STATISTICAL LABORATORY

established 1933

$$\sigma^2 \quad \mu \quad \Omega \quad \chi^2 \quad \Sigma \quad \beta$$
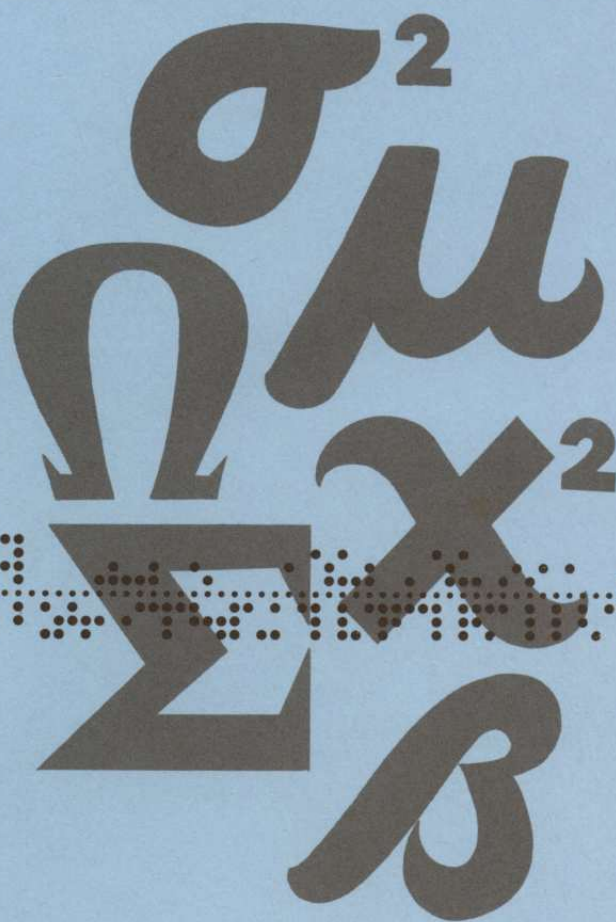
annual report

July 1, 1985 to June 30, 1986

IOWA STATE UNIVERSITY, AMES

Contents

THE STATISTICAL LABORATORY
Iowa State University
1985-86 Annual Report

Update

The Department of Statistics conducted an internal search for a permanent head during the fall semester of 1985. It was recommended, and subsequently approved by the university administration, that Dean L. Isaacson's current acting appointment be changed to director and head, beginning July 1, 1986. It was also decided that the position be reviewed again in 1990 in case opportunities exist at that time for an outside search.

The tight economic conditions in the State of Iowa have been felt in the Statistical Laboratory. This led to concern that there would be a reduction in the quality of our seminar series, Reading Room, reprint series, and annual report. However, it has been possible to retain or improve all of these, as a result of a successful fund-raising effort to which many of you responded. In fact, the reprint series has been changed to a preprint series so that we can distribute new results to our colleagues more efficiently. The positive attitude generated by these funds spilled over to the academic side where faculty started thinking about new challenges rather than reductions.

Iowa State University will expand its research efforts in agricultural biotechnology. There are seven focus areas under consideration, and faculty members from statistics have expressed interest in working in all seven areas.

Iowa State University is also planning the development of a research park near campus. The Statistical Laboratory is playing an active role in trying to recruit companies to locate here. Our expertise in statistical consulting, survey sampling, and statistical computing could be a valuable resource for such companies.

Of course our Industry/University Affiliate Program in Productivity, Quality, and Reliability continues to grow. We have provided services such as short courses, private consulting, software development, and conferences for several Iowa companies. This program may be expanded into a center in the near future.

In addition to the above service activities, basic research in statistics also continues to grow, with an increased number of grants and contracts. The faculty's desire to bring in outside speakers, attend conferences, and disseminate research results remains strong.

The alumni, alumnae, and other friends of the Statistical Laboratory have played a big role in keeping the quality of our program high despite reduced budgets. We deeply appreciate this support, and we look forward to working with you in the future.

David Cox received the Margaret Ellen White Award for Graduate Excellence on June 13 at the ISU Graduate Faculty meeting, as one who has especially extended himself on behalf of graduate students.

Personnel

Yasuo Amemiya spent the academic year at the Department of Statistics, Stanford University, while on faculty improvement leave from Iowa State. During part of this time he worked as a research associate on a National Science Foundation grant project directed by T. W. Anderson.

During his absence, Balvant K. Kale was a visiting professor for the academic year, on leave from the Department of Statistics, University of Poona, India. He is remaining here for the summer 1986 for research with H. A. David on an Army Research Office grant project.

Robert F. Strahan was on faculty improvement leave for the period August 21, 1985-February 21, 1986, primarily working on a research project, described in more detail on p. 17.

Thomas A. Bubolz has been on leave since August 21 to engage in research in the area of health data systems and epidemiological statistics. As a consultant with Codman Research Group, Inc., Lyme, New Hampshire, through December, he designed and implemented a database and analysis software system for an IBM PC-AT. In January 1986 he joined the faculty of the Department of Community and Family Medicine, Dartmouth College, as visiting professor, with responsibility for implementing a national data center for outcome research on morbidity and mortality for various kinds of surgery.

Stephen Vardeman's appointment in the Department of Statistics was changed to a joint appointment with the Department of Industrial Engineering effective July 1, 1985, in recognition of mutual interests in statistics for quality, productivity, and reliability. This is the second joint appointment arranged between the two departments. Vardeman's duties include teaching I E 361, Industrial Quality Control and Inspection. He has been promoted to full professor of statistics and industrial engineering beginning July 1, 1986.

Oscar Kempthorne began phased retirement on July 1, 1985—a program that involves a change from full-time duties to 80 percent in the first year and then gradually phases to 50 percent in the fourth year.

Ronaldo Iachan, a member of the Survey Section, resigned to accept an appointment at the Research Triangle Institute in North Carolina, as research statistician beginning September 1, 1985. His position was not filled during the year, but a search for a replacement is now underway.

Mervyn Marasinghe and Jerome Sacks were approved as full members of the graduate faculty of Iowa State University in December. Marasinghe has been promoted to associate professor of statistics with tenure, effective July 1, 1986.

Noel Cressie was awarded an ASA/Census fellowship for July-December 1985 and June-August 1986. Cosponsors are the American Statistical Association (through a National Science Foundation grant) and the Bureau of the Census. The purpose of the fellowships is to establish on-site cooperation between research statisticians, economists, and demographers, and the Bureau of the Census, giving fellows access to the bureau's facilities and expertise.

David Harville was elected to membership in the International Statistical Institute.

On May 13, 1986, David F. Cox received the Margaret Ellen White Graduate Faculty Award as its second recipient since the award was established. This award consists of $1,000 and a plaque "in recognition of an outstanding commitment to excellence in graduate education and for distinguished service as a member of The Graduate Faculty of Iowa State University."
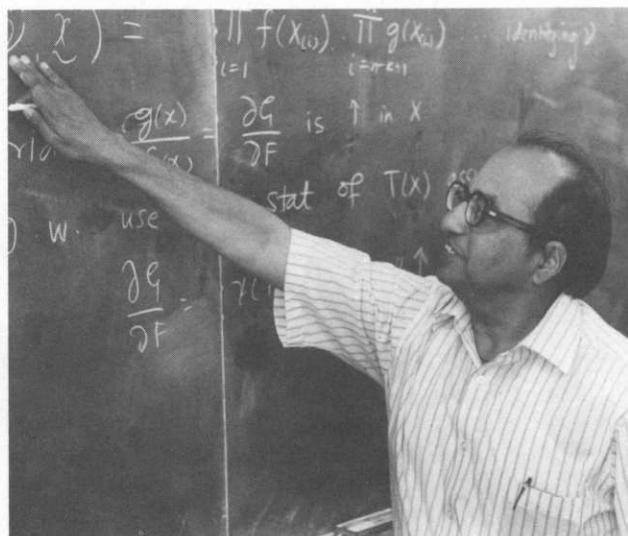
Here for a year as visiting professor is Balvant K. Kale, currently on leave from the University of Poona.

Herbert T. David has been initiated into Phi Kappa Phi Honor Society and Jerome Sacks, into Gamma Sigma Delta, agriculture honorary. C. Philip Cox was inducted into the university Twenty-Five Year Club at its annual meeting on March 17, 1986.

Short-term visitors, other than invited seminar speakers, have included John Polking, mathematician from the National Science Foundation, Washington, D.C., in February. Mariano B. de Ramos, professor and head of the Statistical Laboratory, Institute of Mathematical Sciences and Physics in the University of the Philippines at Los Banos, arrived June 30th to spend several days becoming more familiar with the teaching, consulting, and research programs and discussing a possible cooperative enterprise between ISU and his university. He last visited here in August 1961.

Looking toward next year: Ishay Weissman, head of the statistics area at Technion—Israel Institute of Technology, returns to the Statistical Laboratory for July and August 1986, on a visiting appointment, to work on order statistics and extreme value theory. From ISU he will go to the University of California-Davis School of Administration for the academic year. Weissman was here on an eleven-month visiting appointment in 1979-80.

Krishna Athreya will be on faculty improvement leave for the academic year to engage in research. He plans to visit various statistical centers in India fall semester and then will be at the Mathematical Sciences Research Institute-Berkeley, California.

Fetih Yildirim will be a visiting Fulbright senior scholar here for six months. He is an associate professor and chair of the Department of Statistics at Middle East Technical University, Ankara, Turkey.

George E. Battese rejoins the Survey Section as a visiting professor, starting January 1, 1987, for a year. He has been a senior lecturer in the Department of Econometrics, University of New England, Australia.

Statistical Laboratory Staff—Fiscal Year 1985-86 under the administrative direction of:

W. Robert Parks, Ph.D.—president of the university

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

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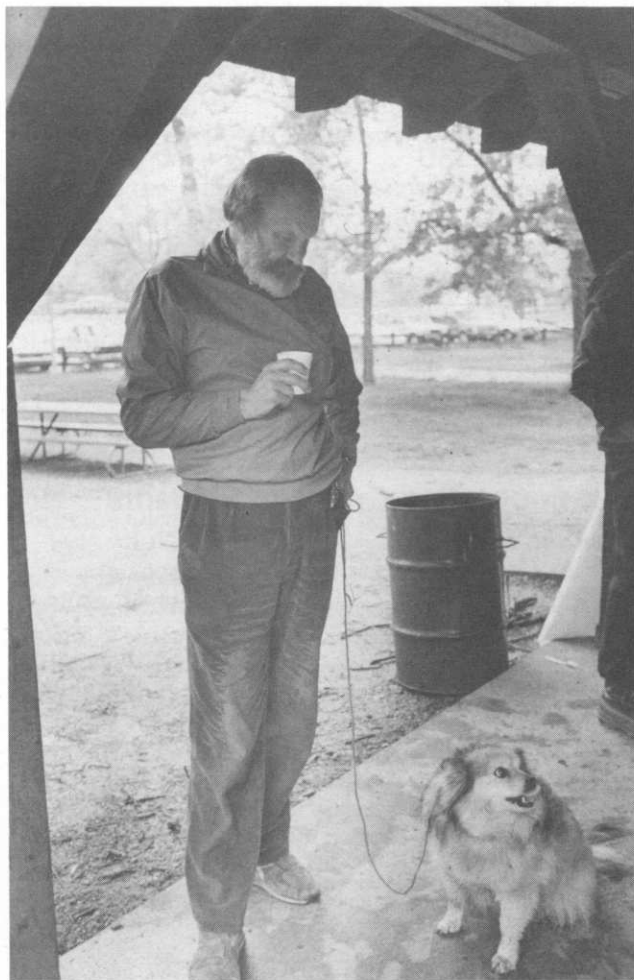
Dean L. Isaacson, Ph.D.—acting director, Statistical Laboratory; acting head, Department of Statistics; acting head, Statistics Department, Iowa Agriculture and Home Economics Experiment Station

Professors

Krishna B. Athreya, joint appointment with Department of Mathematics
Theodore B. Bailey, Jr.
T. A. Bancroft, professor emeritus

C. P. Cox takes a break from preparation of a text at the level of Stat 401. His book is scheduled to emerge from Wiley in November 1986.

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
Leroy Wolins, joint appointment with Department of Psychology

Associate Professors

Kenneth J. Koehler
Frederick O. Lorenz, joint appointment with Department of Sociology and Anthropology
Jerome M. Sacks, USDA collaborator
Mack C. Shelley II, joint appointment with Department of Political Science
Shashikala Sukhatme
Stephen B. Vardeman, joint appointment with Department of Industrial Engineering

Adjunct Associate Professor

Thomas Bubolz

Assistant Professors

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

Temporary Instructor

Paul McGovern

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Visiting Scholars

Vijay K. Bhatia
Shiguang Zhu

Resident Collaborator

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

Predoctoral Research Associates

Terrance P. Callanan
Jorge G. Morel

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.

Edi Abdurachman
Douglas Andrews
Patti Ann Beasley
Stephen D. Boeh
Scott E. Bullock
Donna E. Busch
Michael R. Carley
Alicia Carriquiry
Barbara A. Chisolm
I-Shang Jackson Chow
Jeffrey D. Christman
Lee Ann Crowder
C. Janelle Dombek
John L. Eltinge
Kimberly Erland
Charles M. Farmer
Carol A. Francisco
Fah Fatt Gan
Gloriana Giacobello
   (Fulbright scholar)
Carol A. Gotway
Deanna L. Graf
Eric A. Grau
Renkuan Guo
In Hye Ha
Nancy Hasab-El-Naby
Patrick Homblé
Chong Sun Hong
Frederick Hulting
Daniel R. Jeske
Jane M. Johnson
Yoou-Jen Kang
Song-Ho Kim
Kenneth J. Kortge
Alice S. Lay
Mong-Hong Lee
Klaus Lemke

Jyh-Shiun Lin
Charles A. Liedtke
Tsung-Hua
   (Thomas) Lin
Sharon K. Loubert
Chi-hsien Joseph Lu
Todd Melander
Stephen M. Miller
Karen L. Moore
Grecia F. Morel
Terry Moy
Dennis J. Murphy
Thilagawathy
   Muththiah
Neerchal K. Nagaraj
Nuwan
   Nanayakkara
Sarah M. Nusser
Heon Jin Park
Stephen L. Rathbun
Jill L. Roesler
Michael P. Rogers
Daniel J. Schnell
Darrell Schroeder
David L. Silvis
Gary R. Sullivan
Nae Kyung Sung
James T.
   Symanowski
Kathleen M. Taylor
Miriam B. Tirol
Scott Vander Wiel
Shaw-Ling Wang (Chu)
Susan E. White
Franklin Winters
Danny A. Wolfgram
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
Kevin Anderson—Engineering Research Institute, ISU
Driss Benlemrid—USAID, Morocco
Victor P. Brescia—National Institute of Agricultural Technology, Argentina
Mark F. Bryan—Department of Entomology, ISU
Cai Yilin—Southwest Agricultural College, China
Terry Caliste—Bell Communications Research
Brian Keith Cranford—College of Business Administration and Graduate College
Stephen V. Crowder—Graduate College, ISU
Da Yang—Beijing Agricultural University, China
Mamadou L. Diedhiou—USAID, Senegal
Abdullah Y. A. K. Fagih—Kingdom of Saudi Arabia
Kaisheng Fan—Government of China
Clarice Freire—CAPES, Government of Brazil
Cheng-Der Fuh—Department of Mathematics, ISU
Martin Grondona—National Research Institute in Agronomy, Argentina
Brenda Ihle—Engineering Research Institute, ISU
Karen L. Jensen—Veterinary Medicine Research Institute, ISU
Mohammed Khan—Food and Agriculture Organization, United Nations
Paula M. Lasack—Department of Entomology, ISU
Sueli A. Mingoti—Federal University of Minas Gerais and CAPES, Government of Brazil
Juan Esteban Ramírez C.—Universidad Tecnica del Estado, Santiago, Chile
Margot H. Tollefson—Department of Nuclear Engineering, ISU
M. Katheleen Vasconcelos—National Council for Scientific and Technological Development, Brazil
Wan Azah Wan Ismail—Mara Institute of Technology, Malaysia
Peter Sze-Yan Wong—Department of Mathematics, ISU
Peh-Jen Jenny Wu—Computation Center, ISU
Byoung Chang Yoon—Korean Army
Rahmat Zakaria—World Bank (MUCIA-Indonesia)

Self-Supporting Graduate Students

Jonathan Biele
José A. Calcaño-Collazo
Seong-San Chae
   (in absentia)
John R. Cook
   (in absentia)
Eiichiro Funo
Geun Shik Han
Chihho Hsieh
Ching-Chang Hwang
Byung Hwee Kim
Joo-Hwan Kim
Chiou-Hua Lin

Mark McNulty
   (in absentia)
Saad Eldin M. Saad
   Eldin
Hussein Shamsuddin
Narayan S. Shankar
Shiowlin Su
Michael Tveite
   (in absentia)
Steven P. Vilendrer
   (in absentia)
Kui-Jang Wang

Professional and Scientific Staff

Richard Dorsch, programming consultant, Survey Section
Mary Genalo, research associate, Survey Section

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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, analyst, Statistical Data Processing Services
Harvey Terpstra, data systems manager, Survey
Section
John C. Thompson, research associate, Statistical
Numerical Analysis Services
Jauvanta Walker, information specialist

General Office Staff

Rose Ann Anderson, secretary
Norma Elwick, secretary
Julie Hill, clerk typist, beginning June 9, 1986
Julie Honeick, clerk typist, until September 8, 1985
Jeanette Lagrange, clerk typist
Cynthia Lunning, clerk typist, January 27-April 28,
1986
Donna Nelson, clerk typist
Janice Peters, account specialist
Denise Riker, secretary
Sharon Shepard, clerk typist
Marlene Sposito, clerk typist, beginning February 1,
1986
Darlene Wicks, clerk typist, Statistical Numerical
Analysis and Data Processing Section

Survey Section Staff

Dianne Anderson, clerk
Glenda Ashley, key entry operator
Kathryn Bottorff, field interviewer
Dorothy Edwards, clerk
Vimlesh Gupta, key entry operator
Nancy Heathman, account clerk
Jo Ann Hershey, clerk typist, until July 31, 1985
Marcia Luze, field interviewer
Helen Nelson, secretary
Christine Olson, clerk typist, beginning September 9,
1985
Donna Omundson, clerk
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 has been supported by contracts and grants. This is 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, appointments with the Computation Center and departments of Economics, Forestry, Genetics, Industrial Engineering, Mathematics, Political Science, Psychology, and Sociology and Anthropology. These add considerably to the strength and effectiveness of our program.

