appears in the departmental brochure, "Iowa State University—Graduate Program in Statistics, August 1987," available upon request.

Two courses were offered off-campus during the year. William J. Kennedy taught Stat 227, Introduction to Business Statistics, in West Des Moines from September 10 to November 12 as part of the university's off-campus extension credit program. Mack Shelley taught a section of Stat 401, Statistical Methods for Research Workers, at the IDS-Urbandale Extension Office in the spring, mainly for mid-career professionals in the Des Moines area.

At the graduate level, a special topics course on The Method of Paired Comparisons was offered by H. A. David for one credit during the fall. The course was based on David's Griffin monograph, which has now been revised.

A three-credit experimental course on Statistical Methods for Counts and Proportions was offered by Kenneth J. Koehler in the 1987 summer term. Statistical methods commonly used to analyze discrete data, such as log-linear models and quantal response models, were introduced. The course included illustrations showing how the analyses may be performed with software packages like SAS and BMDP. Large sample properties of maximum likelihood and generalized least squares estimators were reviewed, with some extensions to complex problems involving construction of computer programs.

With the increased emphasis on biotechnology, Stat 535, Biological Statistics, received more student interest. A feature of the course is the presentation and discussion of student seminars. Since both statistics graduate students and students actively engaged in biological research took part, the discussion ranged widely over statistical, biological, and technical aspects of biological assessments, especially their interactions.

Our interest in biotechnology goes beyond the use of statistical applications. Mack Shelley has been appointed a member of the university's Bioethics Committee, which operates through the Graduate College with funding from the Iowa legislature. He is co-chair of a subcommittee examining the impact of funding for biotechnology research at ISU.

Again the major effort in undergraduate teaching of statistics was in the teaching of service courses for students with majors other than statistics. During the academic year, 2,694 students enrolled in Stat 101, 104, 105, 227, and 231. Among *all* enrollments in statistics courses, 70.7 percent were in 100-300 level courses. This percentage has remained fairly constant over the past five years.

At the request of the College of Business Administration, the Department of Statistics introduced Stat 201, Applied Regression Analysis for Business, as an experimental course in the fall semester. This will be given as a regular two-credit course starting in fall 1987. Its purpose is to provide background, in applied multiple regression analysis, the analysis of variance, model building, and time series, not generally included in most three-credit business statistics courses. The new course will be particularly useful for transfer students who have had a three-credit introductory statistics course at another institution.

The number of undergraduate majors reached a high in the 1987 spring term of 53, i.e., 49 majoring in statistics (including joint majors) and four in the biometry program.

Course offerings for the 1986-87 academic year and the 1987 summer session are listed below.

1986-87 Course Offerings in Statistics

Courses for Undergraduate Students Only

100	Orientation in Statistics and Biometry	R	F	Stephenson
101	Principles of Statistics	4	F,S Beam Dombek	 Stephenson Strahan
104	Introduction to Statistics	3	F,S,SS Grau Hotchkiss Nelson	 Sukhatme Vander Wiel White
105	Introduction to Statistics	2	F,S Isaacson Nanayak-kara	 Vardeman
201x	Regression Analysis for Business	2	F	Nanayak-kara
227	Introduction to Business Statistics	5	F,S,SS Beam Busch Graf Kennedy Liedtke Medak	 Melander Moy Payton Roesler Vander Wiel Wettstein
231	Probability and Statistical Inference for Engineers	4	F,S Croos Hasab-El-Naby Homblé	 Meeden Sukhatme Yildirim
305	Engineering Statistics	3	S	Vardeman
328	Applied Business Statistics	3	F,S Kennedy	 Meeker
341	Introduction to Theory of Probability and Statistics	3	F,S Groeneveld Homblé	 Stephenson
342	Introduction to Theory of Probability and Statistics	3	S	Groeneveld

Courses for Graduate Minors and Undergraduates

401	Statistical Methods for Research Workers	4	F,S,SS Bailey C. P. Cox D. F. Cox Groeneveld Hickman Hotchkiss	 Lorenz Roberts Shelley Stephenson Wolins
402	Statistical Design and the Analysis of Experiments	3	F,S Hinz & D. F. Cox Hotchkiss	 Marasinghe Strahan
403	Nonparametric Statistical Methods	2	F	Groeneveld
404	Statistics for the Social Sciences	3	F	Lorenz
405	Applied Econometric Statistics	3	S	Hickman
407	Methods of Multivariate Analysis	2	F	Hinz
421	Survey Sampling Techniques	3	S	Reiser
436	Genetic Statistics for Research Workers	3	F	Bailey
446	Statistical Theory for Research Workers	2	F	Amemiya
447	Statistical Theory for Research Workers	4	S,SS	H. A. David Homblé
451	Applied Time Series	3	S	Meeker
480	Statistical Application of Digital Computers	3	F	Marasinghe
481	Computer Processing of Statistical Data	3	S	Marasinghe
490	Independent Study	Var	S,SS Hickman Meeker	 Reiser Stephenson

Courses Primarily for Graduate Students, Major or Minor

500	Statistical Methods	4	F	Koehler
501	Multivariate Statistical Methods	3	S	Koehler
511	Theory and Application of Linear Models	3	S	Amemiya
512	Design of Experiments	3	F	Harville
513	Response Surface Methodology	3	S	Harville
521	Theory of Sample Surveys I	3	S	Battese
531	Statistics for Quality and Productivity	3	S	Vardeman
534	Ecological Statistics	2	S	Pollak
535	Biological Statistics	2	S	C. P. Cox
538	Econometric Statistics	3	F	Fuller
539	Game Theory	3	F	H. T. David
540	Operations Research Methods and Economic Analysis	3	S	Sposito
542	Theory of Probability and Statistics	3	F	H. A. David
543	Theory of Probability and Statistics	3	S	Cressie
546	Theory of Nonparametric and Asymptotic Methods	3	S	Sukhatme
557x	Statistical Methods for Counts and Proportions	3	SS	Koehler

579	Introduction to Computer Hardware and Software Systems for Statistical Computing	1	F	Kennedy & Marasinghe
580	Statistical Computing	3	F	Kennedy
590A	The Method of Paired Comparisons	1	F	H. A. David
590B	Special Topics: Methods	Arr	S,SS Hinz Hotchkiss	 Meeker Sacks
599	Creative Component	Var	F,S,SS Cressie H. A. David H. T. David Hinz Kennedy Koehler Lorenz	 Marasinghe Meeker Pollak Reiser Sacks Sposito Stephenson