■ 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 mainly by David F. Cox, Theodore B. Bailey, Paul N. Hinz, and Donald K. Hotchkiss. The graduate assistants working with the staff in consulting this year include Alicia Carriquiry, Karen Jensen, Sarah Nusser, Stephen Rathbun, Mark Bryan, and Jorge Morel.

Generalizations about statistical consulting usually include some seemingly reasonable statements about the need for the consultants to have some knowledge of the fields of applications where the problems arise. The impossibility of this can be appreciated by listing just a few of the subjects that were handled by the consultants during the last year:

(1) Sperm counts in cats
(2) Drug effects on fetal rats
(3) Specific gravity of potatoes used in preparing commercial french fries
(4) Pesticide residues in human milk
(5) Temperature and moisture effects on turtle eggs
(6) Synchronization of katydid song patterns
(7) Adherence of packaging material in frozen meat products
(8) Mating systems in cross-bred swine
(9) Machine scoring of string bean firmness
(10) Intercropping systems for field crops
(11) Retention of pesticide residues in fabrics
(12) Preservation of hay bales
(13) Comparison of tuberculin tests

(14) Studies of factors influencing muscle activity
(15) Selection for protein content in oats
(16) Studies of plant growth regulators
(17) Species differences in prey selection in fish
(18) Growth hormone regulation in beef cattle

No one could have a very deep understanding of all those fields, which represent only a fraction of what was encountered over the year. Most of our statistics graduate students majored in mathematics as undergraduates, although several in the consulting section took degrees in the biological sciences. However, no undergraduate program could prepare them for the diversity they must cope with as statistical consultants. A detailed knowledge of the fields is impossible, so the consultants must learn as they work. It requires listening and asking questions and being sympathetic to the research workers' needs. The consultants develop individual styles that work for them as they gain experience. There are always new statistical approaches being proposed and new computer software to be investigated.

Some specific consulting problems are described in more detail below.

A battle that consultants fight when designing experiments for growth chambers is to convince users that good experimental design technique is needed. The difficulty is that chambers look alike, are often made by the same manufacturer, have systems for regulating temperature and humidity, and, therefore, are believed to be able to closely control environmental conditions. It is also easy to believe that environmental conditions within a chamber are highly uniform. Paul Hinz consulted on a tissue culture experiment, from the horticulture department of the experiment station, that provided evidence that blocking and randomization are needed in such cases. A large difference in response was noted from left to right in the chamber, and the cause was ultimately traced to a temperature difference of 5° to 7°C. Although this is not the first time that this type of problem has been noticed, the magnitude of the temperature difference was surprising.

Ted Bailey consulted with researchers involved in a comprehensive study of factors affecting the production of haploid callus, and eventually whole plants, from anthers of tomato plants. Preliminary measurements indicated that environments were not spatially uniform within the growth chambers. For example, radiance was found to vary up to a factor of 100-fold within particular chambers. These results reaffirm the general principle that conditions cannot be expected to be uniform within and among growth chambers, and that good experimental design is critical in such studies. For studies of the type mentioned above, it is widely reported that coefficients of variability are often as high as 100 percent. An attempt was made to identify useful experimental designs to reduce the experiment error as much as possible.

Bailey assisted in the design, analysis, and interpretation of greenhouse studies investigating leaf expansion rates, relative to canopy development, of 10 species of experimental plants. Both warm season and cool season species were included in the replicated study. Measurements were taken on each plot at regular intervals over a period of time. These time-sequences of "repeated measurements" were used to make inferences about leaf expansion rates of the species. The initial analysis consisted of completing a simple analysis of variance for each species for each time period. Subsequent analyses included use of derived variables, e.g., slopes, calculated separately for each species. The relationship between embryo size in the seed and leaf expansion rate was also studied.

Bailey also worked with plant pathologists in the design, analysis, and interpretation of a study to assess the effect of mycoparasitic fungi on yield of corn. To reduce possible confounding effects of variation in soil texture and spray drift (containing the fungi), a latin square design was used. Each experimental unit of the latin square treatment was divided into 16 split plots to which corn genotypes were randomly allocated. Three latin squares were used, each grown on a soil with a different soil cultural history (and thus different soil microflora). An analysis was completed for each square separately and then combined over squares. Where appropriate, results were interpreted by partitioning the degrees of freedom and sums of squares into meaningful single degree of freedom comparisons. Although the results are based on only one year of data, they indicate that the fungi exert varying levels of influence on microflora, growth, and yield of corn.

A food technology project collected data on various types of swiss cheese to see if the flavor could be related to chemical components of the cheese. A taste panel judged the intensity of 17 different flavor components of each of 15 types of cheese and the concentrations of more than 60 chemical compounds. The task of determining which compounds were responsible was approached by Paul Hinz by using principal component analysis to summarize the flavor and chemical information separately and then attempting to find interesting correlations among the principal components. The results did not lead to clear-cut answers but did suggest ways of approaching future studies.

A veterinary pathologist consulted with Donald Hotchkiss on an experiment that randomly assigned animals to four different treatment groups and observed each over five time intervals. The response for each variate in period one (before application of the treatment) was used as a (highly significant) covariate response for each animal.

Hotchkiss also assisted the meat science staff in setting up a balanced incomplete block design in which the two halves of the beef carcass were used to compare four methods of tenderizing meat.

During the 1985-86 fiscal year, V. A. Sposito assisted members of CARD, the university's Center for Agricultural and Rural Development, in the solution of large-scaled linear and quadratic agricultural economic models. One project involved the linkage of a Fortran subroutine to IBM's MPSX system. A large reliability study was conducted by Sposito and

CARD's Burt English to evaluate new IBM mathematical programming softwares.

■ Statistical Numerical Analysis and Data Processing Section

Programming and data processing service support activities carried out by this section are facilitated by its organization into two groups: Statistical Data Processing and Statistical Numerical Analysis. Bud Meador and John Thompson (replacing Thomas Bubolz during his leave of absence) have been in charge of the respective groups. Teaching and research activities of the section are carried out by William J. Kennedy, Vincent Sposito, and Mervyn Marasinghe.

Various large-scaled linear *goal* programming procedures were developed during the past 12 months by Sposito and Lee Ann Crowder. These computational procedures allow the user to use IBM's mathematical programming system; hence, they allow one to solve linear *goal* programming problems with over 16,000 rows, 130,000 variables, and up to 99 objective functions.

Two of these versions utilize either a Fortran or a PL/1 subroutine linked to the MPSX system. Other versions allow the user to direct the computational sequence via IBM's control program.

The Statistical Data Processing group in 1985-86 contained two full-time staff members, Bud Meador and Kathy Shelley, and five graduate assistants. The principal activity during the year involved software development for personal computers, service programming using modern software languages, and the use of statistical data handling packages on the university's mainframe AS/9160 research computer.

The further development of a personal computer database system for use in the Iowa Small Business Data Centers was a dominant project. The section was able to use software developed for Kentucky's SBDC use as a springboard toward developing what is now in service in Iowa—and perhaps elsewhere, since some half dozen states have requested and received information and/or copies of the software.

Some measure of the scope of the SBDC-Iowa software follows: It applies to a nationwide project with the same constraints for data content, editing, reporting method, and reporting frequency as those specified by the U.S. Small Business Administration. Further constraints are specified by the state's central SBDC office to effect data communication, electronic mail, report content, report frequency, etc. There are 11 SBDC subcenters in Iowa; some options for auxiliary data items and reports are exercised for specific subcenter needs. (Further constraints now contemplated could make this a really big project.)

Kathy Shelley and Michael Carley merit recognition for the success, accuracy, and timeliness of the section's work on the SBDC project. Lee Ann Crowder, Fred Hulting, and Thilagawathy Muththiah also participated in the project, particularly in regard to producing data reduction reports, summary

Kathleen Shelley is shown with Jeff Baker, Drake University employee, installing new software developed here for Iowa Small Business Data Centers. Shelley also has visited the University of Northern Iowa to consult on setting up the SBDC personal computer database.

tables, and/or reports based on data subsets. Crowder also integrated the IBM PC data-entry software previously developed in the section with the SBDC survey activity.

The group's involvement with personal computers increased considerably. Some of this resulted from constraint, as mentioned earlier, and some from the improved text editing, plotting, and data transmission routines developed by Hulting. His contribution to the section's inventory of personal computer utility software resulted in easy-to-implement solutions to difficult problems, for example, using the IBM PC-AT to view the output of SAS GRAPH, and controlling the printer for compressed printing. The increase in the group's familiarity with the personal computers as well as the enlarged inventory of software made these computers very valuable tools.

A substantial portion of personnel time was spent in consulting with people who asked for help in using the various statistics and data handling features of the mainframe research computer. Marilyn Eichner was especially heavily involved in this effort. She also handled a number of data processing projects for clients throughout the university. Muththiah and Eichner worked together on an analysis of world sorghum production. The data base for this study is believed to be the only complete inventory of that crop's distribution.

Most of the work done by the Statistical Numerical Analysis group was for the Iowa State Forest Nursery. Miriam Tirol was involved in converting the nursery's Tree Order System to run on the IBM PC-AT. This software version, which replaced an IBM PC version already in use at the nursery, is now in operation, and has helped the nursery speed up and expand its order-handling process. In addition, Tirol and

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Klaus Lemke have written report-generating programs that provide annual sales data summaries.

The migration of the Cultural Practices Evaluation System from the mainframe to the AT was completed. The system maintains a historical record of all materials and labor used to grow seedlings at the nursery. James Symanowski and Kathleen Taylor wrote or modified over 40 component programs to accomplish this task. Because of the size of the database, techniques had to be developed to store the data in a form compact enough to fit into the relatively limited storage space available in a microcomputer environment. With the successful implementation of the Cultural Practices Evaluation System on the AT, the nursery has now divorced itself entirely from the mainframe computer.

These two systems of nursery programs have caught the attention of nursery managers from other states. Tirol adapted the Tree Order System to the operations of the Colorado State Forest Service. The system was installed and is now used to handle Colorado's tree orders. The State of Indiana is purchasing an AT with hopes of incorporating both the Tree Order System and the Cultural Practices Evaluation System into its nursery's operations. Interest has also been expressed by nursery managers in Maine, Tennessee, and Nova Scotia.

Taylor revamped programs to store, update, and retrieve soil test data collected at the Ames and Fort Madison nurseries in Iowa. The new programs provide easier and more flexible access to data than their predecessors; in addition, data storage and retrieval are handled with faster, more efficient methods than before.

■ Survey Section

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

In 1985-86, Survey Section staff provided technical assistance to faculty members from the Department of Family Environment on two studies of housing needs and preferences. The first project, a collaborative study with researchers from the Universities of Illinois, Minnesota, Missouri, Nebraska, Wisconsin, and Iowa State University, addressed the housing needs and preferences of rural and small town residents in the six states. An area sample was drawn, and field interviews were conducted with 506 subjects. Section staff assisted with questionnaire development, designed and selected the sample, trained and supervised interviewers, and then edited and coded the data. Analysis is being performed by project leaders.

The housing needs of Iowa elderly were the focus of a second study, conducted in cooperation with the Iowa Commission on Aging. Survey Section staff

drew a random-digit dial telephone sample and called 2,000 households to identify eligible persons for the study. The sample was designed to yield 300 subjects in the two-way stratification, age of subject (60 to 74 years and 75 years or older) by urban-rural residence. Personal interviews are being conducted by staff interviewers and graduate students from the Department of Family Environment.

The section continued collaboration with the Department of Preventive Medicine, University of Iowa, and the National Cancer Institute on two case-control studies of cancer incidence. A three-year project including eight states involves the study of males diagnosed with breast cancer. The section is interviewing cases and controls in Iowa. The second study is designed to investigate the causal relationship of use of analgesics, particularly phenacetin-containing drugs, and cancer of the renal pelvis. Mary Genalo, with field interviewers Kathryn Bottorff, Mary Rathbone, and Miriam Troyer, attended a training session held at the National Cancer Institute, Rockville, Maryland, May 12-15, to prepare for the study. Within the next year personal interviews will be conducted with approximately 300 cases and controls by staff interviewers.

The section is cooperating with the Cerebrovascular Clinical Research Center at the Mayo Clinic to investigate the decline in the incidence of stroke in residents of Rochester, Minnesota. Section staff consulted with the Mayo Clinic on the design and methodology of the study, selected a random-digit dial sample and a sample of elderly residents living in nursing homes and independent living centers, designed forms, and trained telephone and field interviewers. Two thousand Rochester residents 35 years of age or older will be interviewed and tested by Mayo Clinic personnel.

Telephone interviews were completed with 162 midwest hog producers for an extension economist studying producers' interest in forward-contracting with feed companies. Respondents were first sent a letter describing the research and outlining five specific types of forward-contracting. Section staff assisted with questionnaire design, completed the telephone interviews, and coded and entered the data.

Assistance was given to personnel of the Iowa Conservation Commission on the design of a pilot study to assess the effects of deer depredation on crops grown in fields near a state park. The basic procedure was to fence off plots to protect the crop from the deer and, at the end of the season, to compare the yields from these plots with yields from unfenced control plots. Two control plots were selected for each fenced plot. The study area surrounding the park was divided into three strata determined by distance from the park boundary. The siting of the plots was determined at random within certain constraints with respect to the distance between a fenced plot and its associated control plots. Altogether, 40 fenced plots and 80 control plots were sited.

A sample of approximately 11,000 names was selected for an Iowa State University agronomic research group. The group conducts a biennial mail survey to determine the varieties of corn and soy-

beans being planted by Iowa farmers. An area sample was selected from every county in Iowa. Farm and Ranch directories were used to compile a list of residents' names associated with the area sampling units. The sample selected for this group two years ago was updated using newer editions of the directories. Each year's sample is retained in the study for one additional round after its initial use.

The 1986 Ames Community School District biennial census was completed. In addition to collecting data from all Ames households, section staff processed the data and produced summary tables. Coding and data entry were completed for the World Food Institute for 493 mailed questionnaires evaluating readers' assessment of its annual publication.

Consultative service was provided to students and colleagues from various disciplines. For example, assistance in questionnaire construction was given to a student in economics investigating farmers' use of marketing services provided by banks; questionnaire construction and sampling procedures were discussed with another economics student investigating student usage of instant cash cards and with a student from the College of Design interested in surveying foreign student alumni to assess the relevance of the design curricula to their situations; information needed to prepare a cost estimate for a grant proposal involving a sample survey was provided for a colleague in the Department of Family Environment. Assistance with questionnaire construction, coding, and data entry procedures were provided to the Career Development Office, College of Sciences and Humanities, in an assessment of their programs through a survey of graduating seniors; the Iowa Department of Substance Abuse in an evaluation of existing programs and services by a mail survey; and personnel from the College of Home Economics who collected data on the dietary habits of the elderly population in Story City, Iowa.

Mary Genalo presented two guest lectures to a graduate survey methods class in sociology, focusing on questionnaire design and development and costs and implementation of mail, telephone, and personal interviewing.

Zambia Project

Under the auspices of the ISU-USAID/Zambia agreement, Harold Baker made two trips to Zambia in connection with the Zambia Rural Small Farm Household Survey to be carried out by the Planning Division, Ministry of Agriculture and Water Development, and the Rural Development Studies Bureau. The project called for a benchmark survey, to be carried out in the late fall and early winter of 1986, followed by a year-long panel study to be conducted on a subsample selected from the benchmark survey. The purpose of the first trip, in July, was to participate in a workshop acquainting government personnel with details of the proposed survey and providing them an opportunity to critique drafts of the proposed questionnaires. Information needed to complete the sample design (e.g., types of sampling materials available, restrictions necessitated by limited resources) was obtained also. The purpose of the second

trip, in October, was to complete the sample selection for the benchmark survey and to participate in the interviewer training.

■ Industry and Engineering Sciences

Statistical consultation with engineering and physical science faculty and graduate students and with industry took place with the support of the Engineering Research Institute, the Statistical Laboratory, joint faculty appointments in statistics and industrial engineering, and the new program of collaborative and affiliate industrial research and consulting launched last year.

Much of this work is summarized in the sections that follow. The interface of statistics with engineering and industry, together with the university's concern for science with practice, are exemplified in a design project arising in a course in metallurgical engineering. Stephen Vardeman and Brenda Ihle, as consulting statisticians, worked with the class on the design of an experiment intended to identify important process variables in the production of a critical metal part for a piece of farm machinery produced by an Iowa firm.

Industrial Consulting

During the summer of 1985, H. T. David completed an assignment as visiting scientist with the Department of Mathematical Sciences at IBM's Thomas J. Watson Research Laboratories, while William Q. Meeker, Jr., engaged in consulting and research at AT&T Bell Laboratories, Holmdel, New Jersey. In June 1986 Meeker returned to Bell Labs on the first of three short trips planned for consultation on a software development project and research on other projects.

Stephen Vardeman gave a one-week course in statistical quality control to John Deere engineers in July 1985, while W. Robert Stephenson prepared instructional materials during the summer for the Iowa State University/Industry Affiliate Program for Productivity, Quality, and Reliability. Included in these is *Introductory NOTES* (Notation and Terminology for Statistics), prerequisite material for elementary quality control.

The new university/industry affiliate program, established in June 1985, provides opportunities for the departments of Statistics and Industrial Engineering to cooperate with local companies in an interchange of ideas, techniques, and research needs. The program is presently focused primarily on the industrial statistics area.

Beginning fall semester, a research assistantship was provided by the Graduate College, and sponsored by Boeing Corporation, to support a statistics graduate student under the affiliate program. This assistantship was held by Stephen Crowder, who did thesis research in the area, wrote computer software for industrial statistics, and prepared materials for short courses. The first of these was given for affiliates and others in March 1986, by Stephenson, Vardeman, and

industrial engineering faculty member Roger Berger, in cooperation with ISU Engineering Extension. This course is described more fully on p. 37.

Repeated consultative visits have been made by Crowder, Vardeman, Stephenson, and/or Berger to Rockwell-Collins Avionics in Cedar Rapids, Iowa, to gather information from its engineers regarding their needs for training in the statistical aspects of reliability and maintainability. Stephenson, Vardeman, and/or Berger participated in several group projects to design and perform industrial experiments at the Sundstrand Corporation Hydro-Transmission Division in Ames.

Two more companies became affiliates during the fiscal year: John Deere in Moline, Illinois, and the Kooima Manufacturing Division of Hayes-Albion Corporation, Rock Valley, Iowa, which makes piece parts for the automotive industry. Peter Cyr, an industrial engineering graduate student, is working at Kooima this summer and is serving as liaison with Berger and Vardeman, through phone consultations, on the implementation of a statistical process control program. Berger and/or Vardeman will make several consulting visits to Rock Valley in the coming fiscal year.

Engineering Research Institute

Consulting on the following projects, on the part of Herbert T. David, Stephen Vardeman, Brenda Ihle, and, in the summer of 1985, Kevin Anderson, was largely made possible through the support of the Engineering Research Institute, in the form of an assistantship held by Anderson and then by Ihle.

A civil engineer asked for an adaptation of an Air Force program for fitting strength-stress relations to the ISU mainframe research computer. A chemical engineering staff member needed development of methodologies for the nonstandard problem of comparing and testing unnested regression models. Plant outage rate estimation in a nuclear engineering project called for development of a system reliability model.

Analysis-of-variance approaches to the comparison of alternative predictors of technological change were discussed in connection with an industrial engineering project. A study of the availability and throughput efficiencies of flexible manufacturing systems required an application of Markov process modeling.

A graduate student in civil engineering wanted advice on estimation of the life distribution of bridges and its possible dependence on vintage, on the basis of incomplete and pooled data. Discussions with another civil engineering student concerned the statistical properties of products and ratios of Poisson counts, in connection with the analysis of coal mineral composition data.

A graduate student in physics was studying noise and distortion afflicting configurations of dish-type antennas. He was advised on the estimation of the corellograms of certain random fields, with special regard to the role of mesh size. A staff member in geodesy, interested in the estimation of spatial patterns, received advice on the utilization of kernels other than covariance kernels.

Graduate students and faculty in chemical engineering brought in several problems. Consulting involved construction of a response-surface model to determine levels of flocculation intensity and polymer concentration for optimal rates of pyrite extraction. This led to the planning of a follow-up study. One project required assistance in developing and fitting a non-linear regression model relating normalized maximum contraction velocity of certain muscle tissue to degree of phosphorylation. An experiment on the mechanics of corrosion placed special emphasis on reconciling theoretical with empirical edge pit diameter distributions. A fourth project involved the study of spectroscopic frequency amplitude plots as mixtures of Gauss-Lorentzian distributions.

Research in engineering mechanics led to discussions of the possibility of studying the vibrational nodes of space platforms through the conditioning of certain associated multivariate noise distributions. Conferences with a graduate student from the Department of Materials Science and Engineering centered on a nonlinear regression problem and later on developing appropriate L_1 and L_2 measures predicting accuracy in a simulation study. A problem in geotechnical engineering raised questions about the adequacy of empirically determined coefficients required in prediction of the settling rate of structures. Consultations with a graduate student in hydrology addressed the formulation and estimation of stochastic models of the dispersion of a pollutant in an aquifer, taking account of both flow and diffusion.

■ Social Sciences

Kenneth J. Koehler has served as one of the investigators on two grant projects headed by Harry Lando, Department of Psychology. One is a project on long-term modification of chronic smoking behavior, supported by a grant from the American Cancer Society for the period January 1984-December 1985. The other is a project for social learning analysis of smoking cessation clinics, supported by the U.S. Department of Health and Human Services for the period July 1985-June 1988.

Both projects are concerned with assessing the long-term effectiveness of several procedures for helping smokers to quit. Considering the time from the quit date to the resumption of smoking as a survival time, survival models for limited failure populations have been used effectively. Analyses are complicated by right and interval censoring of observed survival times and the fact that smokers are treated in groups. Bootstrap methods are being investigated as a way to obtain reliable standard errors for estimates of model parameters.

Mack Shelley consulted with students, staff, and faculty members from political science, family environment, economics, ISU Extension, and history. A special project concerned analysis of data on elections to the second and third Dumas in czarist Russia. Another project, for an Iowa manufacturing company, dealt with tests of normality as applied to their data analysis problems.

Robert F. Strahan provided statistical consulting for a number of graduate students and faculty, and for a few students from other institutions in counseling psychology internships in or near Ames. Topics of some of the research for which consulting was provided are teacher evaluation, vocational counseling, effect of counselor appearance on counselor evaluation, parental behaviors of cerebral palsied and normal children, development of a religiosity inventory, evaluation of a music learning technique, investigation of race differences in the healthiness of newborns, and analysis of speech dysfluencies. Departments for which consulting was provided were Psychology; Child Development; Hotel, Restaurant, and Institution Management; Professional Studies in Education; Industrial Education; Family Environment; and Speech Communication.

Frederick Lorenz continues to work primarily with graduate students and faculty in the social sciences. One particularly interesting consulting project has concerned a sociological study to identify factors that inhibit cooperation among agencies involved in soil conservation at the local level. The agencies are county-level offices of the Soil Conservation Service, the Cooperative Extension Service, the Agricultural Stabilization and Conservation Service, and the Farmer's Home Administration. General categories of factors that inhibit cooperation include resource scarcity and uncertainty about future resources, interpersonal conflict, and the beliefs of organizational leaders about the benefits of interorganizational cooperation. Lorenz designed the analysis strategy for the study, to obtain appropriate contrasts.

Roy Hickman and Leroy Wolins were asked by the Graduate College to assist with the evaluation of covers and layout for a graduate school brochure. This study, involving responses of thirty graduate students to a constellation of stimuli, used classical psychophysical methods and simple chi-square statistics. The analysis provided rather clear bases for selecting the most preferred cover and layout.

Wolins assisted the Department of Child Development in aggregating data derived from children, three to ten years of age, in order to obtain normative data on performance of a perceptual-motor task. The complexity of the problem stemmed from the fact that some of the children were repeatedly measured, providing longitudinal data, whereas other children were measured only once. The investigators were concerned about possible carry-over effects, which apparently were not present, and subsequently with estimating sampling error.

■ Other Consulting/Cooperation

An ongoing collaboration with C. Philip Cox was initiated by researchers in the Department of Botany. It concerns the assessment of the probit, and the provision of alternative, transformations for the analysis of data on the growth of algae from different environmental locations. One objective is to obtain a procedure sensitive enough to detect possible genetic differences.

Cox also collaborated, by correspondence, with a faculty member in the University of Natal, South Africa, on the effects of residuals, outliers, and missing values in the analysis of a randomized block field plot experiment.

Noel Cressie continued research with a colleague in agronomy into robust/resistant estimation of spatial relationships among soil-water infiltration data. This led to a joint article, which has been revised for publication in *Water Resources Research*.

Kenneth J. Koehler tested the randomness of the jackpot wheel for the Iowa Lottery Commission in 1985 at the outset of the state lottery program. He has continued to consult with the commission on probability questions.

Wayne Fuller worked with the research information systems manager of the Garst Seed Company Research Department, Slater, Iowa, on a project using sampling to make early season sales forecasts.

One of the regular features of Stat Lab outdoor get-togethers, rain or shine, is volleyball. On this side of the net, left to right, are Alicia Carriquiry, Terry Moy, Fred Hulting (jumping), and Scott Bullock. On the far side are Steve Rathbun, Noel Cressie (caught mid-air), Janelle Dombek, and Jeff Christman.

Leroy Wolins gave a one-day workshop, on personnel management and practices for management personnel, in San Juan, Puerto Rico, on October 17. This was sponsored by Consultores de Relaciones Corporativas, based in Hato Rey, Puerto Rico.

Wolins also consulted with Iowa Power Services, Sioux City, Iowa, in April 1986 on the reanalysis of data from a customer survey.

Keith Cranford provided regular statistical consulting assistance on problems arising in the College of Business Administration, under an assistantship supported jointly by that college and the Graduate College. This has involved both long-term responsibilities such as performing statistical analyses for faculty research projects and short-term responsibilities such as running computer programs and helping graduate students with minor problems. For example, he worked extensively with a professor in the Department of Finance to establish the statistical framework for a model concerning net interest cost on municipal bonds, and then to perform the computer work necessary to analyze this model. For faculty in the Department of Marketing, he assisted with some SPSS-X programs, changing SPSS programs to SPSS-X and manipulating data to set up a new data set; he also adapted a Fortran program provided by AT&T Bell Laboratories to work on the ISU mainframe computer.

A broad-form cooperative agreement between the U.S. Department of Agriculture and the university provides funds for statistical guidance and improved statistical methodology for the Agricultural Research Service through resident collaborator Jerome Sacks. Working under his direction for varying lengths of time in 1985-86 were research assistants Stephen Crowder, Danny Wolfgram, Yoou-Jen Kang, and I-Shang Jackson Chow.

Two other graduate students were involved in collaborative work under the direction of Sacks. Mamadou Diedhiou collaborated with agricultural engineering faculty. The influence of spatial variation in light intensity and ambient temperature on plant dry weight in two growth chambers was analyzed to provide experimental design recommendations for future corn and soybean research. Light, temperature, and plant dry weight exhibited significant spatial variation, but light and temperature were not correlated with dry weight. For future experiments, an empirical design was suggested in which each chamber would be divided into three blocks. Analyses indicated that almost all of the dry weight spatial variation resided in block variation and the same design suited both growth chambers.

Mohammed Khan worked on an agronomy project. Eight oat cultivars were compared for their relative tolerance or resistance to oat crown rust in a series of greenhouse experiments. Resistant plants do not permit rust to grow, whereas tolerant plants are susceptible to rust yet able to maintain grain yields. The results indicate that differences in tolerance exist among the eight cultivars and suggest a breeding program for tolerance to crown rust. Khan has given design recommendations for future greenhouse experiments.

Current Research

This section summarizes individual research and research supported by grants or sponsored by contracts. New grant projects were established in 1985-1986 with the support of the National Science Foundation, Bureau of the Census, and Office of Naval Research. Previous agreements were renewed with the Army Research Office, Bureau of the Census, and NSF. Also the very large cooperative agreement with the U.S. Soil Conservation Service and a long-term agreement with the USDA Statistical Reporting Service were renewed to support joint investigations involving soil data base management and national resources inventories. In addition, funds were provided 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 within the university.

■ AES Project 890

Oscar Kempthorne has been considering the use of randomization in comparative experiments. The standard randomized designs, such as the completely randomized design, the randomized block design, and the latin square design, have features that should be questioned unless the experimenter has no suspicions about the nature of the experimental units other than those that are incorporated in the restrictions imposed in the randomization process that is used. This situation is considered to be rather rare. In agronomic experiments, for instance, the position of the experimental units, the field plots, is known. The experimenter surely has suspicions about the covariability of experimental units, which are not reflected by the restrictions used in the randomization process. This fact was the basis for the extensive controversy in the 1930s on the merits and demerits of what were called systematic designs. The thesis of present thought is that it is possible via computation to obtain a set of plans that will reflect better the opinions of the experimenter on the pattern of covariability that is present. The resulting set of plans should then be used, it is thought, as a basis for choice of actual plan and for the use of randomization tests and statistical uncertainty intervals for treatment effects. The outcome is that inference is based nearly totally on how the experiment was planned and not on the basis of assumed linear models and the widely, and even uniformly, used assumptions about error.

The nature and theory of the selection index in quantitative inheritance has also been studied by Kempthorne. The idea of choosing an index to obtain a prechosen direction of change, which has received attention in the literature, has been examined, and is seen to be a very special case of restricted selection indices. It is considered that it does not represent a really useful approach and does implicitly incorporate a very restricted concept of economic value of individuals.

■ AES Project 2699

The U.S. Bureau of the Census and 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 1985-1986 was through Joint Statistical Agreements J.S.A. 85-1 and J.S.A. 86-2. Wayne Fuller is principal investigator. Other personnel working on the project include Yasuo Amemiya, Nancy Hasab-El-Naby, John Eltinge, Stephen Miller, Neerchal Nagaraj, Carol Francisco, Daniel Schnell, and Sharon Loubert.

Research continued on the effect of the response error on reported employment status and reported changes in employment status. Fuller and Tin Chiu Chua of the University of South Dakota presented a paper at the Annual Research Conference of the Bureau of the Census, in Washington, D.C., March 1986.

Several topics associated with measurement error models were explored. Miller studied the properties of residuals obtained from the fitted model. He obtained limiting results for the residual process that can be used in tests of normality, tests for outliers, and tests for variance homogeneity. Schnell and Amemiya continued research on properties of estimators for the nonlinear model. Hasab-El-Naby investigated the behavior of estimators for models with heterogeneous error variances. Amemiya obtained large sample results for the multivariate functional and structural relationships in which the covariance matrix is a function of an unknown parameter vector.

Fuller, Eltinge, and Miller studied the use of measurement error models for small area estimation. Both random and fixed models were investigated.

Nagaraj studied estimators for nonstationary autoregressive processes. He derived the limiting distribution for estimators constructed subject to nonlinear constraints. The results have application to the estimation of regression equations containing autoregressive errors.

Estimation of the cumulative distribution function and related statistics, such as the median and interquartile range, in complex surveys was investigated by Francisco and Fuller. Large sample properties of estimators constructed from stratified cluster samples were obtained.

■ PC CARP

The Statistical Laboratory has a contract with the International Statistical Programs Center of the U.S.

Bureau of the Census to develop variance estimation software for complex surveys. Support for the project was also provided through the laboratory's contract with the Soil Conservation Service. The objective of the Census Bureau is to provide developing countries with software that can be used locally to process survey data collected locally. The Iowa State University project on variance estimation is part of a larger project that includes the development of software for survey management, data editing, and tabulation.
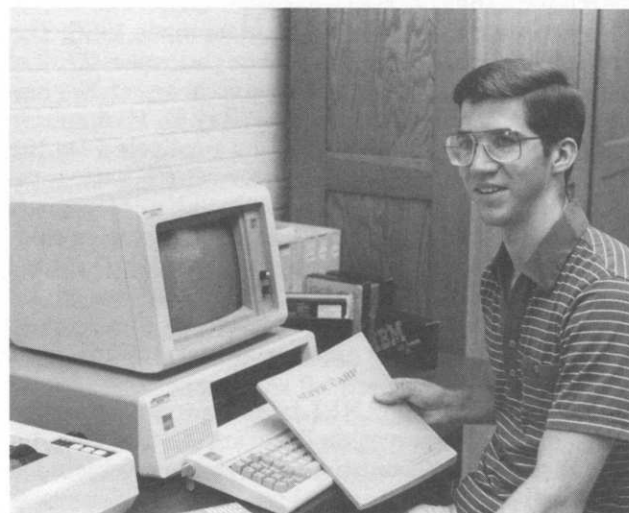
Gary Sullivan, pictured, is working with Dan Schnell, Heon Jin Park, and W. J. Kennedy on rewriting and improving SUPER CARP for use in the IBM-PC. The result is appropriately named PC CARP and is primarily intended to provide developing countries with software for local processing of survey data.