Courses for Graduate Students, Major or Minor

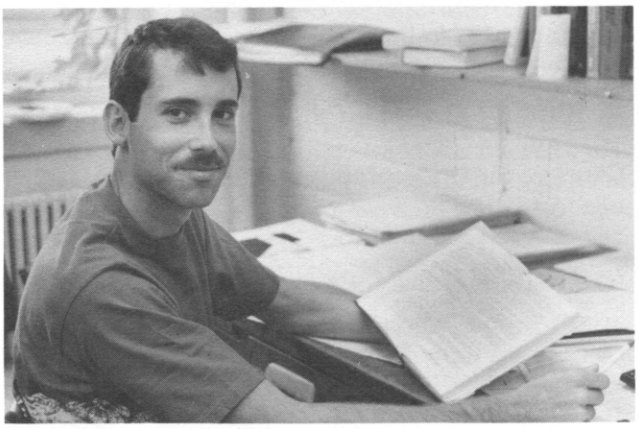
611	Advanced Linear Model Theory	3	F	Kempthorne
639	Stochastic and Abstract Programming	3	SS	Sposito & H. T. David
642	Measure Theory and Probability	3	S	Meeden
643	Theory of Estimation and Testing of Hypothesis	3	F	Cressie
647	Multivariate Analysis	3	F	Amemiya
699	Research	Var	F,S,SS Athreya Cressie H. A. David H. T. David Fuller Harville Hinz	 Kennedy Koehler Marasinghe Meeden Meeker Sposito Vardeman

Graduate Students

Seven Ph.D.degrees and 16 M.S. degrees were granted in the Department of Statistics during the fiscal year. Graduate College Research Excellence Awards were given to Stephen Miller and Dale Zimmerman at commencement in December. These awards recognize research accomplishments demonstrated by completion of outstanding dissertations. Each award consisted of $300, a letter of commendation from President Eaton, a certificate of achievement, and special recognition.

All of the masters' degrees were conferred on a nonthesis basis, with candidates completing creative components based on independent study. Abstracts of Ph.D. dissertations appear in the Publications Section.

Names of graduate degree recipients, with names of major professors, time of graduation, and employment or educational decisions, are given below. An asterisk signifies that the student has chosen to remain at Iowa State to work toward a doctorate in statistics.



Research excellence awards went to Dale Zimmerman (pictured) and Stephen Miller for their doctoral research.

M.S. Recipients

Danyal bin Abdul Malik (Spring 1987; Frederick Lorenz) returned to his position as statistician in the Statistics Department, Government of Malaysia, in Kuala Lumpur.

Cai Yilin (Fall 1986; Paul N. Hinz) returned to the People's Republic of China to teach as lecturer at Southwest Agricultural University, Chongqing, Sichuan.

***Michael Ray Carley** (Spring 1987; William J. Kennedy).

***Alicia Laura Carriquiry** (Fall 1986; David A. Harville).

***Brian Keith Cranford** (Fall 1986; Stephen B. Vardeman).

Kimberly Erland (Summer 1986; Stephen B. Vardeman) joined Pratt & Whitney Division of United Technologies, West Palm Beach, Florida.

Kaisheng Fan (Spring 1987; Edward Pollak) is continuing graduate study at Iowa State University toward a doctorate in mathematics.

***Carol Anne Gotway** (Summer 1986; Noel A. C. Cressie).

***Renkuan Guo** (Summer 1986; Stephen B. Vardeman).

Joo-Hwan Kim (Fall 1986; Glen Meeden) began studies toward a doctorate in the Department of Mathematics and Statistics, University of New Mexico.

Charles Allen Liedtke (Spring 1987; Frederick Lorenz) joined Process Management Institute, Bloomington, Minnesota, as a statistical consultant.

***Heon Jin Park** (Spring 1987; Mark Reiser).

***Gary Robert Sullivan** (Summer 1987; William J. Kennedy).

***James Thomas Symanowski** (Fall 1986; Mervyn G. Marasinghe).

Kathleen Marie Taylor (Fall 1986; Mark Reiser) joined AT&T as supervisor in the Marketing Department, Basking Ridge, New Jersey.

Franklin Winters (Fall 1986; Mervyn G. Marasinghe) has been working as mathematical statistician and computer programmer in the Agriculture Division, U.S. Bureau of the Census.

Ph.D. Recipients

Edi Abdurachman (Fall 1986; Herbert T. David) returned to Indonesia to become a survey statistician, Indonesian Department of Agriculture, at the Centre for Agricultural Data Processing, AARD, in Jakarta.

Charles Milton Farmer (Fall 1986; Mervyn G. Marasinghe and David A. Harville) accepted a visiting assistant professorship in the Department of Statistics, University of Kentucky, for the 1986-87 academic year and now has a tenure-track position at James Madison University.

Sharon Kay Loubert (Fall 1986; William Q. Meeker, Jr.) joined Process Management Institute, Bloomington, Minnesota, as a statistical consultant in September 1986.

Stephen Mitchell Miller (Fall 1986; Wayne A. Fuller) began work at the U.S. Bureau of Labor Statistics in August 1986 as a mathematical statistician in the Division of Statistical Research & Evaluation, Office of Research and Evaluation, Washington, D.C.

Neerchal Kashiviswanath Nagaraj (Fall 1986; Wayne A. Fuller) joined the Department of Mathematics, University of Maryland-Baltimore County, in August 1986 as instructor and was promoted to assistant professor upon completion of his Ph.D. program.

Daniel James Schnell (Spring 1987; Wayne A. Fuller) remained in the Survey Section for approximately two months as a postdoctoral research associate, until beginning work as statistician in the U.S. Centers for Disease Control, Division of Sexually Transmitted Diseases, Atlanta, Georgia.

Dale Lee Zimmerman (Fall 1986; David A. Harville) accepted a position as assistant professor in the Department of Statistics and Actuarial Science, University of Iowa, beginning in August 1986.