The program under development represents a complete revision and updating of algorithms in SUPER CARP. The program will provide the user with estimates and estimated standard errors for totals, ratios, means, and proportions for subdivisions of the sampled population. Regression equations can also be estimated.

The project is under the direction of Wayne Fuller and William Kennedy. Daniel Schnell and Gary Sullivan have had primary responsibility for code development of the statistical procedures. Kennedy wrote the interface for the menu-driven program. Heon Jin Park has been an assistant on the project and is working on a section for quantile estimation with Carol Francisco and Sharon Loubert.

■ Crop Production Estimation

Cooperative research with the Statistical Reporting Service, U.S. Department of Agriculture, continued under the direction of Wayne Fuller. Mark Reiser, Carol Francisco, Sharon Loubert, and Shaw-Ling Wang worked on the project.

Research on the construction of variance estimators for the objective yield surveys conducted by the Statistical Reporting Service continued. A Monte Carlo study comparing random groups and Taylor estimators of variance was conducted. Both procedures gave satisfactory results, with the Taylor method superior because of larger degrees of freedom.

Research was initiated on methods of early season forecasting for corn yield. The current forecasting procedure was evaluated by studying the contribution of the several components of the model to the mean square error. Forecast methods wherein years are treated as random effects are being investigated.

■ AES Project 2739

The Survey Section continued cooperative research with the U.S. Soil Conservation Service (SCS). This joint work has been carried on 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.

Tabulation and analysis of data collected for the 1982 National Resources Inventory (NRI) were completed for use in the SCS national publication. County and multi-county resource inventories completed by some states in conjunction with the 1982 NRI are still being processed. These data are edited and preliminary estimates computed and sent to states for review. After appropriate corrections, final tables are produced.

A subset of the 1982 NRI database was used for the Great Plains Conservation Program (GPCP) Evaluation. A total of 519 counties in 10 states are included in the GPCP. NRI data for these counties were categorized according to type of GPCP contract and then used to summarize resource conditions in the GPCP area.

A final report on a statistical quality evaluation of the 1982 NRI, summarizing analysis results and recommendations for procedural modifications of future national resource inventories, has now been completed by Carol Francisco. The quality evaluation had involved revisitation of a subsample of the original sample throughout the U.S. and the Caribbean to collect independent on-site observations. Estimates of the measurement error associated with data collection and data processing procedures used in the 1982 NRI provide a means of identifying and evaluating potential problems in the inventory's resource database.

Staff members assisted resource inventory specialists in editing, formatting, and analyzing data collected in the SCS remote-sensing pilot project. Completed for the State of Oklahoma, this study was designed to test the feasibility of collecting resource inventory data from aerial photography, rather than from on-site inspection. The purpose of the pilot test is to compare data obtained by remote-sensing techniques with on-site ground-truth data to evaluate the associated measurement error.

Sample design and selection procedures for the 1987 NRI were initiated during the year. Since this inventory will be an update of the 1982 NRI with primary focus on resource changes, the sample is basically a subsample of approximately 100,000 primary sampling units (PSUs) from the 330,000 used in the 1982 NRI. Prior to subsampling, all 1982 PSUs were post-stratified according to 1982 geographical location, land use, and soil class and subclass. Approximately 2,500 new PSUs were selected in certain urbanizing areas in order to more precisely estimate agricultural land being converted to urban use. Form designs and field instructions for the 1987 NRI were drafted cooperatively with the SCS National Inventory and Monitoring staff. Plans were developed to preprint 1982 data values on the 1987 PSU worksheets by computer.

Survey Section personnel working on resource inventory projects during the year were Carol Francisco, Wayne Fuller, Harold Baker, Mark Reiser, Richard Dorsch, Harvey Terpstra, Art Kuhl, Jeanne Sorenson, Kathie Reinertson, Sue Verkade, Sheri Lin, Dorothy Edwards, Mary Genalo, John Eltinge, Gloriana Giacobello, Sharon Loubert, Heon Jin Park, and Gary Sullivan.

Roy Hickman conferred with SCS personnel at the South National Technical Center, Fort Worth, Texas, regarding remote-sensing procedures as applied to resource inventories. Dorsch, Kuhl, and Hickman attended a training session on the 1987 NRI held at Fort Worth for state SCS inventory and monitoring specialists in the southern region. Kuhl and Hickman also attended regional training sessions in Lincoln, Nebraska; Reno, Nevada; and Chester, Pennsylvania.

Part of the SCS cooperative work involves continued development of the soils interpretations database of soil series in the United States. Harvey Terpstra directs this work and is assisted by Deborah Reed-Margetan, Jan Seagrave, and Jeanne Sorenson. With the addition of 1,500 new records this past year, the database now contains nearly 27,000 records. Over 11,000 of these dynamic soils records were updated this year. All scientific plant symbols on the soils interpretations records were revised to match the Smithsonian-Fort Worth National List of Scientific Plant Names, which is now in use by SCS. Planning began on a major reformatting of the soils data records to allow inclusion of many new data elements.

Much work was done to prepare for moving the SCS soil classification data file to the Statistical Laboratory. This file contains the official soil classification for all series in the U.S. Plans are to store the data in the SPIRES database management system available at the ISU Computation Center. Using this system, SCS personnel will be able to interactively update, search for, and display records under the guidance of a menu-driven program. Reed-Margetan has led the work on the project.

Updating of the SCS map unit file continued, with data for 2,150 soil survey areas now in storage. Nearly 500 of these survey areas were reviewed and updated in preparation for the computerized creation of map unit interpretation records that will be downloaded to a relational database management system on microcomputers in SCS offices. The map unit interpretation records will also be used by SCS in computerized geographic information systems to produce graphic displays of soil properties.

Harvey Terpstra traveled to Fort Collins, Colorado, in October to attend an SCS System 2000 DBMS training session; to Portland, Oregon, in November to confer with SCS offices; and to Washington, D.C., in May to attend the annual SCS DBMS

workshop. Deborah Reed-Margetan traveled to Philadelphia in February to attend a training session of AT&T UNIX-based microcomputers, one of which was recently purchased by SCS and the Statistical Laboratory Survey Section.

Reliability and Censored Data Analysis

William Q. Meeker, Jr., and Luis Escobar (Louisiana State University) have been investigating methods of assessing the effects of departures from model assumptions and for detecting influential observations when using regression analysis with censored data.

George Ostrouchov (Oak Ridge National Laboratory) and Meeker have been using Monte Carlo simulation to investigate the accuracy of large sample approximate confidence intervals for distribution parameters and percentiles when data are interval censored. Such data arise in practice when failures in a life test are detected only at particular inspection times. The results show that the number of inspections does not have a large effect on accuracy. However, the most striking result is that, although the accuracy of the normal theory confidence intervals can be quite poor, likelihood ratio based confidence intervals have excellent accuracy, even with sample sizes as small as 10 or 20.

Sequential Decision Theory

The short-term visit of Peter B. Morgan, University of Western Ontario, in March continued joint research with Noel Cressie. Under more realistic assumptions than those usually imposed in the sequential analysis literature, they have developed a variable-sample-size-sequential probability ratio test (VPRT) that dominates the usual sequential probability ratio test (SPRT), in that the Bayes risk of the VPRT is lower than the Bayes risk of the SPRT. Moreover, the VPRT was shown to minimize the expected total sampling cost. Cressie and Morgan are currently developing the software to compute stop/continue boundaries, and are investigating their shape in various special cases.

Spatial Statistics

Noel Cressie, in joint research with Geoffrey M. Laslett, CSIRO, Australia, is investigating spatial models that are not second-order stationary. Degrees of nonstationarity are determined by how much spatial differencing is needed to achieve stationarity. The implications for kriging, i.e., spatial predictions, and the link with time series models, are under investigation. Cressie's part of this research is being carried out under a two-year grant from the National Science Foundation.

Under his ASA/Census fellowship, Cressie continued study of small area estimation using spatial models. With ASA/NSF Census associate N. H. Chan, he has developed estimation procedures for detecting spatial relationships between neighboring small areas.

Statistical Prediction

With support from a grant by the Office of Naval Research, David Harville is investigating the problem of predicting the value of a random variable w, based on knowledge of n observable random variables $y_1,...,y_n$, where the expected values of w, $y_1,...,y_n$ depend linearly on unknown parameters $\beta_1,...,\beta_p$. Satisfactory point and interval predictors are already available for the case where the covariance matrix V of w, $y_1,...,y_n$ is known (up to a scalar multiple). Unfortunately, in most applications, the elements of V are not known but rather are functions of an unknown parameter vector θ. In such applications, it is common practice, in predicting the value of w, to act as though an estimator $\hat{\theta}$ of θ is the true value of θ. When this practice is followed, the variance of the error of the point predictor is understated, and the prediction interval is overly optimistic.

The main objective in Harville's research is the development of prediction procedures suitable for various cases where V is unknown. The point predictor, say $\hat{w}(\hat{\theta})$, obtained by acting as though $\hat{\theta}$ is the true value of θ is being studied. More specifically, improved approximations for the variance $V[\hat{w}(\hat{\theta}) - w]$ of the prediction error are being sought, and, using $V[\hat{w}(\hat{\theta}) - w]$ as a criterion, different choices for the estimator $\hat{\theta}$ are being compared. Also, Bayesian point predictors are being studied. Prediction intervals for the value of w (that improve on the intervals obtained by acting as though $\hat{\theta}$ is the true value of θ) are being devised.

Multivariate Analysis

Yasuo Amemiya's research on multivariate analysis during the year was conducted primarily during his residency at Stanford University but also received some support from the Sciences and Humanities Research Institute at Iowa State.

For multivariate functional and structural relationships with general error covariance structure, Amemiya investigated properties of estimators and test statistics that can be computed by the standard computer packages. Asymptotic inferences using the estimated standard errors and chi-square goodness-of-fit tests derived under the normal assumption were shown to be valid for a broad class of models. Two commonly used test procedures for determining the number of relationships were compared, based on their asymptotic powers against models with incorrectly specified numbers of relationships.

The limiting distribution of the characteristic roots of a random symmetric matrix in the metric of the identity or another random symmetric matrix was characterized under a general set of assumptions. Under these assumptions, the distributional forms of the random matrices are not completely specified. The true roots depend on n, the index of the sequence, and approach constants at a certain rate as n increases. The multiplicity of the true roots at the limit may be different from that for every finite n. Applications of the general results to some multivariate testing problems were considered.

In collaboration with T. W. Anderson at Stanford, Amemiya obtained some new results in factor analysis. Two types of goodness-of-fit test statistics were shown to have a common limiting chi-square distribution under the model specification for a large class of factor analysis models with possibly nonnormal factors and nonnormal errors. In the confirmatory (restricted) factor analysis, the limiting distribution of the estimated factor loadings was shown to be common for virtually any type of factor and error vectors, provided that the components of the error vector are independent and that the model is identified by restrictions only on the factor loading matrix.

■ Bayesian Statistics

Glen Meeden worked on various methods for incorporating prior information in a Bayesian-like way for problems with large parameter spaces. In addition he worked on some admissibility questions using the stepwise Bayes technique. This work was supported in part by a grant from the National Science Foundation.

■ Order Statistics and Robust Inference

A novel method for selecting the best object in a round-robin type paired-comparison experiment has been studied by H. A. David, principal investigator, and Douglas Andrews, with support of a new three-year grant from the Army Research Office. Objects are paired sequentially, and the experiment is stopped as soon as one object has achieved a number of preferences that no other object could equal (weak curtailment) or surpass (strong curtailment) in the completed tournament. The method was motivated by the closed adaptive sequential procedures introduced by Bechhofer and Kulkarni for selecting the best of several Bernoulli populations.

Michael Rogers completed research on selection using a dichotomized auxiliary variate (see his dissertation abstract on p. 35). H. A. David wrote a note on the estimation of the mean of a selected random effect in a components-of-variance or mixed model.

B. K. Kale, visiting professor, and U. Gather (University of Iowa) have prepared an extensive critical review article on outlier generating models. The review includes discussions of the k-outlier model, the exchangeable model, and the labeled model. Outlier-proneness of distributions and the Bayesian approach to outliers are also reviewed. There is a large bibliography.

■ Sciences and Humanities Research Institute (SHRI)

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 1985-86. The work of Amemiya, David, and Meeden has been described in previous sections.

Mervyn Marasinghe, under SHRI, constructed a new computing algorithm for computation of certain interaction sums of squares in linear models. He continued work with Charles Farmer on interaction in mixed and multivariate linear models. Then in June, with support from a university research grant, he went to Montana State University to spend a month in joint research with Robert J. Boik, Department of Mathematical Sciences.

Krishna Athreya's research during the 1985-86 year was supported by SHRI and by a grant from the National Science Foundation. It dealt with the following areas: bootstrap asymptotics, Bessel function asymptotics, Markov processes, branching processes, density of states, and Ito processes.

In the area of bootstrap methods, the work initiated last year continued. It was shown that, if $X_1, X_2, \ldots$ are i.i.d. with c.d.f. F in the domain of attraction of a stable law of order α with $0 < \alpha < 2$, then the random distribution function of the bootstrap mean appropriately normalized converges weakly in the Skorohod space $D(-\infty, +\infty)$ to a random c.d.f. whose canonical measure is a Poisson random measure.

Using the global central limit theorem and its local version, Athreya established the following asymptotics concerning Bessel functions. Let $I_\rho(x) = \Sigma_0^\infty (k!)^{-1} (\Gamma(k + \rho))^{-1} (x/2)^{2k+\rho}$ for $x \geq 0$, $\rho \geq -1$.

a) For fixed ρ, $\lim_{x \to \infty} I_\rho(x)\sqrt{x}\, e^{-x} = 1/\sqrt{2}$.

b) If $a(x)/\sqrt{x} \to \alpha$, $0 \leq \alpha < \infty$, then $I_{a(x)}\sqrt{x}\, e^{-x} \to \phi(\alpha)$.

c) $\Sigma_{0 \leq \rho \leq a(x)} [I_\rho(x)e^{-x}] \to \Phi(\alpha) - 1/2$, where $\phi(\alpha)$ and $\Phi(\alpha)$ are the standard normal p.d.f. and c.d.f., respectively.

The famous result of Darling and Kac on the limiting distribution of occupation times or, more generally, of functionals of the form $\int_0^t f(X(u))\, du$, where $X(\cdot)$ is a Markov process, was extended by Athreya to a wider class of function when $X(\cdot)$ satisfies a regenerative property.

For the case where $\{X(t)\}$ is a regenerative process with invariant measure $\Pi(\cdot)$ and A_n is a sequence of sets such that $\Pi(A_n) \to 0$, limit theorems for the hitting times T_{A_n} were established, under the hypotheses of positive and null recurrence, and applied to the age process of a renewal sequence.

A result was obtained in the area of branching processes that is a significant improvement over the results of A. Pakes and H. Weiner. Let $\{Z_n\}^\infty$ be a critical branching process and $M_n = \max_{1 \leq j \leq n} Z_j$. It was shown that if $E(Z_1^2|Z_0 = 1) < \infty$ then $(E\, M_n)(\log n)^{-1} \to i$ if $Z_0 = i$ with probability 1.

In collaboration with two scientists of the Ames Laboratory of the U.S. Department of Energy, Krishna Athreya developed a formalism for calculating the density of states function for tunneling systems in amorphous materials. A paper on this joint research has been accepted by the *Journal of Physical Chemistry*.

In collaboration with faculty in the Department of Mathematics, he obtained a minimal process construction of a solution to an Ito process with both diffusion and jumps.

■ Other Research

C. Philip Cox continued research on procedures applicable when variances depend on population means. Previously obtained results have been extended to the analysis of two or more groups.

Interparametric dependence also obtains for binomially distributed data. Cox conducted research in this area to provide a joint regional estimation procedure for two proportions estimated from large samples. The procedure also gives a conservative interval for the odds ratio. In related research, the powers of two statistics commonly used to discriminate between two population proportions were compared, and situations where relative power advantages can occur were defined.

Ted Bailey, in collaborative research with two agronomists, K. Takeda and Kenneth Frey, evaluated the pattern of changes in the mean, variance, and covariance of quantitative traits measured in oat populations from successive generations of backcrosses. Bailey prepared a paper based on this work for presentation at the 1986 North Central Region 2 Corn Quantitative Genetics Conference. The materials used in the study were F_2-derived lines from the eight possible matings among two *Avena sativa* pure lines and four *A. sterilis* collections. Eighty seeds from each backcross generation (BC_1-BC_5) and each parent were space sown in the field. Thus the experimental material consisted of 50 populations each with 80 lines. It was concluded that, in general, genotypic associations among traits in matings of *A. sativa* × *A. sterilis* cannot be manipulated by increasing the proportion of germplasm from the *A. sativa* parent.

This constancy of genotypic correlations observed over generations of backcrossing can perhaps most easily be explained as a consequence of inbreeding. The linkage disequilibrium generated in the original matings of homozygous parents persists because little opportunity for recombination exists, due to the inbreeding associated with the backcross method. Therefore, backcross breeding in general would not be a useful procedure for breaking undesirable trait associations.