M.S. Candidates

bin Abdul Malik, Danyal
Bearrood, Douglas
Brescia, Victor P.
Brown, Kimberly
Busch, Donna E.
Cai Yilin
Chien, Keng-tang
Chisolm, Barbara A.
Cho, Tae-Kyoung
Dombek, C. Janelle
Erland, Kimberly
Fagih, Abdullah Y.A.K.
Fan, Kaisheng
Fredolin Tangang @ Tajudin Mahmud
Freire, Clarice
Gau, Shiow-Lan
Goh, Jooi-Tow
Graf, Deanna L.
Grau, Eric A.
Grondona, Martin O.
Han, Geun-Shik
Huang, Mu-Yeh
Huang, Shu-Mei
Huang, Zhaofeng
Iversen, Philip W.
Johnson, Jane M.
Kim, Joo-Hwan
Kuo, Bojein
Lay, Alice S.
Lee, Kyung-Hee Ghang
Liedtke, Charles A.
Liou, Ge-Shean Albert
Liu, Shwu-Fen
Melander, Todd E.
Misambo, Barnabas M.
Morel, Grecia
Moy, Terry
Murphy, Dennis J.
Nelson, Teresa A.
Nusser, Sarah M.
Payton, Kathrina E.
Poggemann, Anne M.
Rathbun, Stephen L.
Roesler, Jill L.
Sabran, Muhamad
Salihima, Astini
Sayler, Mary E.
Schroeder, Darrell
Shamsuddin, Hussein
Steenhard, David
Su, Shiowlin
Taylor, Kathleen M.
Thompson, John C.
Vander Wiel, Scott
Vasconcelos, M. Katheleen
Wang, Kui-Jang William
Wang (Chu), Shaw-Ling
Wettstein, Susan A.
White, Susan E.
Williams, Eric R.
Winters, Franklin (in absentia)

Ph.D. Candidates

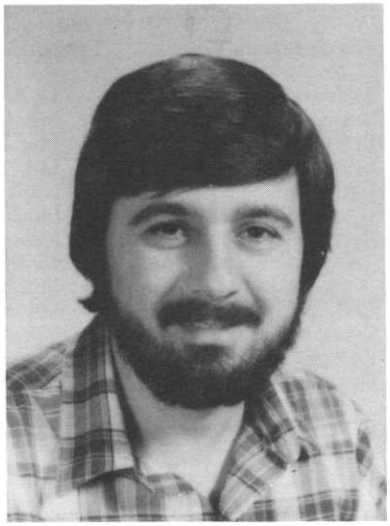
Abdurachman, Edi
Al-Mahmoud, Ahmad M. A.
Andrews, Douglas M.
Beam, Craig A.
Biele, Jonathan
Bryan, Mark F.
Carley, Michael R. (joint statistics-economics)
Carriquiry, Alicia (joint animal science-statistics)
Cranford, B. Keith
Croos, Joseph H. R.
Eltinge, John L.
Farmer, Charles M. (in absentia)
Francisco, Carol A.
Fuh, Cheng-Der (joint mathematics-statistics)
Funo, Eiichiro
Gotway, Carol A.
Guo, Renkuan
Ha, In Hye
Hasab-El-Naby, Nancy Eyink
Homblé, Patrick R.
Hong, Chong Sun
Hulting, Frederick
Jensen, Karen
Kang, Yoou-Jen
Kim, Song-Ho
Lasack, Paula M. (joint entomology-statistics)
Lee, Mong-Hong
Lemke, Klaus (joint statistics-economics)
Li, Seung-Chun
Lin, Chiou-Hua
Lin, Jyh-Shiun
Lin, Tsung-Hua Thomas
Loubert, Sharon K.
Lu, Chi-hsien Joseph
Masoud, Sami M. A.
Medak, Frederick M.
Miller, Stephen M.
Mingoti, Sueli A.
Morel, Jorge G.
Nagaraj, Neerchal K.
Nanayakkara, Nuwan
Park, Heon Jin
Sarkar, Sahadeb
Schnell, Daniel J.
Sriplung, Kai-One (joint economics-statistics)
Sullivan, Gary R.
Sung, Nae Kyung
Symanowski, James T.
Tirol, M. Bridget (joint industrial engineering-statistics)
Tollefson, Margot H.
Ver Hoef, Jay (joint botany-statistics)
Wang, Chung-Ching Morgan
Zakaria, Rahmat S. (joint statistics-industrial engineering)
Zimmerman, Dale L.

A number of students took off-campus internships for part of the year. Deanna Graf interned with Weyerhaeuser Company, Forest Paper Products, in Hot Springs, Arkansas, from January through May 1987. Scott Vander Wiel (June through December 1986) and Darrell Schroeder (June 1, 1987 on) worked at Process Management Institute, Bloomington, Minnesota.

Jonathan Biele and Susan Wettstein went to Mayo Clinic for the 1987 summer. Carol Gotway went to RAND Corporation, Santa Monica, California, June 1 on an internship with its Economics and Statistics Department to work on inventory control and reliability problems. Douglas Andrews joined Procter & Gamble, Cincinnati, Ohio, for the summer to work on paired comparisons.

Mu Sigma Rho

The Iowa Alpha chapter of Mu Sigma Rho was able to obtain William Cleveland of AT&T Bell Laboratories to present its annual lecture. His talk, entitled "Dynamic graphics for data analysis," featured a videotape of data analysis using interactive graphics. The large audience, consisting of students and faculty from a variety of disciplines, was also entertained by a short video of computer-generated animation. The growing interest in graphics was well served by this timely, accessible presentation. The lecture was co-sponsored by Iowa STAT-ers; the Statistics Club; the departments of Statistics, Mathe-



Statistical graphics expert William Cleveland gave the 1987 Mu Sigma Rho lecture.

matics, Computer Science, Economics, Industrial Engineering, and Art and Design; the Media Resources Center; and the university Committee on Lectures.

Cleveland is a leading figure in the area of statistical graphics. His research has looked not only at the development of graphical techniques but also at how graphs are perceived. His other research interests include regression analysis, local fitting, and time series analysis. He is the author of over 60 research publications, co-author of the book *Graphical Methods for Data Analysis,* and author of *The Elements of Graphing Data.*

Prior to the lecture on March 26, 23 members were initiated into Mu Sigma Rho at the annual banquet. These new members were graduate and undergraduate students from the Department of Statistics and other departments who had demonstrated ability in statistics courses.

Alicia Carriquiry and Keith Cranford received the Mu Sigma Rho award for outstanding contributions to the department.