In addition to research associated with miscellaneous studies in psychometrics and personality assessment, Robert Strahan began a new psychophysiological research program based on work of some years ago. Properties of a dry electrode, portable measure of electrical skin conductance were investigated. A simpler device was constructed for use in the measurement of physiological arousal. An early application of this device was in its loan to a University of Maryland graduate student, who used it, along with heart rate and self report measures, in November at the national luge (bobsled) competition at Lake Placid, New York. His intent was to track the arousal level of competitors leading up to their actual runs. Possibilities exist for the employment of the device in other settings in which measurements of physiological arousal are desired within seconds.

While on faculty improvement leave, Strahan developed a set of annotated computer programs for analysis of typical research problems. These are intended for use in statistical consulting with graduate students and faculty in the social and behavioral sciences and in education.

Carl Roberts is working with a colleague at the University of Notre Dame on a content analysis of accounts of exorcisms from the fourth to the seventeenth centuries. They have translated their sample of 300 accounts from Latin to English. Funded by an ISU grant, the coding of the accounts is now almost completed. The general purpose of this study is to explore changes in how exorcism was promoted by the Catholic church, starting with the introduction of the technique in the fourth century, continuing with the questioning of its efficacy during the plagues, and ending with its declining popularity toward the end of the seventeenth century.

In response to a paper Roberts presented at the American Sociological Association meeting in Washington, D.C., on the linguistic technique used in coding the exorcism accounts, he received an invitation to write a short Sage Series publication on content analysis. This work is progressing.

From fall 1984 to fall 1985 Roberts conducted three surveys of the Ames religious community. On the basis of data from the first interview survey, four churches were selected for in-depth study. Data from the second survey have now been partially analyzed. In fall 1985, questionnaires were sent to a random sample of 234 Ames households to provide a base of comparison for the other surveys. Roberts has written one paper using some of these data and is currently working with a sociology graduate student on further analyses. The general purpose of the study is to explore whether different psychological and/or interpersonal needs are met by different types of churches.

Fred Lorenz's research this past year has primarily been directed at the analysis of a new data set that provides insights into the survival of regional councils under conditions of declining federal support. In August 1985 the National Association of Regional Councils (NARC) released the results of a survey that showed that between 1980 and 1983 about 140 rural regional councils closed out operations. In metropolitan areas, most regional councils still are in operation, but approximately 80 percent had declines in budgets and over 70 percent have had to cut staff. Data from census reports, the *County & City Databook, 1977,* and other sources have been merged with the NARC data in order to test theories that predict which regional councils will survive and which will fail.

In addition, Lorenz continues to work with sociological colleagues on research related to the strategic adaptation of social service agencies to declining federal support. In other collaborative research he has worked on an evaluation of the Land & Water Conservation Program, a more unified theory of organizational effectiveness, and a study of perceptions of development problems among world development experts and leaders.

Professional Activities

"Why did statistical thinking take so long to be recognized? Is it recognized at all adequately even at the present time? I think not. . . . But part of the problem originates with the statistical profession itself. It has not given adequate recognition to real applied statistics. The statistical profession has not 'sold' statistical ideas and statistical thinking as well as it should have. . . ."
—Oscar Kempthorne, from the President's Column, *The Institute of Mathematical Statistics Bulletin* 14:5 (1985) 233-237.

Oscar Kempthorne completed his term as president of the Institute of Mathematical Statistics in August 1985 at the annual meeting in Las Vegas, Nevada. In addition to other duties he organized and chaired the Special 50th Anniversary Session: Origins and Early Days of IMS and chaired the 50th Anniversary banquet. He had also instituted a series of President's Columns in the institute's *Bulletin*. Those and other published remarks by Kempthorne are referred to in the Publications Section of the current annual report (pp. 28 and 31-32) and the 1984-85 report. He continues to serve on the executive committee as immediate past president.

H. A. David is chair of the IMS Memorials Committee and vice-chair of the American Statistical Association Committee on ASA Archives; Herbert T. David is chair of the IMS Archives Committee.

William J. Kennedy was elected to the American Statistical Association Board of Directors for 1986. Kenneth Koehler completed a three-year term as governor of the District 6 Council of Chapters for the ASA in 1985. William Q. Meeker is on the advisory board of the ASA Section on Physical and Engineering Sciences. Stephen Vardeman is a member of the ASA's Committee on Quality and Productivity and the 1986 Program Committee. W. Robert Stephenson is serving on the ASA Section on Statistical Education Committee to Prepare Guidelines for Undergraduate Programs in Statistics.

Stephenson also was selected as director-at-large for 1986-89 for Mu Sigma Rho national statistics honorary society.

Wayne Fuller continued to serve as a member of the National Research Council's Panel on Decennial Census Methodology and completed a three-year term on the council's Committee on National Statistics. He attended meetings in Washington, D.C., in September and in October 1985 and May 1986, respectively. Fuller also was a member of a three-person panel that reviewed the research program of the Statistical Reporting Service, U.S. Department of Agriculture, in Washington, D.C., January 28-30, 1986.

H. A. David is chair of the Electorate Nominating Committee, Section U, American Association for the Advancement of Science.

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

From late June through mid-July 1985, Mervyn Marasinghe taught a lecture course on multivariate analysis as visiting lecturer in the new Department of Statistics and Computer Science, University of Colombo, Sri Lanka. He also formulated test questions on the course content for the university's 1985 M.Sc. examination in applied statistics. While there, he had an opportunity to work with the British-developed GLIM program, a well-known statistical package, on the Data General Computer, and studied how Colombo is using BBC microcomputers for teaching undergraduate and graduate students.

"[Statistics] is a primary tool in getting a useful picture of our world as it is, and as a means of developing a *dynamic* picture or model. . . . The big advance in human thinking of this century is, I believe, the idea of models. We have to develop models of the dynamics of this real world in which we have been placed. . . ."
—Oscar Kempthorne, from the President's Column, *ibid.*

While in Washington, D.C., as an ASA/Census fellow, Noel Cressie gave a series of six lectures, "Statistics of spatial data," to the Statistics Research Division, Bureau of the Census, in October, November, and December 1985. Then between May 27 and June 10, 1986, as visiting lecturer, he gave a course of twelve lectures on spatial statistics in Lausanne, Switzerland, for the Troisième Cycle Statistique et Probabilités Appliquées offered jointly by the Universities of Geneva and Lausanne.

On behalf of the Food and Agriculture Organization, United Nations, H. A. David went to New Delhi, India, for the month of December 1985 as a consultant on curriculum development and training at the Indian Agricultural Statistics Research Institute. He then met with FAO personnel in Rome, Italy, to report on his activities.

Shashikala Sukhatme visited the Centre of Studies in Resource Engineering, Indian Institute of Technology, Bombay, on December 26 to observe the methods of data collection and analysis in geotechnical surveys.

David F. Cox attended a short course on biological assay conducted by D. J. Finney in connection with the meetings of the Biometric Society in Atlanta, Georgia, March 14, 1986.

On June 19-21, in Chicago, Illinois, William Q. Meeker, Jr., took part in a working conference, "Making Statistics More Effective in Schools of Business," cosponsored by the Graduate School of Business Administration, University of Chicago, and by components of both the American Statistical Association and the National Research Council.

As usual, faculty and staff took part in a wide variety of professional conferences. Papers presented are listed later in this section. Other forms of participation are mentioned below.

Krishna Athreya attended the American Mathematics Society's Summer Conference on Function Estimation held at Humboldt State University July 28-August 2, 1985.

At the joint annual statistical meetings in Las Vegas, Stephen Vardeman chaired a session on Quality Management and Training.

Shashikala Sukhatme participated in the Order Restricted Inference Conference sponsored by the Office of Naval Research and the University of Iowa and held in Iowa City, on September 11-13.

Theodore B. Bailey, Jr., attended the Gordon Research Conference on Quantitative Genetics and Biotechnology, held in Santa Barbara, California, on January 19-24, 1986.

Wayne A. Fuller and Tsung-Hua Lin went to the 11th Annual Conference of the SAS Users Group International, held in Atlanta, Georgia, February 9-12.

William J. Kennedy chaired a session on Statistical Computing for Sample Surveys at the 18th Symposium on the Interface of Computer Science and Statistics, Fort Collins, Colorado, in March.

At a workshop during the Midwestern Sociological Society meeting in Des Moines, Iowa, on March 26, Carl Roberts discussed and demonstrated PLCA, a program he had written for linguistic content analysis.

Jauvanta Walker received an ISU Professional and Scientific Continuing Education grant to attend a seminar on Newsletter Editing, Design, and Production held in Des Moines, Iowa, April 21, by Promotional Perspectives, Ann Arbor. She has continued to serve as second vice president of the Iowa Poetry Association.

On June 3-5, Stephen Vardeman attended the 1986 Quality and Productivity Research Conference at Oakland University, sponsored by Ford Motor Company, Oakland University, Bell Communications Research, the University of Wisconsin, AT&T, and the Ellis Ott Foundation.

Glen Meeden took part in the NSF/CBMS Conference on Hierarchical and Empirical Bayes Models and Methods, held in Bowling Green, Ohio, June 5-9. Then he and Noel Cressie attended the 4th International Symposium on Statistical Decision Theory and Related Topics, held in West Lafayette, Indiana, June 16-20.

John Eltinge went to Columbia, Missouri, to attend the International Research Conference on Reliability and Quality held there June 9-11 and sponsored by the U.S. Air Force Office of Scientific Research, the Army Research Office, the Office of Naval Research, and the University of Missouri-Columbia.

Stephen Miller and Daniel Schnell received fellowship grants from the American Statistical Association to attend its Conference on Survey Research Methods in Agriculture, held in Leesburg, Virginia, June 15-18.

■ Papers Presented, Lectures, and Seminars

At the 1985 joint statistical meetings of the American Statistical Association, the Biometric Society (ENAR and WNAR), and the Institute of Mathematical Statistics in Las Vegas, Nevada, August 5-8:

AMEMIYA, Yasuo: "Tests for the multivariate functional and structural relationships";

Anderson, K. K., and K. B. ATHREYA: "Limit theorems for renewal processes in the infinite mean case";

COX, David F.: Discussant, session titled Statistical Consulting: Developing Its Role in Académe;

DAVID, H. T., Stephen B. VARDEMAN, and J. Marcus Jobe (Iowa State University and Miami University of Ohio): "Invariant Poisson process discrimination";

Fenech, Alan P., and David A. HARVILLE: "Confidence regions for variance components in unbalanced mixed linear models";

Gan, F. F., and Kenneth J. KOEHLER: "Goodness-of-fit statistics for location-scale distributions";

Gibson, C. L., G. D. Buswell, William Q. MEEKER, Jr., and D. H. Myers: "STAR: Software for the analysis and presentation of reliability data";

GOEBEL, J. Jeffery (Iowa State University and U.S. Soil Conservation Service), Mark REISER, and Roy D. HICKMAN: "Sampling and estimation in the 1982 National Resources Inventory";

HARVILLE, David A.: "Invariant inference for variance components";

Mazloum, Reda (Cairo University, Egypt), and Glen MEEDEN: "Using the stepwise Bayes technique to choose between experiments";

STEPHENSON, W. Robert: "Statistical quality control: Can we practice what we teach?"; also panel discussant: Guidelines for Minimum Degree Requirements in Undergraduate Statistics Degree Programs;

SUKHATME, Shashikala: "Kriging with perturbed variogram";

van Schaik, Jan W. J. (Upjohn Company), and Kenneth J. KOEHLER: "Incorporating a judge effect into the Bradley-Terry model for paired comparisons";

VARDEMAN, Stephen B.: "Inspection, rectification, and acceptance sampling"; also discussant, session on Standards for Statistical Methods and Sampling;

Wagner, Annette E. (A. C. Nielsen Company), and William Q. MEEKER, Jr.: "A survey of statistical software for life data analysis."

At the Centenary Session of the International Statistical Institute, Amsterdam, the Netherlands, held August 12-22, 1985:

CRESSIE, N.: "A geostatistical analysis of the Mercer and Hall wheat data";

DAVID, H. A.: "Order statistics for random variables expressible as sums";

Fuller, Wayne A., and Rachel M. Harter (Iowa State University and A. C. Nielsen Company): "Small area estimators based upon the components of variance model";

IACHAN, Ronaldo, and B. Jones: "The structure of rotation sampling designs."

At the annual spring meeting of the Biometric Society (ENAR), Atlanta, Georgia, March 17-18, 1986:

CRESSIE, Noel: "Kriging to produce maps";

FULLER, Wayne A.: "Measurement error models for multinomial variables."

At the joint meetings of the Iowa sections of the Mathematical Association of America, Society of Industrial and Applied Mathematics, and American Statistical Association, Iowa City, Iowa, April 12:

CRESSIE, Noel: "Spatial prediction of acid rain using kriging";

STEPHENSON, W. Robert: "Quality control: Helping industry in Iowa."

At other locations:

AMEMIYA, Yasuo: "Estimation for the nonlinear implicit functional relationship" and "Multivariate linear errors-in-variables model with general error covariance structure," seminars at Stanford University for the Department of Statistics, November 12, and the Department of Economics, November 20, 1985, respectively.

"A bias-adjusted estimator for the nonlinear functional relationship," Department of Statistics colloquium, University of California, Berkeley, May 6, 1986.

ATHREYA, Krishna: "On bootstrap methods in statistics," seminar for the departments of Statistics at Gauhati University and the University of Madras, India, December 10 and 17, 1985, respectively.

"Bootstrap asymptotics," seminar for the Statistics and Mathematics Division, Indian Statistical Institute, Calcutta, December 13; also an invited address with the same title, Indian Science Congress, New Delhi, January 7, 1986.

"Renewal theory in the infinite mean case—recent results," seminar, Indian Statistical Institute, New Delhi, January 10.

"Maximum of critical branching process," seminar for the Institute of Mathematical Sciences, Madras, June 6.

"Hitting times of decreasing sets," seminar for the Department of Statistics, University of Madras, June 12.

"Bootstrap asymptotics I," lecture at the Department of Mathematics, Manipur University, Imphal, India, June 26.

BAILEY, Theodore B., Jr.: "Trait associations with backcrossing," at the North Central Region 2 Corn Quantitative Genetics Conference, Des Plaines, Illinois, February 25.

"Quantitative genetics, biotechnology, and statistical consulting," to the Osborn Research Club, Iowa State University, March 17, 1986.

Carriquiry, Alicia L.: "Analysis of multiple traits when one variate is censored," by Carriquiry, Rohan L. Fernando, and Daniel Gianola, at the national meeting of the American Society of Animal Science, Athens, Georgia, August 14, 1985.

COX, David F.: "Summarizing data from experiments in entomology," Department of Entomology seminar, Iowa State University, October 28.

CRESSIE, Noel: "Spatial statistics," seminar presented for the U.S. Bureau of the Census July 27, 1985, and for the National Bureau of Standards September 26 in Washington, D.C.

"Spatial analysis of data on lattices," seminar for the Bureau of the Census, Washington, D.C., on September 18, which was also presented at the University of Maryland, College Park, on October 24, at Johns Hopkins University November 20, at the University of North Carolina, Chapel Hill, on November 25, and at the University of Chicago December 2.

"A graphical representation of nonstationarity," for Probability and Statistics Day, University of Maryland, on December 7.

Discussant, Washington Statistical Society session on An Application of Spatial Modeling for the Estimation of Census Nonsampling Variance, Washington, D.C., March 13, 1986.

"The VPRT: Optimal sequential and nonsequential testing," at the 3rd International Symposium on Decision Theory and Related Topics, Purdue University June 16.

DAVID, H. A.: "Concomitants of order statistics: Theory and applications," two seminars on December 11 and 12, 1985, and "Robust estimation in the presence of outliers," a seminar on December 24, all presented at the Indian Agricultural Statistics Research Institute, New Delhi, India.

"Closed adaptive sequential tournament selection procedures," seminar for the Department of Statistics and Applied Probability, University of Alberta, Edmonton, Canada, April 11, 1986.

DAVID, Herbert T.: "An analysis of warranty data," by David, Tony Lin (Iowa State University and General Motors Institute), and J. Marcus Jobe (ISU and Miami University of Ohio), at the 13th annual Mathematics and Statistics Conference, held at Miami on September 27, 1985.

"Saddle point strategies—Rationale and rationality," seminar for the Department of Statistics and Actuarial Sciences, University of Iowa, November 14.

FULLER, Wayne A.: "Least squares estimation for the errors-in-variables model," lecture for the Central Missouri chapter of the American Statistical Association, Rolla, Missouri, July 8, 1985; also a paper by the same title at the 10th Symposium on Operations Research, Munich, West Germany, August 27.

"Small area estimation" and "Topics associated with errors-in-variables," lectures presented for the Department of Statistics and Econometrics, Fern University, Hagen, West Germany, August 30.

"Using PROC NLIN for time series prediction," at the 11th Annual Conference of the SAS Users Group International, Atlanta, Georgia, February 10, 1986.

"Response error models for changes in multinomial variables," by Fuller and Tin Chiu Chua (ISU and University of South Dakota), at the 2nd Annual Research Conference sponsored by the Bureau of the Census, March 26 at Reston, Virginia.

"A measurement error model for multinomial variables," seminar, Department of Statistics, Purdue University, April 10.

"Small area estimation as a measurement error problem," at the ASA Conference on Survey Research Methods in Agriculture, Leesburg, Virginia, June 16, and at the U.S. Bureau of the Census, Washington, D.C., June 18.