Serving as faculty adviser for Mu Sigma Rho this year was W. Robert Stephenson. Karen Jensen was president, John Eltinge vice president, and Craig Kollman secretary-treasurer. Officers have not yet been elected for the 1987-88 academic year.

Iowa STAT-ers

The Iowa STAT-ers, a graduate statistics club open to all graduate students in the department, continued to be very active in 1986-87. Its main project was still the seminar series. Seven seminars were presented in the fall (by three out-of-town speakers, one faculty member from another ISU department, one statistics faculty member, and two students), and seven seminars in the spring (with one speaker from out-of-town, one faculty member in statistics and one from another ISU department, two student speakers, and two ASA video tapes). Support from the Department of Statistics is evidenced through a permanent budget assigned to the STAT-ers seminar series. These seminars have consistently had a large attendance, both from Statistics and from other departments.

Activities this past year included the ISU Statistics t-shirt sale in the fall, which brought extra money to the STAT-ers treasury, and an update of the picture directory identifying statistics faculty, staff, and students. The new directory was a joint effort by Eiichiro Funo, Anne Poggemann, and Douglas Andrews, who did the picture taking, layout, and typesetting, respectively. The department contributed financially.

Money obtained from t-shirt sales and dues was used to finance both academic activities (such as seminars) and social activities. This year the STAT-ers brought back the Winter Party, an old Department of Statistics tradition. Social chairs Kathy Payton and Teresa Nelson were responsible for organizing and getting everything together. Other social activities were the beginning- and end-of-the-year pizza parties.

The university Government of the Student Body allocated funds to the STAT-ers that was spent on the seminar series and on books donated to the Statistics Reading Room.

Officers for the year were Alicia Carriquiry, president; Sarah Nusser, vice president; Keith Cranford, treasurer; and Jill Roesler, secretary. John Eltinge was the student representative at faculty meetings. Offices were modified so that, starting in 1986, the vice president occupies the seminar chair. Kenneth J. Koehler serves as faculty adviser to Iowa STAT-ers.

T. A. Bancroft Award

Alicia Laura Carriquiry was chosen to receive the 1987 T. A. Bancroft Award in March. This award is given for outstanding performance as a doctoral candidate with either a joint major in statistics and another field or a minor in statistics. Carriquiry has a joint major program in animal science and statistics.

Carriquiry received the degree of Ingeniero Agronomo in animal science and agronomy from the Universidad de la Republica, Montevideo, Uruguay, in 1982. Between 1980 and 1982 she had taught animal breeding at Jackson Agricultural School and worked as an extension officer at the National Institute of Settlement in Uruguay. She completed a master's program in animal science at the University of Illinois, Champaign/Urbana, receiving the degree in 1985 after having begun studies for a doctorate at Iowa State. Carriquiry elected to complete a full master's program in statistics here and is continuing with the joint Ph.D. program.

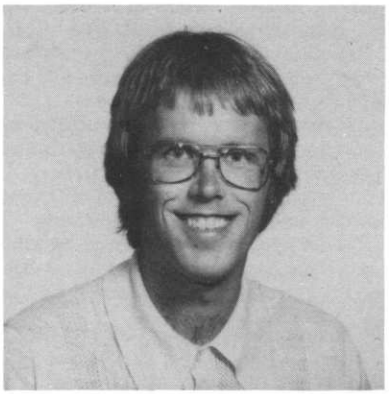
Under her assistantship she has been active as part of the statistical consulting group working with experiment station researchers. She has published, presented papers, and given seminar talks based on her work at the University of Illinois and in Uruguay. Last summer she taught a combined agriculture-and-engineering oriented section of Stat 401, Statistical Methods for Research Workers. Currently she is

working under David Harville's Office of Naval Research grant.

The Bancroft award consists of a cash prize and a subscription to a statistically-oriented journal. It honors the late T. A. Bancroft, former director and head of the Statistical Laboratory and Department of Statistics.

No George W. Snedecor Award was given this year.

George Zyskind Memorial Lecture



COPSS Award winner James O. Berger gave this year's Zyskind lecture.

The twelfth George Zyskind Memorial Lecture was presented by James O. Berger on October 7, 1986. Berger is Richard M. Brumfield Distinguished Professor of Statistics at Purdue University. He spoke on the topic "Bayesian analysis: Myths and reality."

Berger received the prestigious COPSS Award in 1985, an annual award given to an outstanding statistician under the age of 40. He has primary interests in Bayesian statistics and decision theory. Berger is author or co-author of a well-respected book on *Statistical Decision Theory,* monographs, and numerous papers.

The Zyskind lecture series honors the late George Zyskind, professor of statistics at ISU from 1959 to 1974. While here, Berger also gave a seminar talk in the regular Statistical Laboratory series.

Undergraduates

Undergraduate majors in statistics received a number of recognitions and awards during the academic year. Mary Anne Dellva was chosen as a member of Lampos, the Sciences and Humanities honorary society, during the fall term. She also received recognition as the Outstanding Ames Area Collegiate Sorority Woman during the spring term. Dellva, Julie Haubrick, Scott Kongable, Jeffrey Larson-Keller, and David Steenhard were initiated into membership in Mu Sigma Rho at the annual banquet in March.

At the annual Scholarship Recognition Dinner on April 20, 1987, sophomores Rochelle Milbrath, Kathy Jenkins, and Barbara North were recognized as standing in the top two percent of their class. Dellva was recognized similarly, as a junior, at the April 21 banquet. On April 26, another junior, Craig Kollman was initiated into Phi Beta Kappa. During a chartering reception, the Golden Key National Honor Society at ISU inducted David Steenhard.

Twelve students received B.S. degrees in statistics during the period July 1, 1986 to June 30, 1986. Three of these had joint majors. Names and employment or study plans, when definite, follow.

Azizah R. Ahmad (Spring 1987, statistics) has been accepted for graduate study in mathematics by West Virginia University.

Randy John Bartlett (Fall 1986, computer science and statistics) is working in statistical software development as an associate statistical support specialist with STSC, Inc., Rockville, Maryland.

Erik John Field (Spring 1987, statistics and economics) has joined the Quality Assurance Department of IBM in Boca Raton, Florida.

Brian D. Gregory (Spring 1987, economics and statistics) accepted a position in the U.S. Bureau of the Census beginning in August 1987.

Scott James Groth (Fall 1986, statistics) is a statistical analyst, Marketing Statistics Research Department, A. C. Nielsen Company, Northbrook, Illinois.

Mitchell Rex Hoppenworth (Spring 1987, statistics).

Gail Marie Lien (Spring 1987, statistics) has also joined A. C. Nielson, as a junior statistician.

Jae P. McKeown (Spring 1987, statistics) plans to work toward a master's degree in statistics at Iowa State University.

Ellen Marie Merfeld (Spring 1987, statistics) is a research assistant at the Midwest Research Institute, Kansas City, Missouri.

Robert Scott Plager (Spring 1987, statistics).

David Darrel Steenhard (Spring 1987, statistics) is continuing his studies in statistics at Iowa State University under a graduate assistantship.

Ted Arthur Tatone (Spring 1987, statistics) has accepted a position as quality engineer with NOK in LaGrange, Georgia. This is the American subsidiary of a Japanese firm that manufactures oil seals.

Kathy A. Jenkins, a junior statistics major, is working for a six-week period in summer 1987 in a paid internship program for women in science and engineering. This program is supported through the university's Office of Academic Affairs. She is working with a professor in the Department of Veterinary Anatomy on a project involving statistical image processing via a graphics terminal.

Statistics Club

For the Statistics Club, 1986-87 was a busy year with many activities and speakers. Functions sponsored by the club are aimed at promoting interest in the field of statistics among undergraduates.

The events began in September with a presentation by representatives of the Management Systems Division of Procter & Gamble, Cincinnati, Ohio. The presentation focused on the division's activities and how people with quantitative backgrounds fit in.

Eli Lilly and Company sponsored a careers night for students interested in pursuing computer-related careers. Several undergraduate statistics majors had a chance to discuss career opportunities and to participate in mock interviews.

The STAT CLUB FAC & pizza party in November gave club members a chance to meet each other and enjoy pizza and beverages provided by the club.

In December Cathryn Dippo of the U.S. Bureau of Labor Statistics, Washington, D.C., visited Iowa State. In addition to conducting job interviews, she made a presentation to the club. She covered careers with the federal government in general and the Bureau of Labor Statistics in particular.

The spring semester started off with an early February meeting to plan upcoming events. Also in February, representatives from Electronic Data Systems (EDS) gave a presentation on "Trends in information processing." A campus recruiting brochure used by EDS features former undergraduate statistics major Wendy Iverson.

The major spring event was a field trip to St. Paul, Minnesota, to visit 3M Corporation. On April 24, a group of seven undergraduate statistics majors and the club's faculty adviser visited 3M's Statistical Consulting group. On the following day they visited the Industrial Specialties Division and toured the tape production plant.

Elections were held in May. The 1987-88 officers are:

president: Michael Stamp
vice president: Kathy Jenkins
treasurer: Glenn DesJardins
secretary: Diane Hamilton.

Julie Haubrich and Craig Kollman were chosen as co-recipients of the 1987-88 Statistics Club Award. W. Robert Stephenson serves as faculty adviser to the club.

Seminars

The series of regular weekly noncredit seminars offered by the Statistical Laboratory and the Department of Statistics during the 1986-87 year was planned by Noel Cressie, Mark Reiser, and Dean Isaacson.

Statistical Laboratory Seminars

Summer 1986

July 9 The limiting behavior of residuals from measurement error regressions. Stephen M. Miller

16 Convergence in total variation of sample extremes. Ishay Weissman, Technion—Israel Institute of Technology

21 Robust empirical Bayes estimation in finite population sampling. Malay Ghosh, Department of Statistics, University of Florida

23 Inference procedures for the piecewise exponential model when the data are arbitrarily censored. Sharon Loubert

28 A random field approach to spatial experiments. Dale Zimmerman

30 A study of nonadditivity in the two-way classification with no replication. Charles M. Farmer, Department of Statistics, University of Kentucky

August 4 Design of experiments to estimate multivariate genetic parameters. Robin Thompson, A.F.R.C. Animal Breeding Research Organization, University of Edinburgh, Scotland

Fall 1986

September 3 T. A. Bancroft: The builder of the present-day Stat Lab. Oscar Kempthorne

10 Latent trait and correlation models with indicators of mixed measurement level. Gerhard Arminger, Bergische Universitat Wuppertal, Federal Republic of West Germany (co-sponsored by the departments of Economics and Sociology and Anthropology)

12 An optimal closed adaptive sequential procedure for selecting the Bernoulli population which has the largest probability. Robert E. Bechhofer, Cornell University School of Operations Research and Industrial Engineering

19 History of selection and some recent results. C. R. Henderson, Department of Animal Science, Cornell University (co-sponsored by the Iowa STAT-ers)

24 The Inter-University Consortium for Political and Social Research: A social science data archive. Mack C. Shelley II

October 1 Entropy. Arnold Faden, Department of Economics, Iowa State University

8 Testing precise hypotheses: Are error probabilities reasonable measures of accuracy? James Berger, Department of Statistics, Purdue University

15 Time series and structural methods of estimating supply response for agricultural commodities. Stanley R. Johnson, Center for Agricultural and Rural Development, Iowa State University

22 Quick simultaneous confidence intervals for multinomial proportions. Alistair J. Scott, Department of Mathematics and Statistics, University of Aukland, New Zealand, and Department of Statistics, University of Wisconsin-Madison

29 Estimation for stochastic difference equations with parameters satisfying nonlinear restrictions. Neerchal K. Nagaraj, Department of Mathematics, University of Maryland-Baltimore County

November 5 Estimation of quantiles and the interquartile range in complex surveys. Carol Ann Francisco, Syntex Labs, Palo Alto, California

12 Processes with delays. Edi Abdurachman

19 Ranking from unbalanced paired-comparison data. H. A. David

December 3 Empirical distribution functions and power of some rank tests. Shashikala Sukhatme

10 Understanding undercount in the decennial census. Noel A. C. Cressie

Spring 1987

January 14 On the teaching and practice of Statistics. C. Philip Cox

21 Time series and measurement error models. John Eltinge

28 Statistical estimation of parameters of the three-parameter Weibull distribution. Fetih Yildirim

February 4 Statistical consulting in 2033 A.D. David F. Cox

11 Multivariate nonlinear models for vectors of proportions: A generalized least squares approach. Jorge G. Morel

18 Nested multinomial logit models of death-sentencing data: The Georgia experience. George Woodworth, Department of Statistics and Actuarial Science, University of Iowa