HARVILLE, David A.: "Prediction in mixed linear models and in general" and "Confidence intervals for a variance ratio, or for heritability, in an unbalanced mixed linear model," seminars for the Department of Statistics, University of Florida, October 31 and November 1, 1985.

HOTCHKISS, Donald K.: "Effect of acid and alkaline pyrophosphate blends on the natural flora of a cooked meat system," by

J. A. Marcy, A. A. Kraft, Hotchkiss, D. G. Olson, H. W. Walker, and P. J. White, at the 46th annual meeting of the Institute of Food Technologists, Dallas, Texas, June 17, 1986.

IACHAN, Ronaldo: "Robustness in survey sampling," seminar at the Federal Technical Institute, Zurich, Switzerland, August 8, 1985.

"Efficient sampling strategies," seminar for the Department of Statistics, Dortmund University, Dortmund, West Germany, August 9.

KALE, B. K.: "Masking effect on tests for outlier" and "Optimal unbiased estimation," seminars for the Department of Mathematics and Statistics, Miami University of Ohio, March 10 and 11, 1986.

KEMPTHORNE, Oscar: "The role and future of statistics," at Bellcore Statistics Day, November 14, 1985, Livingston Corporate Center, Bell Communications Research, Morristown, New Jersey.

"Nature and nurture in human abilities: An exercise in correlation and causation," general research colloquium, Bell Communications Research, Morristown, November 15.

"Comparative experiments and randomization," seminar for the Department of Statistics and Actuarial Science, University of Iowa, April 24, 1986.

LORENZ, Frederick O.: "Grant-getting, decision rules, and community characteristics: A program evaluation of the Land and Water Conservation Fund Distribution Patterns," by Gary Mattson and Lorenz, at the Southwestern Political Science Association meetings, San Antonio, Texas, March 21.

"The maintenance of metropolitan organization: The case of regional councils," by Lorenz and Daniel Muhwezi, at the Midwest Sociological Society meetings, Des Moines, Iowa, March 26; also "Barriers to interorganizational relationships: A comparative analysis," by Thomas J. Hoban, Peter F. Korsching, Lorenz, and Charles L. Mulford, March 27.

MEEDEN, Glen: "Incorporating prior information in a pseudo-Bayesian way in finite population sampling problems," at the 4th Midwest Statistics Conference, East Lansing, Michigan, November 9; also a paper by the same title at the 15th Anniversary Meeting of the National Bureau of Econometric Research-National Science Foundation Seminar on Bayesian Inference in Econometrics, in Mexico City, Mexico, January 16, 1986; and a seminar at the University of Kentucky March 31.

"Where is the center of a population?"—lecture to the Department of Statistics, Waldorf College, November 14, 1985, sponsored by the COPSS Visiting Lecturer Program.

"Admissibility of the Kaplan-Meir and other maximum likelihood estimators in the presence of censoring," seminar for the Department of Statistics, University of Minnesota, May 30, 1986, and an invited paper by the same title, by Malay GHOSH (ISU and University of Florida), Meeden, C. Srinivasan, and Stephen B. VARDEMAN, at the Institute of Mathematical Statistics Regional Meeting, West Lafayette, Indiana, June 14.

MEEKER, William Q., Jr.: "Tools and methods for field performance and laboratory data analysis," August 15, 1985, at Bell Communications Research, Inc., Red Bank, New Jersey.

"Statistical and practical considerations for planning accelerated life tests," March 10, 1986, at the Army Research Office Workshop on Life Testing, hosted by George Washington University in Washington, D.C.

"How to plan an accelerated life test—Some practical guidelines," by Meeker and Gerald J. Hahn, at the American Society for Quality Control Annual Quality Congress, Anaheim, California, May 20.

POLLAK, Edward: "Some results for partially inbreeding finite populations," at the 1986 annual meeting of the American Society of Naturalists, Pacific Grove, California, May 27.

REISER, Mark R.: "Estimators of some latent structure models," by Reiser and Karl Schuessler, at the 50th annual meeting of the Midwest Sociological Society, March 27, in Des Moines, Iowa.

"A comparison of estimators for some latent structure models," seminar, Department of Sociology, Indiana University-Bloomington, April 12.

ROBERTS, Carl W.: "Coding exorcisms: How to translate words to numbers and back again," for the Summer Cultural and Recreational Events Lecture Series, Iowa State University, July 18, 1985.

"Other than counting words: A linguistic approach to content analysis," at the annual meeting of the American Sociological Association, Washington, D.C., August 28, 1985.

Schnell, Dan, Gary Sullivan, William J. KENNEDY, and Wayne A. FULLER: "PC CARP: Variance estimation for complex surveys," at the 18th Symposium on the Interface of Computer Science and Statistics, in Fort Collins, Colorado, March 14, 1986.

Scott, Margaret E. (Indiana State University-Terre Haute), and Edward POLLAK: "Conditions under which stable equilibrium frequencies and those maximizing the mean fecundity coincide," at the 54th annual meeting of the Genetics Society of America, in Boston, Massachusetts, August 13, 1985.

SHELLEY, Mack C. II: "Conservative coalition success in the U.S. Congress: A transfer function analysis," at the annual meeting of the American Political Science Association, New Orleans, Louisiana, August 1985.

"Howard W. Smith and the conservative agenda: The evidence from roll-call analysis," at the annual meeting of the Southern Historical Association, Houston, Texas, November.

STEPHENSON, W. Robert: "Improvement of quality and productivity: How statistical methods help American industry," seminar presented at Mankato State University on November 6 and at St. Olaf College on November 7.

STRAHAN, Robert F.: "Scope of correlational analysis in statistical investigations," at the annual meeting of the Iowa Educational Research & Evaluation Association, Waterloo, Iowa, November 14.

SUKHATME, Shashikala: "Kriging with perturbed variogram—An application of perturbation theory," seminar, Department of Statistics, University of Poona, India, January 10, 1986.

"On some applications of perturbation theory in statistics," given as a seminar, Department of Statistics, University of Bombay, India, January 16, and as a Graduate School and Department of Statistics colloquium at Ohio State University March 11.

VARDEMAN, Stephen B.: "The ISU Industry/University Affiliate Program in Productivity, Quality, and Reliability," presentation to the Center for Industrial Research and Service (CIRAS) Advisory Board, Iowa State University, October 1985.

"Inspection, rectification, and acceptance sampling," graduate student seminar, Department of Industrial Engineering, Iowa State University, November.

WOLINS, Leroy: "Bias in ratings: The observational unit mistake (again)," seminar for the Department of Professional Studies in Education, Iowa State University, March 31, 1986.

Zimmerman, Dale: "A random field approach to spatial experiments," seminar, Cornell University Statistics Center, April 14.

Publications and Dissertation Abstracts

William Q. Meeker, Jr., has been appointed editor-elect of *Technometrics* for 1986. He will be the editor for issues appearing during 1987-1989. Denise Riker is serving as editorial assistant. Meeker has been an associate editor for the past six years. He also continues to serve as an editorial board member of *Selected Tables in Mathematical Statistics*.

William J. Kennedy continues as editor of *The American Statistician*. He is also on the international editorial board of *Communications in Statistics—Simulation and Computation* and is coeditor of its Algorithms Section.

The associate editors of *The American Statistician* include Wayne Fuller, Glen Meeden, V. A. Sposito, and Stephen Vardeman.

In 1985 Meeden completed a six-year term as associate book review editor of the *Journal of the American Statistical Association*. Noel Cressie and David Harville continued to serve as associate editors of the *Journal of the American Statistical Association* Theory and Methods Section.

Other editorial positions held by faculty members follow.

Krishna Athreya is an associate editor of *Zeitschrift für Wahrscheinlichkeitstheorie,* now known as *Probability Theory and Related Fields;* he also serves on the editorial board of *Statistics & Probability Letters.*

In 1986 Noel Cressie was appointed editorial board member of the new international journal *Chemometrics and Intelligent Laboratory Systems,* published by Elsevier.

Wayne Fuller is an associate editor of the *Journal of Business and Economic Statistics.*

Paul Hinz continues as an associate editor of the *Iowa State Journal of Research.*

B. K. Kale is an associate editor of the *Journal of the Indian Statistical Association* and of *Utilitas Mathematica* (Winnipeg, Canada). He continues preparing reviews of published journal articles for inclusion in *Zentralblatt für Mathematik.*

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

Edward Pollak continues as an editorial board member of *Mathematical Biosciences,* and Mark Reiser as a board member for *Sociological Methods & Research.*
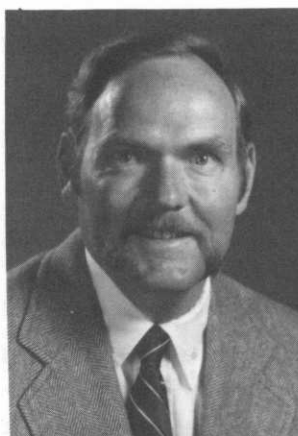
William J. Kennedy, editor of *The American Statistician*

William Q. Meeker, Jr., editor-elect of *Technometrics*

Stephen Vardeman was appointed associate editor of *Technometrics.*

Leroy Wolins is an associate editor of the *Journal of Educational Statistics* and a member of the board of editors for *Educational and Psychological Measurement.*

The Statistical Laboratory initiated a preprint series in 1986. A set of abstracts of the first 30 technical reports in the series is available on request. Any of these preprints can be requested by number directly from the author.

Copies of many articles in the older Statistical Laboratory Reprint Series, through SLRS 609, are still available on request. No additional titles will be formally added to that series, since our emphasis has shifted to the preprint series. However, copies of articles listed in this annual report may be available from individual authors.

Abstracts of recent books and papers published by faculty and graduate students appear below, along with summaries of doctoral dissertations completed here in statistics during the 1985-1986 year. Indicated by title are book reviews and occasional publications, including some of an editorial nature.

■ Books

Institute of Mathematical Statistics, editor; **W. J. KENNEDY** and R. E. Odeh, coeditors. *Selected Tables in Mathematical Statistics,* Volume VIII. American Mathematical Society (Providence, Rhode Island) 1985. v + 270 pp.

This volume presents a collection of three groups of tables. The first article, by B. J. Trawinski, on "Expected sizes of a selected subset in paired comparison experiments," includes tables, and some examples of their application, for the design and analysis of a balanced paired comparison experiment intended to select from a set of treatments a subset containing the best treatment. Robert E. Bechhofer and Ajit C. Tamhane present tables of admissible and optimal balanced treatment incomplete block (BTIB) designs for comparing treatments with a control. Finally, M. L. Tiku and S. Kumra present evaluations of

the expected values, variances, and covariances, of order statistics of random samples from a family of symmetric distributions reducible to Student's t.

Bardes, Barbara A., **Mack C. SHELLEY II,** and Steffen W. Schmidt. *American Government and Politics Today: The Essentials.* West Publishing Company (St. Paul, Minnesota) 1986. xxviii + 570 pp., soft-cover.

This introductory undergraduate textbook is an updated and streamlined edition of a larger-sized text published in 1985. It is supplemented by a computerized tutorial and test file, student study guide, and instructors' manual.

■ Published Research

AMEMIYA, Yasuo. Instrumental variable estimator for the nonlinear errors-in-variables model. *Journal of Econometrics* 28:3 (1985) 273-289.

Estimation for the nonlinear errors-in-variables model is considered. It is assumed that additional information is available in the form of observations on instrumental variables. An estimation procedure is presented for the parameters of the model. Asymptotic properties of the estimator are investigated.

ATHREYA, K. B. Another conjugate family for the normal distribution. *Statistics & Probability Letters* 4:2 (1986) 61-64.

It is shown that the family of densities $f(z) = cz^p \exp(\lambda_1 z^{-1} + \lambda_2 z)$, $\lambda_1, \lambda_2 \geq 0$, $-\infty < p < \infty$, $z \geq 0$, $c > 0$, as marginals for the variance, gives rise to a new conjugate family for the normal distribution. This family includes the normal-gamma family and is minimal in an appropriate sense. This family is known as the generalized inverse Gaussian distribution.

ATHREYA, Krishna B., and Sastry G. Pantula. A note on strong mixing of ARMA processes. *Statistics & Probability Letters* 4:4 (1986) 187-190.

We establish that certain stationary autoregressive moving average (ARMA) processes are strong mixing.

Takeda, K., **T. B. BAILEY,** and K. J. Frey. Changes in mean, variance, and covariation among agronomic traits in successive backcross generations of interspecific matings (*Avena sativa L.* × *A. sterilis L.*) of oats. *Canadian Journal of Genetics and Cytology* 27:4 (1985) 426-432.

F_2-derived lines from BC_0 through BC_5 of eight *Avena sativa* × *A. sterilis* matings were evaluated for days to heading, plant height, biomass, grain yield, straw yield, harvest index, vegetative growth rate, and unit straw weight. The *A. sativa* lines were used as the recurrent parents in all backcrosses. The evaluation experiment was conducted in a randomized-block design with two replicates and microplots each sown with 30 seeds. For summary purposes, the means, variances, and genotypic correlations from the four matings with the same recurrent parent were pooled within each level of backcrossing. Regression analyses were used to describe the rates of change for genotypic variances and correlations as number of backcrosses increased. In all matings, the trait means regressed toward the recurrent parents as backcrossing progressed.

Harvest index was controlled by additive gene action; earliness was partially dominant and tallness was completely dominant; heterobeltiosis occurred for high vegetative growth rate; straw yield and biomass showed either heterobeltiosis or complete dominance; and high grain yield was partially dominant. Unit straw weight showed a positive heterobeltiosis. Log genotypic variances decreased significantly over backcrosses for days to heading, straw yield, and harvest index, whereas for plant height and unit straw weight the reductions were not significant. Regressions of genotypic correlations were significant for only 12 of 56 trait associations, and changes that did occur were of little consequence.

Dahlgren, Robert B., and **Thomas A. BUBOLZ.** Members of conservation-related organizations: Their characteristics, readership, and activism in relation to sport hunting. *Iowa State Journal of Research* 60:1 (1985) 89-106.

This study is based on a mailed questionnaire survey of a random sample of Iowa residents 18 years of age or older. Sampling methodology was designed and carried out by the Statistical Laboratory Survey Section at Iowa State University.

Adult Iowans who were members of national conservation-oriented organizations were far more politically active on hunting issues than nonmembers were. Further, only those members who read these organizations' publications were politically active. When background variables were considered, education and income were not associated with political activity, but males were more active than females; persons raised in small- and medium-sized towns were more active than those raised on farms or in cities; persons under 30 were the most active organization members; and persons who currently hunt were most politically active as members of prohunting groups. Publications of national conservation-oriented organizations afford natural resource managers an opportunity to convey information to the group of politically active persons most likely to use such information to the managers' advantage. Finally, professional conservationists interested in promoting prohunting causes should be aware that organization members against hunting are as likely as their counterparts, who are for hunting, to be actively pursuing their beliefs.

CRESSIE, Noel. Fitting variogram models by weighted least squares. *Journal of the Interna-*

tional Association for Mathematical Geology 17:5 (1985) 563-586.

The method of weighted least squares is shown to be an appropriate way of fitting variogram models. The weighting scheme automatically gives most weight to early lags and downweights those lags with a small number of pairs. Although weights are derived assuming that the data are Gaussian, they are shown to be still appropriate in the setting where data are a smooth transform of the Gaussian case. The method of generalized least squares, which takes into account correlation between variogram estimators at different lags, offers more statistical efficiency at the price of more complexity. The method of weighted least squares for the robust estimator based on square root differences, is less of a compromise.

CRESSIE, Noel. A geostatistical analysis of the Mercer and Hall wheat data. Pp. 277-278 in *Contributed Papers, Book 1,* 45th Session of the International Statistical Institute, held August 12-22, 1985, in Amsterdam, the Netherlands. 1985.

Characterizing the dependence structure among data dispersed through space is a delicate problem. Possible approaches include those using spatial autoregressions, Markov random fields, and geostatistics. We consider here the famous Mercer and Hall (1911) data set of wheat yields. The first two approaches yield unsatisfactory fits. However, a less parametric geostatistics approach, where local drift is removed by median polish, is seen to arrive at the second-order spatial relationships, without a confounding of the first-order drift.

CRESSIE, Noel. When are relative variograms useful in geostatistics? *Journal of the International Association for Mathematical Geology* 17:7 (1985) 693-702.

The relative variogram has been employed as a tool for correcting a simple kind of nonstationarity, namely, that in which local variance is proportional to local mean squared. In the past, this has been linked in a vague way to the lognormal distribution, although if $\{Z_t; t \in D \}$ is strongly stationary and normal over a domain D, then, clearly, $\{ \exp (Z_t); t \in D\}$ will *still* be stationary but lognormal. The appropriate link is made in this article through a universal transformation principle. More general situations are considered, leading to the use of a "scaled variogram."

CRESSIE, Noel. Discussion of B. W. Silverman's paper: Some aspects of the spline smoothing approach to non-parametric regression curve fitting. *Journal of the Royal Statistical Society* B, 47:1 (1985) 34-35.

CRESSIE, Noel. Comment: Discussion of F. L. Bookstein's paper: Size and shape spaces for landmark data in two dimensions. *Statistical Science* 1:2 (1986) 226.