23 Smooth estimates of mixture distributions. Ian Harris, Department of Statistics, University of Birmingham, Birmingham, England

25 Point process modeling of temporal rainfall. Efi Foufoula-Georgiou, Department of Civil Engineering, Iowa State University

March 4 Aspects of nonlinear errors-in-variables estimation. Daniel G. Schnell

18 Frontier production functions and technical efficiencies of firms. George E. Battese

25 Locally-weighted regression: An approach to regression analysis by local fitting. William S. Cleveland, AT&T Bell Laboratories, Murray Hill, New Jersey

April 8 Sweating through Snedecor: The statistics of arousal. Robert F. Strahan

13 Statistics and statisticians at P&G. Mel Peterson, Procter & Gamble Company, Cincinnati, Ohio

15 A factor analysis of seventy-eight personality variables using PC/SAS. Leroy Wolins

22 The use of elemental sets for outlier identification. Douglas M. Hawkins, Department of Applied Statistics, University of Minnesota

29 A family of nonparametric statistics for comparing diagnostics tests. H. Samuel Wieand, Mayo Clinic, Rochester, Minnesota

May 6 Duality of maximum likelihood estimation for loglinear models and I-projections under cone constraints. Richard Dykstra, Department of Statistics, University of Iowa

11 Reconstruction and prediction of individual growth curves. Mats Rudemo, Institute of Mathematical Statistics, The Royal Veterinary and Agricultural University, Copenhagen, Denmark, and the University of North Carolina-Chapel Hill

Summer 1987

June 20 Univariate extremes: Basic concepts. J. Tiago de Oliveira, Department of Statistics, Operations Research, and Computation, University of Lisbon, Portugal

24 Strongly consistent modified maximum likelihood estimation of U-shaped hazard functions. Mong-Hong Lee

Special Lectures and Seminars

October 7 12th George Zyskind Memorial Lecture. Bayesian analysis: Myths and reality. James Berger, Department of Statistics, Purdue University

March 26 Mu Sigma Rho Lecture. Dynamic graphics for data analysis. William S. Cleveland, AT&T Bell Laboratories, Murray Hill, New Jersey (co-sponsored by Iowa STAT-ers; Statistics Club; departments of Statistics, Mathematics, Computer Science, Economics, Industrial Engineering, and Art and Design; Media Resources Center; and Committee on Lectures)

April 1 Interdisciplinary Lecture in Statistics (held at Drake University). Forecasting economic time series: An overview. Steven Hillmer, School of Business, University of Kansas (sponsored by the Iowa Chapter of the American Statistical Association, Drake University College of Business Administration, Iowa State University Department of Statistics, and University of Iowa Department of Statistics and Actuarial Science)

Iowa STAT-ers Seminar Series

September 19 [See Statistical Laboratory Seminar Series, pp. 44.]

October 6 On rating students and municipal bonds: What's the difference? Keith Cranford

16 The role of the statistician in the chemical industry. Robert D. Koller, Rohm and Haas Company, Spring House, Pennsylvania

21 Tests of hypotheses with paired survey data. Robert F. Woolson, Department of Preventive Medicine and Environmental Health, University of Iowa

November 10 Deterministic and stochastic behavior of linear systems—an example. Wolfgang Kliemann, Department of Mathematics, Iowa State University

18 Applications, practical considerations, and pitfalls of life data analysis. William Q. Meeker, Jr.

December 4 Measures of association for tables of frequencies obtained from cluster sampling. Grecia Morel

January 23 Educational needs beyond the statistics degree for consulting in a medical setting. Kenneth Offord, Mayo Clinic, Rochester, Minnesota

February 9 Some glimpses of the history of statistics. H. A. David

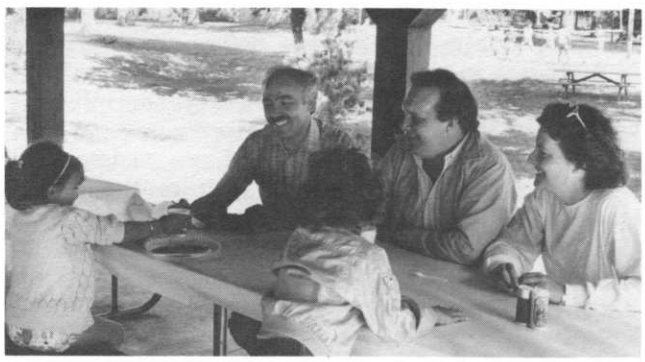
March 2 (American Statistical Association videotape) Practice and theory: Some personal experiences. George Box and William Hunter

23 (American Statistical Association videotape) Statistics in industry: Implications for statisticians and statistical education. W. Edwards Deming, G. McDonald, F. C. Leone, C. Eisenhart, and L. Nelson

April 6 Analysis of censored data using mixed models. Alicia Carriquiry

27 Genetic evaluation with data containing major locus genotypes using mixture distribution models. Ina Hoeschele, Department of Animal Science, Iowa State University

May 4 The concept of the experimental unit and its consequences. Mark Bryan



Fetih Yildirim, visiting Fulbright scholar, and his daughter (L) enjoy the Stat Lab Spring Breakfast with the Bill Meeker family.

In Memoriam

Theodore Alfonso Bancroft, 1907-1986*

Theodore Alfonso Bancroft died at his home in Ames, Iowa, on July 26, 1986. At the time of his death, he was Professor Emeritus in the Department of Statistics at Iowa State University, having retired in 1977.

T. A. Bancroft was born January 2, 1907, in Columbus, Mississippi. His early education was in Alabama; he attended Howard College in Birmingham, and received the A.B. degree in mathematics from the University of Florida in 1927. He taught in the Alabama public high schools before obtaining the M.A. degree in mathematics from the University of Michigan in 1934. He then taught at Vanderbilt University and Mercer University before coming to Iowa State University (ISU) as a graduate assistant in 1941. He completed his doctorate in mathematical statistics in 1943 with W. G. Cochran. His dissertation was titled "Tests of Significance Considered as an Aid in Statistical Methodology." The dissertation initiated research in the general area of preliminary testing that Bancroft conducted throughout his career. Bancroft remained on the ISU staff until 1946, when he left for a year at the University of Georgia and two years at Auburn University.

In 1949 he returned to ISU, and in 1950 he became Head of the Department of Statistics, Director of the Statistical Laboratory, and head of the Statistics Department of the Iowa Agriculture and Home Economics Experiment Station, positions he held until 1972. Ted was fond of saying that he wore three hats. He received an ISU Faculty Citation in 1968. In 1972 he relinquished administrative responsibilities but remained on the staff, and in 1977 he became Professor Emeritus.

When Dr. Bancroft became director of the Statistical Laboratory, there were 12 faculty members and 5 graduate assistants. When he stepped down from administrative duties in 1972, there were 30 faculty members and 25 graduate assistants. Numbers do not do justice to Bancroft's commitment to the laboratory or to the development of the statistics program at ISU during his tenure as head. He fostered the growth of service teaching, statistical computing, and statistical consulting. He initiated an undergraduate major program in statistics, in addition to promoting and enlarging the graduate program. The concentration of statistics in a single unit at ISU is originally due to George Snedecor; the continued centralization and expansion of statistics is a tribute to Bancroft.

In addition to his administrative duties, Bancroft found time to teach and to direct graduate students. There can be no doubt that Bancroft cared deeply about the lives and the concerns of students. The initial advising of all graduate students within the Department of Statistics was done by Bancroft while he was head. He and his wife, Lenore, made their home a haven for students and staff.

With R. L. Anderson, Bancroft wrote the book *Statistical Theory in Research,* widely used as a theory book for research workers. Later he authored *Topics in Intermediate Statistical Methods.* Bancroft wrote many papers on applied statistics, the teaching of statistics, and the organization of a university-wide statistical effort. His principal area of research, and the basis for many papers, was the topic he called "incompletely specified models." Working with Oscar Kempthorne, John Gowen, and Jay Lush, Bancroft coedited *Statistics and Mathematics in Biology,* based on a 1952 international biostatistics conference held at ISU. He was editor of *Statistical Papers in Honor of George W. Snedecor,* published in 1972. During his retirement, Bancroft and a former colleague, C. P. Han, published *Statistical Theory and Inference in Research,* a revision of the book by Anderson and Bancroft.

Bancroft's interests extended well beyond ISU. He served as president of both the American Statistical Association (1970) and the Biometric Society, Eastern North American Region (1964). He was a Fellow of the American Statistical Association, a Fellow of the Institute of Mathematical Statistics, a Fellow of the American Association for the Advancement of Science, and an elected member of the International Statistical Institute. He served on many national committees and advisory boards. Bancroft also

served as a consultant to numerous U.S. and foreign universities. Visiting professorships and assignments with the Food and Agriculture Organization of the United Nations, the Rockefeller Foundation, and the Ford Foundation took him to Chile, Colombia, England, Egypt, India, Iraq, Italy, Mexico, the Philippines, Syria, and Yugoslavia.

After his retirement, Bancroft lived a quiet life with his family and close friends. He took some short-term assignments and continued his research, particularly in cooperation with C. P. Han. Lenore, his wife of 48 years, died in 1981 of cancer after a protracted illness. During that long illness, Ted remained close to Lenore. After Lenore's death, he divided his time between Ames and Florida. He is survived by two daughters, Alice Damp of Ithaca, New York, and Louise Glawe of Waterloo, Iowa.

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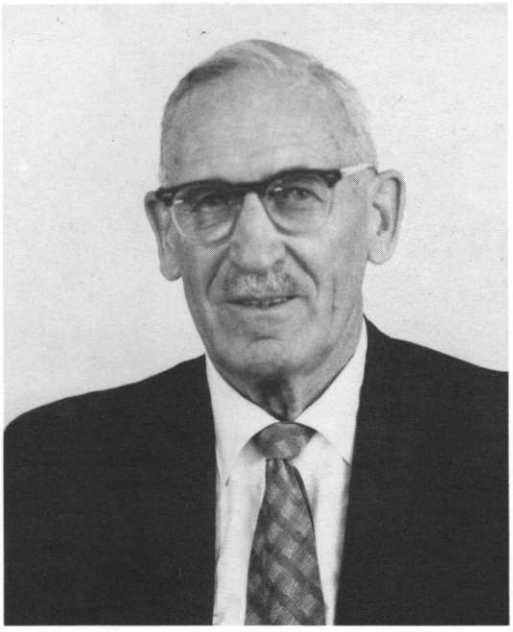
*By Wayne A. Fuller and Oscar Kempthorne (text reprinted with permission from *The American Statistician,* Vol. 41, No. 3, August 1987).

Alvah Esmond Brandt 1892-1986



A. E. Brandt, one of the pioneer figures in applied statistics at Iowa State University, died in Orange City, Florida, on June 29, 1986, at the age of 93.

Born in Larchwood, Iowa, he completed his undergraduate program at Iowa State, worked briefly as an extension specialist in Illinois, then served in the U.S. Navy from 1917 to 1919. He was an assistant professor of farm mechanics at Oregon State College until 1923, when he returned to Iowa State.

His interest in applied statistics was apparent in the research completed for an M.S. degree in meats and genetics (1926) and a Ph.D. in genetics and animal husbandry (1932). Both of the theses involved statistical studies of swine data.

Brandt became an assistant professor of mathematics (and statistics) at Iowa State in 1924. With George W. Snedecor, he was put in charge of the department's newly-created Mathematics Statistical Service in 1927. When the Statistical Laboratory was formed in 1933 with Snedecor as director, the other staff consisted of Brandt, Gertrude Cox as research assistant, and Mary Clem as computer specialist, working with him to encourage the sound application of statistical methods in research elsewhere on campus. Meanwhile he continued to teach through the Department of Mathematics.

One of A. E. Brandt's major contributions was to advance the use of calculating machine methods for statistical computations. Snedecor made 12 citations of his work in *Statistical Methods,* 4th edition. He referred to "a convenient method of computing chi-square, sometimes referred to as the Brandt and Snedecor method." He also cited Brandt for "his ingenious method of testing significance in switch-back or reversal trials," extending "Student's" t-test to experiments involving two or more test periods.

Publications dating from this period include "The use of machine factoring in multiple correlation" by Brandt in the *Journal of the American Statistical Association* and "Application of punched card equipment to the analysis of complex spectra," by J. V. Atanasoff (co-inventor of the first digital computer in the U.S.) and Brandt, in the *Journal of the Optical Society of America,* discussing how tabulating and sorting equipment generally used in statistical and accounting work could be applied in empirical spectroscopy.