CRESSIE, Noel, and Marinus Borkent. The moment generating function has its moments. *Journal of Statistical Planning and Inference* 13:3 (1986) 337-344.

Traditionally, the moment generating function of a random variable X is used to generate positive integer moments of X. However, moments of quite general transformations of X can be obtained by judicious differentiations and weighted integration of the moment generating function. The particular case of X^γ; $-\infty < \gamma < \infty$; is treated in detail, and applications are given.

CRESSIE, Noel, and Timothy R. C. Read. Do sudden infant deaths come in clusters? *Statistics & Decisions.* Supplement Issue No. 2: Selected Papers presented at the 16th European Meeting of Statisticians, Marburg, West Germany, September 3-7, 1984. Pp. 333-349. 1985.

County data from North Carolina (number of live births and number of sudden infant deaths in the period 1974-1978) as reported by Symons, Grimson, and Yuan [*Biometrics* 39 (1983) 193-205] are analyzed. The data are spatial in nature, and various exploratory data analytic techniques are modified to take into account the data's spatial labels. A geostatistical type analysis, based on estimation of the variogram of the error process after trend effects have been removed, is performed on the transformed death rates. The results show interesting negative correlation up to 60 miles. Building Markov random field models based on auto-Poisson and autonegative binomial schemes is the next step of the analysis; these results will be reported on elsewhere.

CRESSIE, Noel, and Allan Seheult. Empirical Bayes estimation in sampling inspection. *Biometrika* 72:2 (1985) 451-458.

This paper considers an empirical Bayes approach to estimating the number of defectives in a hypergeometric distribution. It involves application of an empirical Bayes identity that has proved useful in providing simple Bayes estimates for various other models. Data on the reliability of coding the answers to questions from a household survey illustrate how an empirical Bayes estimate can be computed without knowledge of the prior distribution of the number of defectives.

CRESSIE, N. A. C., and H. J. Whitford. How to use the two sample t-test. *Biometrical Journal* 28:2 (1986) 131-148.

This work discusses how two sample t-tests behave when applied to data that may violate the classical statistical assumptions of independence, heteroscedasticity, and Gaussianity. The usual two sample t-statistic based on a pooled variance estimate and the Welch-Aspin statistic are treated in detail. Practical rules-of-thumb are given along with their applications to various examples so that readers will easily be able to use such tests on their own data sets.

Dahm, P. Fred (Texas A&M University), and **Wayne A. FULLER.** Generalized least squares estimation of the functional multivariate linear errors-in-variables model. *Journal of Multivariate Analysis* 19:1 (1986) 132-141.

Generalized least squares are applied to the sample matrix of mean squares and products to obtain estimators of the parameters of the functional multivariate linear errors-in-variables model. It is shown that these estimators are consistent and asymptotically multivariate normal. Estimators constructed under the assumption that the true values are multivariate normal are shown to be appropriate for the model with fixed true values.

DAVID, H. A. Order statistics. In *Encyclopedia of Statistical Sciences,* Vol. 6: *Multivariate Analysis to Plackett and Burman Designs,* pp. 504-510. Samuel Kotz and Norman L. Johnson, editors-in-chief. John Wiley & Sons, Inc. (New York). 1985.

Both theory and applications of order statistics are reviewed.

DAVID, H. A., and **In-Hye Ha.** Replacement of parents by meritorious offspring in within-family selection. *Biometrics* 41:4 (1985) 1045-1048.

In within-family selection it may be advantageous not to replace a parent automatically by the best offspring of the same sex but, if necessary, to postpone such replacement until there is a group with a sufficiently meritorious offspring. Roux [*Biometrics* 39 (1983) 479-483] studied this option by an approximate approach. When exact methods are used instead, substantially lower values of selection gain due to the option are obtained. It is concluded that the option is advantageous only under rather restricted circumstances.

DAVID, H. T. Variables on two familiar industrial statistics themes. *Communications in Statistics—Theory and Methods* (Special Issue: Conference on Advances in Statistics in Quality Control) 14:11 (1985) 2607-2620.

This paper deals with acceptance sampling of Bernoulli lots, and with acceptance control plans for assemblies. With regard to the first, and based on previous M.S. work of H. B. Eisenberg (1959) and M. Smith (1967), the point is made that economically optimum plans are not necessarily "all-or-none" when loss is other than linear. With regard to the second, a proposal is made for incorporating into such plans the geometric details of the assembly process, and the statistical features of a part's intended "mate."

DOREA, C. Y. Chang (Universidade de Brasilia, Brazil). Limiting distribution for random optimization methods. *SIAM Journal on Control and Optimization* 24:1 (1986) 76-82.

Let f be a function defined on some domain $\Omega \subset R^d$. We consider the problem of finding the global minimum of f subjected to some constraints, say $g_i(x) \leq 0$, i = 1,...,m. When differentiability is not assumed, random optimization methods provide an alternative way to estimate the minimum. For two such methods we study the existence of the limiting distribution and the estimation of the parameter of the limiting distribution.

Escobar, Luis A. (Iowa State University and Louisiana State University), and **William Q. MEEKER, Jr.** Planning accelerated life tests with type II censored data. *Journal of Statistical Computation and Simulation* 23:4 (1986) 273-297.

This paper presents methods for planning accelerated life tests for models in which the logarithm (or some other appropriate transformation) of time-to-failure follows a location-scale distribution and the location parameter is a function of stress. We give exact expressions for the BLUE of the $100P^{th}$ percentile of the life distribution at design conditions and for the variance of this estimator. Then we describe methods for evaluating the important properties of test plans and for finding approximate continuous and exact discrete optimum test plans. A numerical example illustrates the methods.

FULLER, Wayne A. Least squares and related analyses for complex survey designs. *Survey Methodology* 10:1 (1984) 97-118.

The large sample behavior of nonlinear functions of estimated totals constructed from complex survey data is described. Applications to estimation and testing in the regression context are given. The concept of a large sample is discussed.

FULLER, Wayne A. Nonstationary autoregressive time series. In *Time Series in the Time Domain (Handbook of Statistics, Vol. 5),* pp. 1-23. E. J. Hannan, P. R. Krishnaiah, and M. M. Rao, editors. North-Holland Publishing Company (Amsterdam). 1985.

Large sample properties of least squares estimators of the parameters of autoregressive time series are described. Time series with a unit and time series with a root greater than one are discussed. Estimation, prediction, and testing procedures are illustrated.

Pantula, Sastry G., and **Wayne A. FULLER.** Computational algorithms for the factor model. *Communications in Statistics—Simulation and Computation* 15:1 (1986) 227-259.

Algorithms for computing the maximum likelihood estimators and the estimated covariance matrix of the estimators of the factor model are derived. The algorithms are particularly suitable for large matrices and for samples that give zero estimates of

some error variances. A method of constructing estimators for reduced models is presented. The algorithms can also be used for the multivariate errors-in-variables model with known error covariance matrix.

GHOSH, Malay (University of Florida and Iowa State University). Berry-Esseen bounds for functionals of U-statistics. *Sankhyā* A 47:2 (1985) 255-270.

The paper obtains Berry-Esseen rates of convergence to normality for suitably standardized functions of U- and V-statistics. The sharpest rate $O(n^{-1/2})$ is obtained by assuming only finiteness of the third moment of the kernel. The same error rate is achieved for studentized jackknifed functionals of U-statistics, assuming finiteness of the $(4 + \delta)$th moment of the kernel for some $\delta > 0$.

GROENEVELD, Richard A. Measurement of skewness and kurtosis for the generalized Tukey lambda distributions. *Communications in Statistics—Theory and Methods* 15:2 (1986) 329-343.

Generalizations of the symmetric Tukey lambda distributions to asymmetric random variables are considered. These distributions, defined via the inverses F^{-1} of their distribution functions, yield simple algorithms useful in Monte Carlo studies, and they are also useful in fitting data. Here a recently recommended measure of skewness is used to determine the skewness of such distributions. This skewness measure is also adapted to the measurement of the kurtosis of members of the symmetric class. Applications to the simulation of symmetric long-tailed distributions and to the selection of appropriate members of the Tukey families as approximations are considered. Some insight into the interpretation of Monte Carlo studies of tests of normality is presented.

HARVILLE, David A. Using ordinary least squares software to compute combined intra-interblock estimates of treatment contrasts. *The American Statistician* 40:2 (1986) 153-157.

Consideration is given to the computational aspects of the analysis of data from a comparative study, involving two or more treatments, where the experimental units are arranged in b blocks. It may seem desirable, in making inferences about treatment contrasts, to carry out a combined intra-interblock analysis. Practitioners are sometimes reluctant to employ this analysis, because of the computational requirements, which they regard as severe, and because they may not have ready access to directly applicable computer software. It is shown that, by augmenting the actual data with b pseudo-observations, all of the computations can be accomplished efficiently, using only ordinary least squares software.

Hein, G. L., J. J. Tollefson, and **P. N. HINZ.** Design and cost considerations in the sampling of northern and western corn rootworm (Coleoptera:

Chrysomelidae) eggs. *Journal of Economic Entomology* 78:6 (1985) 1495-1499.

Cost and design considerations for egg sampling of the northern and western corn rootworm, *Diabrotica barberi* Smith & Lawrence (NCR) and *D. virgifera vergifera* LeConte (WCR), respectively, were examined by using sampling data collected in eight commercially grown cornfields. Considerable variability was found in horizontal and vertical distributions of NCR and WCR eggs. Therefore, sampling for NCR and WCR eggs should use a method that samples the entire inter-row width, and samples should be taken to a depth of at least 20 cm. Deeper sampling may be necessary when drought cracks allow females to oviposit more deeply.

Sampling characteristics of the frame sampling method were examined. Indices of aggregation for the NCR and WCR did not differ significantly. The index of aggregation (1.49) calculated from pooled data (NCR + WCR) indicated aggregated egg populations. Sampling cost analyses show that the most efficient method to reduce sampling variability is to take one or two samples per frame from a large number of frames within a field. Sample size estimates for different sampling strategies are given.

Norton, D. C., J. Edwards, and **P. N. HINZ.** Nematode populations in maize and related species. *Maydica* 30:1 (1985) 67-74.

Cultivars of several cultivated maize types and species related to maize were evaluated for population levels of nematodes in the field and greenhouse. *Zea diploperennis* supported the fewest *Pratylenchus scribneri* and *Helicotylenchus pseudorobustus* in two years of field study. It also supported 1/10 to 1/2 as many *P. hexincisus* as other maize types in two greenhouse tests. Pod corn and *Zea mexicana* were generally good hosts for *Pratylenchus* spp. Twenty maize gene pools from CIMMYT were evaluated in the field and ranged widely in their susceptibility to the nematodes present.

Dupont, Jacqueline, William V. Lumb, A. Wendell Nelson, Joan P. Seegmiller, **Donald HOTCHKISS,** and H. Peter Chase. Portacaval shunt as treatment for hypercholesterolemia: Metabolic and morphological effects in a swine model. *Atherosclerosis* 58 (1985) 205-222.

Yucatan miniature swine were fed a high-fat (American-type) diet or an atherogenic (added-cholesterol) diet. After eight months, portacaval shunt surgery was performed on half of the animals in each group. After eight more months on their diets, both groups were examined to observe if the progression of atherosclerosis was slowed by the surgery.

Blood lipids and numerous biochemical indices were measured and subjected to a multiple regression analysis because of the disproportionate numbers of observations in the groups. The effects and interactions of sex, diet, and type of operation were evaluated. Progression of atherosclerosis was slowed by portacaval shunting. Low density lipoprotein and serum insulin concentration were positively correlated with the severity of atherosclerosis, while high density lipoprotein concentration was negatively correlated. Cholesterol synthesis was increased by the shunting and decreased by cholesterol feeding.

Hanson, K. B., P. A. Garcia, and **D. K. HOTCHKISS.** Estimation of body composition from anthropometric and physiological measurements of obese college women. *Nutrition Research* 5:10 (1985) 1055-1066.

Journal Paper No. J-11780 of the Iowa Agriculture and Home Economics Experiment Station, Projects 1965 and 2213.

Relationships between anthropometric and physiological measurements and body composition were examined in 42 obese college women. Estimates of body density (BD), fat weight (FW), and fat-free weight (FFW) were obtained by the helium dilution method. Anthropometric measurements included height, weight, 4 body diameters, 4 body girths, hand grip strengths, and 7 skinfold thicknesses; physiological measurements were daily urinary creatinine and basal metabolic rate. Simple correlation coefficients between each of these measurements and the estimates of body composition were less than 0.7, indicating little predictive accuracy from single measurements. Multiple correlation coefficients (R) were higher for FW (R = 0.83 to 0.88) than for BD (R = 0.64 to 0.75) or FFW (R = 0.72 to 0.80). The equations that most accurately estimated body composition included skinfold thickness, hand grip strength, basal metabolic rate, and a variable calculated from height and weight. When equations selected from the literature were used, BD and FFW were consistently overestimated and FW underestimated.

Molins, R. A., A. A. Kraft, D. G. Olson, H. W. Walker, and **D. K. HOTCHKISS.** Inhibition of *Clostridium sporogenes* PA3679 and natural bacterial flora of cooked vacuum-packaged bratwurst by sodium acid pyrophosphate and sodium tripolyphosphate with or without added sodium nitrite. *Journal of Food Science* 51:3 (1986) 726-730.

Journal Paper No. J-11830 of the Iowa Agriculture and Home Economics Experiment Station, Projects 2252 and 2365.

The substitution of selected phosphate compounds for nitrites for preserving vacuum-packaged bratwurst was studied. Use of the phosphate compounds as described in the paper did not affect the aerobic bacterial counts but did reduce the clostridial and anaerobic counts at low storage temperatures. Sodium acid pyrophosphate did inhibit all bacterial growth at elevated temperatures, for up to 48 hours, especially when combined with 100 ppm of sodium nitrite.

Reece, W. O., P. O. Brackelsberg, and **D. K. HOTCHKISS.** Erythrocyte changes, serum iron concentration and performance following iron injection in neonatal beef calves. *Journal of Animal Science* 61:6 (1985) 1387-1394.

Thirty-three fall calves and 35 spring calves representing three breed groups were randomly assigned to an iron-dextran injected group and a control group. Several blood parameters and the average daily gain were evaluated using a split plot analysis for unbalanced data. Injection of iron-dextran at birth resulted in significant increases in erythrocyte count and hemoglobin concentration and other blood parameters, although no calves were judged to be anemic. Breed differences in the blood parameters were noted, as was a higher iron concentration in calves born in the spring.

IACHAN, Ronaldo (Research Triangle Institute). Optimum stratum boundaries for shellfish surveys. *Biometrics* 41:4 (1985) 1053-1062.

The problem of finding stratum boundary points that minimize the variance of the survey estimates is reviewed. The practical case when stratification is on auxiliary variables is examined and applied to bottom trawl surveys of shellfish, making use of data on surf clams and ocean quahogs obtained by the National Marine Fisheries Service.

KALE, B. K. A note on the super-efficient estimator. *Journal of Statistical Planning and Inference* 12:2 (1985) 259-263.

The exact sampling distribution of the well-known Hodges-LeCam superefficient estimator T is obtained in the case of a normal distribution with known variance. It is shown that the Fisher information about θ in T, $I_T(\theta)$, is the same as that in $\bar{x}$, $I_{\bar{x}}(\theta) = n$. It is shown that T is first-order efficient and equivalent to $\bar{x}$ as defined by Rao [*Linear Statistical Inference*, Wiley, New York (1974)]. Further it is shown that there exist sequences $\theta_n \to 0$ and $\varepsilon_n > 0$, such that the coverage probability $P_\theta[\,|\,T - \theta_n\,| \leqslant \varepsilon_n] = 0$ for each $n \geqslant 1$, although $\lim_{n \to \infty} P[\,|\,\bar{x} - \theta_n\,| \leqslant \varepsilon_n] = 1$. This undesirable feature of T is analogous to the already known feature that there exists a sequence $\theta_n \to 0$ such that $\lim_{n \to \infty} nE[(T - \theta_n)^2 \,|\, \theta_n] > 1$.

Bendre, S. M., and **B. K. KALE.** Masking effect on tests for outliers in exponential models. *Journal of the American Statistical Association* 80:392 (1985) 1020-1025.

The masking effect in cases of tests for outlier(s) is defined and quantified by the loss in power due to the presence of more than the anticipated number of discordant observations in the sample. This effect is illustrated in cases of some commonly used outlier tests for exponential samples—namely, Dixon-type tests and the Cochran test. A comparison between the performances of the modified Dixon-type test and the

Cochran test is made. Tables for powers of these tests are presented for different sample sizes and different values of discordancy parameter. An illustrative example is presented to support the conclusion that Cochran and modified Dixon-type tests do not suffer from the masking effect in the presence of two outliers.

KEMPTHORNE, Oscar. Archives. *The Institute of Mathematical Statistics Bulletin* 14:6 (1985) 334-335.

A procedure for development of archives for the Institute of Mathematical Statistics is described. A contractual agreement has been negotiated between IMS and the Department of Special Collections, the Parks Library, Iowa State University, to build a collection of the records of IMS.

KENNEDY, William J. Comments on what researchers need in microcomputer statistical software packages. *Computers and the Social Sciences* 2:1/2 (1986) 69-70.