In 1937 Brandt accepted the newly created position of senior mathematical statistical analyst in the U.S. Soil Conservation Service. He remained with the USDA until 1943, when World War II caused him to serve as operations analyst in the AAF. After the war, he became statistical consultant to the technical director of the U.S. Naval Ordnance Laboratory. Then in 1948 he joined the U.S. Atomic Energy Commission to begin an illustrious career as biometrician and later Biometrics Branch chief in the Health and Safety Laboratory of the AEC's New York Operations Office.

Following retirement from the Atomic Energy Commission in 1958 on reaching 65, he joined the faculty of the University of Florida as statistician in its Agricultural Experiment Station. In 1962 he became head of a newly created Department of Statistics in the College of Agriculture and continued to serve as head of the experiment station.

A. E. Brandt retired from the University of Florida in 1963 but maintained an office in the Northeast Regional Data Center located on campus. In 1977, when he was 84, he was awarded the University of Florida President's Medallion "for his pioneering work in machine-aided computation; his contributions to the field of applied statistics; and his service to UF, especially toward the establishment of the Statistics Department and his participation in the development of a large computing center from its modest beginnings as the UF Statistical Lab."

Dorothy St. John Cooke 1906-1986

Dorothy Cooke, a former faculty member and a former editor of the Statistical Laboratory Annual Report in the 1940s, died at her home in Santa Barbara, California, on February 3, 1987, at the age of 80. She had been involved in international statistics for much of her career.

Born in Chicago, Illinois, Dorothy Alice St. John attended Morton Junior College and, briefly, Iowa State College. She worked as a statistical clerk for a public utility company and married Paul Cooke before completing her undergraduate degree at the University of Chicago in 1937. She taught at Hull House in Chicago for five years on a volunteer basis. Then, with her husband in service during World War II, she worked for the Office of Price Administration and the Smaller War Plants Corporation in Chicago. Her husband died in the Philippines during World War II, leaving her with two young children.

Cooke received an M.S. degree in consumption economics and statistics at Iowa State in 1946. She first joined the Statistical Laboratory in 1944 as a research associate in the Survey Section, then from 1948 to 1950 held a dual appointment as research associate and instructor. Cooke assisted George W. Snedecor in the laboratory portions of his new general introductory course for undergraduates, Stat 301, which was introduced in the spring quarter 1946. She also served as editor for the statistical center.

In 1950 she accepted a temporary position in the U.S. Bureau of the Census to help with processing of the 1950 decennial census, then resigned from Iowa State in order to remain with the bureau as a training officer in its international statistics program. Between 1953 and 1958 she held positions in the Washington, D.C., area as statistician with Ordnance Engineering Corporation (organized by J. V. Atanasoff), the Home Economics Research Branch of the U.S. Agricultural Research Service, and the Inter-American Statistical Institute. She became editor of *Estadistica* as part of her work with IASI.

In 1958 Cooke rejoined the Bureau of the Census, eventually becoming chief of the International Statistics Programs training branch. She worked abroad as statistical adviser to the governments of Pakistan, Jordan, and Vietnam.

In 1964-65 she worked at the International Labor Organization headquarters in Geneva, Switzerland, developing comparable cost of living indexes. Then she returned to Washington, D.C., as chief of the International Research Branch of the National Center for Health Statistics. Cooke finally retired in 1974 as adjunct professor in the School of Public Health at the University of North Carolina-Chapel Hill, and moved to Santa Barbara, California. She is survived by a daughter and a son, two brothers, and eight grandchildren.

Arnold J. King 1906-1987

Word has been received that Arnold J. King died on July 9, 1987 and was buried in Cheyenne, Wyoming. King was a leader in the first wave of resident collaborators that enlarged the size and the scope of activities of the Statistical Laboratory in the late 1930s and 1940s. He came to Iowa State in 1937 as a representative of the Bureau of Agricultural Economics, USDA, succeeding Charles F. Sarle. King was in charge of USDA research in sample survey methods and a study of weather yield relationships to forecast crop yields. Responsibility for this work was transferred to the university in 1938. King was appointed resident collaborator, and both the project and the sampling staff were enlarged. King was also influential in developing additional cooperative agreements between the Statistical Laboratory and the U.S. Bureau of Agricultural Economics, Bureau of the Census, and Weather Bureau.

With Raymond J. Jessen, King was responsible for the design of the Master Sample of Agriculture. This nationwide area probability sample was used in connection with the 1945 Agricultural Census, the population sample census taken in 1946, the 1950 censuses, and a number of other large-scale sampling projects. The weather yield study led to the development of an objective method of sampling the wheat crop at harvest to estimate acreage, yield, and quality of the crop.

Recognized as an able administrator and a farsighted leader in research, in 1945 King was appointed as research associate professor in the Statistical Laboratory, while retaining a part-time connection with the BAE. Under George W. Snedecor's directorship, he was put in charge of the administrative work of the laboratory, while Snedecor continued to be responsible for policy and for selection of professional staff.

In 1946, King took part in a State Department mission in Greece to design samples to assess the freedom of the Greek elections. When, at age 65, Snedecor stepped down from the directorship in 1947,

King served on a three-man executive committee (with Jessen and Alexander Mood) to oversee the statistical center, including the new Department of Statistics established in what is now the College of Sciences and Humanities.

Arnold King resigned from the Statistical Laboratory in 1948 to become managing director and later president of National Analysts, Inc., in Philadelphia, Pennsylvania, which was engaged in taking sample surveys for business, universities, and the federal government. He was named a fellow of the American Statistical Association in 1953. On short visits to Korea in 1960 and 1961, he developed a plan for a yearly agricultural statistical program for Korea based on sample surveys.

Following retirement in 1968 as president and chair of the Board of Directors of National Analysts, King was in charge of a staff of American statistical advisers to Brazil until 1971. This group, over a ten-year period, carried out a broad statistical program for Brazil, including censuses and yearly sample surveys. During King's tenure, the portion of the program for agriculture was put into operation.

In 1983 King wrote, "We are enjoying retirement in Sunny California in the same town [San Jacinto] in which Mr. Snedecor spent his last years . . . . We are both in good health and spend part of the year in Maryland and Connecticut, visiting the family. They also take advantage of our weather and visit us in winter." He is survived by his wife, Mary, four sons—Donald, Paul, David, and Arthur, and nine grandchildren.

Photo Credits

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