KOEHLER, Kenneth J. Goodness-of-fit tests for log-linear models in sparse contingency tables. *Journal of the American Statistical Association* 81:394 (1986) 483-493.

The asymptotic normality of the likelihood ratio goodness-of-fit statistic is demonstrated for testing the fit of log-linear models with closed form maximum likelihood estimates in sparse contingency tables. Unlike the traditional chi-squared theory, the number of categories in the table increases as the sample size increases, but not all of the expected frequencies are required to become large. Some results of a small Monte Carlo study are presented. The traditional chi-squared approximation is reasonably accurate for the Pearson statistic for many sparse tables, but cases are presented for which it fails. The normal approximation can be much more accurate than the chi-squared approximation for the likelihood ratio statistic, but the bias of estimated moments is a potential problem for very sparse tables.

Gutierrez-Espeleta, Edgar E, Kenneth J. KOEHLER, and Carl W. Mize. Fitting an equation to a two-way table. *Northern Journal of Applied Forestry* 3:1 (1986) 33-34.

A number of yield tables, site index curves, and volume tables were developed graphically. Many of those tables exist only in table form and not in equation form. This paper describes a quick technique that can be used to develop a regression equation that will estimate values in many of those two-variable tables. These equations can be incorporated into computer programs for easier calculation of values.

Stone, Janis F., Kenneth J. KOEHLER, Charles J. Kim, and Sara J. Kadolph. Laundering pesticide-soiled clothing: A survey of Iowa farm families. *Journal of Environmental Health* 48:5 (1986) 259-264.

Laundering practices in homes of Iowa farmers were investigated through a survey using a sample of 1,200 private pesticide applicators. A 61 percent return was obtained with launderers answering questions about care of pesticide-soiled clothing. Survey results identified 53 brands of pesticide as usually used or frequently contaminating clothing. Laundering methods used in most families were generally consistent with procedures recommended from recent laboratory-laundering research findings. Low frequency of perception of poisoning symptoms suggests that laundering procedures used were relatively safe for launderers, but findings also suggest that additional laboratory research on laundering methodology is needed. Further educational efforts are needed to increase safety awareness and to improve understanding of appropriate methods for laundering pesticide-soiled clothing.

Anderson, Dean F., Fred O. LORENZ, and Dale G. Pease. Prediction of present participation from children's gender, past participation, and attitudes: A longitudinal analysis. *Sociology of Sport Journal* 3:2 (1986) 101-111.

This investigation examined the change in children's participation and attitudes toward sport team involvement from late elementary school to the beginning of high school. A questionnaire designed to measure importance of rewards was given to all 5th and 6th graders (n = 238) from a community with an extensive sports program. Five years later, as 10th and 11th graders, 166 (71%) of the original group participated in the follow-up study. Factor analysis extracted two consistent factors at both questionnaire administrations. One was labeled "extrinsic reward" while the other was labeled "intrinsic satisfaction." A logit analysis using weighted least squares indicated that past participation and gender as well as the interaction of the importance given to the two reward systems contributed significantly to predicting present participation. An additional model including present value given to reward systems suggested that present value for intrinsic satisfaction might improve prediction of present participation.

MARASINGHE, Mervyn G. Asymptotic tests and Monte Carlo studies associated with the multiplicative interaction model. *Communications in Statistics—Theory and Methods* 14:9 (1985) 2219-2231.

Several authors have proposed approximations to percentage points required for testing certain hypotheses associated with the multiplicative interaction model. Alternative approximations based on the asymptotic joint distribution of the characteristic roots of a noncentral Wishart matrix are proposed in this paper. The type I error rates of the resulting tests

and the existing procedures are then compared using Monte Carlo methods.

MARASINGHE, Mervyn G. A multistage procedure for detecting several outliers in linear regression. *Technometrics* 27:4 (1985) 395-399.

A new statistic, F_k, is proposed for detecting multiple outliers in linear regression. This statistic is incorporated into the following multistage procedure: Initially, a subset of k observations is selected to be tested. If F_k is found to be significant, the most extreme observation in the subset as determined by the largest studentized residual is deleted and the test repeated for the $(k - 1)$ observations in the subset using the remaining sample. The procedure is stopped when a test fails to reject the no-outlier hypothesis. A Monte Carlo study is used to evaluate the performance of this procedure.

MEEDEN, Glen. Sufficiency and partitions of the class of all possible discrete distributions. *The American Statistician* 40:1 (1986) 42-44.

For discrete statistical models it is shown that any statistic induces a partition of the set of all possible distributions defined on the sample space. This partition identifies the subsets of the parameter space for which the statistic is sufficient.

MEEKER, William Q., and Gerald J. Hahn. *How to Plan an Accelerated Life Test—Some Practical Guidelines.* Volume 10 of *The ASQC Basic References in Quality Control: Statistical Techniques,* edited by John A. Cornell and Samuel S. Shapiro. American Society for Quality Control, 1985. viii + 36 pp.

Accelerated life tests provide timely information about the life distribution of materials and products. Information from tests at high levels of stress is extrapolated, through a physically reasonable statistical model, to obtain estimates of life at lower, normal levels of stress. This booklet provides some practical guidelines for planning an accelerated life test. After a brief introduction to accelerated life testing, we present an example to estimate a percentile of the time-to-failure distribution at the design stress using a "standard" test plan that was proposed initially. As a basis for comparison, we briefly present a statistically optimum test plan and then suggest an alternative plan that meets practical constraints, and that still has desirable statistical properties. After comments on the graphical analysis of censored accelerated life test data, we give a table and some general guidelines for planning accelerated life tests that are both robust to moderate departures from the model assumptions and reasonably efficient when compared with theoretically optimum plans. The guidelines are used to develop the alternative accelerated life test plan for the example.

Peixoto, Julio L. (Iowa State University and University of Houston), and **David A. HARVILLE.** Comparisons of alternative predictors under the balanced one-way random model. *Journal of the American Statistical Association* 81:394 (1986) 431-436.

Prediction of an arbitrary linear combination of the random effects of a balanced one-way random model is investigated. Alternative two-stage predictors are compared on the basis of their conditional (on the random effects) and unconditional bias and mean squared errors. When the true value of the ratio of expected mean squares is known, there exists a best linear unbiased predictor (BLUP). When the true value is unknown, a two-stage predictor, obtained from the BLUP by replacing the true value with an estimated value, can be used. When the ratio of expected mean squares is estimated by maximum likelihood, Bayesian methods, or various related methods, a two-stage predictor is obtained whose properties compare favorably with, for example, those of the least squares predictor and the positive-part James-Stein predictor.

POLLAK, Edward. On three methods for estimating mutation rates indirectly. *American Journal of Human Genetics* 38:2 (1986) 209-227.

Methods for estimating a mutation rate μ have been proposed by Kimura and Ohta; Nei; and Rothman and Adams. It is shown here that all three methods are best applied to rare alleles and that they are all based upon the assumption that all alleles ultimately become extinct. If there is a neutral allele in a growing population, there is conditioning on ultimate extinction, which implies that the underlying stochastic process can be approximated by a branching process for which the mean number of offspring is less than 1. The low numerical values of t_0, the mean time to extinction of a line descended from a single mutant, found in two simulation studies, can be attributed to two features. First, the data on which these studies were based came from a fairly rapidly growing population. In such a population, we would expect that extinction, if it does occur, takes place quickly. A second factor is that the effective population size is somewhat lower than the actual number of adults. Population subdivision and migration does not seem to play a significant role. Conservative high and low estimates of mutation rates are computed, and an estimate is obtained for the standard deviation of the estimate of μ. These allow a rough estimate of a 95 percent confidence interval, which contains estimates of μ found by Neel and Rothman.

Willham, R. L., and **Edward POLLAK.** Theory of heterosis. *Journal of Dairy Science* 68:9 (1985) 2411-2417.

The theory of heterosis is expressed by simple genetic models. Relevant population means are deduced for differences in gene frequencies among pop-

ulations. Heterosis for the one-locus, two-allele model is a function of the square of the difference in gene frequency multiplied by the dominance deviation. Heterosis, for a model with two loci and two alleles at each locus, contains an additive by additive epistatic term as well. Recombination loss in the F_2 or the mating of similar crosses inter se is a function of the recombination fraction between loci, differences in gene frequencies, and additive by additive and dominance by dominance epistatic effects. These results are discussed with emphasis on the dairy cattle breeding situation.

REISER, Mark, Michael Wallace, and Karl Schuessler. Direction-of-wording effects in dichotomous social life feeling items. Chapter 1 in *Sociological Methodology 1986,* edited by Nancy Brandon Tuma, pp. 1-25. The American Sociological Association (Washington, D.C.). 1986.

This chapter investigates inconsistencies in responding to negative and positive agree/disagree social life feeling items. It addresses the proposition that survey respondents are as likely to disagree with a positive statement (people are trustworthy) as they are to agree with a negative statement (people are not trustworthy), other things being equal. The study is motivated by the concern that conclusions about social life feelings may differ appreciably according to the direction of the items used to measure those feelings.

First we consider differences between 174 items grouped by direction of wording (positive or negative); then we analyze differences within 10 pairs of negative and positive items matched for meaning. All such differences—whether between groupings of two or more items or between individual items within pairs—bear on the issue of whether respondents are more willing to endorse a negative social life feeling item than to reject a positive one, all else remaining the same.

ROBERTS, Carl W. The use of discriminant analysis in the quantification of a syndrome. Pp. 179-180 in *Contributed Papers, Book 1,* 45th Session of the International Statistical Institute, held August 12-22, 1985, in Amsterdam, the Netherlands. 1985.

This paper illustrates the use of discriminant analysis as a technique of generating a continuous dependent variable for use in studies of disparate groups. The technique is illustrated using data on two groups. One group consists of families with sons showing behavior symptomatic of "gender identity disorder of childhood" (APA, 1980), and the second group, of families with sons showing behavior more typical of their gender.

ROBERTS, Carl W., and Kurt Lang. Generations and ideological change: Some observations. *The Public Opinion Quarterly* 49:4 (1985) 460-473.

The recollections of 28 cohorts of college graduates—all of them former recipients of Woodrow Wilson Fellowships for graduate study—of historical events between 1945 and 1971 and their participation in activities specifically associated with the peace movement and student activism of the 1960s were brought to bear on Mannheim's theory of generations. The analysis suggests proportionately greater sensitivity to the events of the 1960s among those who reached the age of 20 near the middle of the decade, a finding that bears out generational theory. But despite this apparently heightened sensitivity among those the right age at the right time, the effect of these recollections and experiences on attitudes expressed in 1973 was consistently overshadowed by even stronger attitudinal effects attributable to an early commitment to activism. The latter was more closely related to the family milieu than to having come of age politically in a particular historical period. The data were obtained from a mail survey of 1,321 former Wilson Fellows.

Heiman, Julia R., Brian A. Gladue, **Carl W. ROBERTS,** and Joseph LoPiccolo. Historical and current factors discriminating sexually functional from sexually dysfunctional married couples. *Journal of Marital and Family Therapy* 12:2 (1986) 163-174.

Clinical literature has noted numerous past and current psychosocial factors characteristic of sexually dysfunctional individuals. However, there is almost no empirical documentation of factors discriminating sexually functional from dysfunctional couples. The present study compared the responses of 94 clinical couples accepted for sex therapy with 110 nonclinical couples, selected from the same community. The couples were in their mid-30s, married an average of 12 years, middle income, rather well educated; over 75 percent had at least one child. Individuals completed a 517-question Personal History Questionnaire (PHQ), and sex and marital defensiveness scales. The PHQ was clinically and empirically developed, resulting in 54 internally consistent scales. The best discriminators were sexual functioning scales, historical and affective scales for women, and current and fantasy scales for men. Several surprising results appeared, including the importance of first coitus and the lack of importance of marital satisfaction, communication, and sexual history scales. Four conclusions were discussed relevant to the separation of sex and relationship satisfaction, the separation of sexual functioning and sexual satisfaction, and the differential impact of sexual problems on men and women.

Thurston, John R., William Cook, Kim Driftmier, John L. Richard, and **Jerome M. SACKS.** The decreased complement and bacteriostatic activities in the sera of cattle given single or multiple doses of aflatoxin. *American Journal of Veterinary Research* 47:4 (1986) 846-849.

Five steers given a single dose of partially purified aflatoxin at concentrations sufficient to provide 0.2 mg to 0.8 mg of aflatoxin B_1 equivalents (AFB_1)/kg

body weight were compared to four steers given 14-day daily doses of 0.25 mg AFB_1/kg body weight for complement activity and bacteriostasis. Complement activity was measured by hemolysis in gel and bacteriostasis by growth inhibition of *E. coli* in liquid medium. In the single-dose group both complement activity and bacteriostasis declined by day 2.4 (57 hours) post-dosing, and both returned to near normal by day 7. In the daily dose group only bacteriostasis declined, and the decline persisted 2 weeks after aflatoxin dosing had ended. Apparently aflatoxin may affect both complement-dependent and independent serum bacteriostasis.

SPOSITO, V. A., and B. C. English. Reliability of linear programming software: An experience with IBM's Mathematical Programming System Series: Comments. *American Journal of Agricultural Economics.* 68:2 (1986) 370-372.

In 1984, Tice and Kletke raised some serious reliability questions regarding IBM's Mathematical Programming Software. Inasmuch as an uncountable number of agricultural research models require the use of a reliable large-scale linear programming software, a reinvestigation of the claims of Tice and Kletke was conducted.

Findings of our reinvestigation are given, and proper guidelines are noted that have proven to eliminate inconsistent solutions.

SPOSITO, V. A., and **Michael D. Tveite** (St. Olaf College). On the estimation of the variance of the median used in L_1 linear inference procedures. *Communications in Statistics—Theory and Methods* 15:4 (1986) 1367-1375.

Recent results in the literature have considered the distribution of the LAV estimator, $\widetilde{\beta}$, i.e., under the criterion of minimizing the sum of absolute deviations. It has been shown that $\sqrt{n}\,(\widetilde{\beta} - \beta)$ is approximately normally distributed with mean zero and covariance matrix $\lambda^2 n(X'X)^{-1}/n$ where λ_2/n is the variance of the median for a sample of size n. Subsequent research has shown how the asymptotic results can be used in inference procedures; these procedures are based on λ being known.

This paper considers the estimation of λ as suggested by Cox and Hinkley [*Theoretical Statistics,* Chapman & Hall, London (1974)]. In that spirit a Monte Carlo study was conducted using various distributions over various sample sizes. Guidelines for using Cox and Hinkley's estimate of λ in LAV inference procedures are also discussed.

STEPHENSON, W. Robert, and **Malay GHOSH** (Iowa State University and University of Florida). Two sample nonparametric tests based on subsamples. *Communications in Statistics—Theory and Methods* 14:7 (1985) 1669-1684.

The paper introduces a general class of nonparametric tests for the two-sample location problem based on subsamples. Included in this class is the Mann-Whitney (or the Wilcoxon rank sum) test. General formulas for the Pitman efficacy for different methods of subsampling are derived. A small sample power simulation compares the performance of members of this class.

Zbaracki, Jacqueline U., Samuel G. Clark, and **Leroy WOLINS.** Children's interests inventory, grades 4-6. *Educational and Psychological Measurement* 45:3 (1985) 517-521.

A factored interest inventory for children was developed from interest items obtained from literature review and an open-ended questionnaire, the Preliminary Children's Interest Inventory, administered to children, parents, and teachers. These items, collapsed to form a 121-item Children's Interest Inventory, were rated on a 5-point like-dislike scale by 517 children in grades four, five, and six from Marshalltown, Iowa. Teachers rated each child's scholastic, social, and creative ability. Factor analyses showed nine boys' factors and eight girls' factors. Athletic, mechanical, science, verbal, religion, and social are interests found in the adult work and in the present work. Children's interests were not related to ability ratings, lowly related to grade, and highly related to gender.

■ Book Reviews, Etcetera

AMEMIYA, Yasuo. *Functional Relations, Random Coefficients, and Nonlinear Regression with Application to Kinetic Data,* by Søren Johansen. New York: Springer-Verlag, 1984. vi + 126 pp. $12.00 (paperback). Reviewed in *Journal of the American Statistical Association* 80:392 (1985) 1068-1069.

COX, C. Philip. Letter to the Editor [regarding interval estimates for the ratio of the means of two normal populations with variances related to the means]. *Biometrics* 41:4 (1985) 1103.

CRESSIE, N. A. C., L. J. Sheffield, and H. J. Whitford. Response [to a Letter to the Editors: Use of the one sample t-test in the real world, by F. Rebecca Burr and Richard McHugh]. *Journal of Chronic Diseases* 38:12 (1985) 1030.

DAVID, H. A. *Outliers in Statistical Data,* 2nd edition, by V. Barnett and T. Lewis. Wiley, Chichester, England, 1984, 463 pp. £29.95/$49.95. ISBN 0-471-90507-0. Reviewed in *Biometrics* 41:4 (1985) 1099.

DAVID, H. A. Bias of S^2 under dependence. *The American Statistician* 39:3 (1985) 201.

KEMPTHORNE, Oscar. President's Column. *The Institute of Mathematical Statistics Bulletin* 14:5 (July 1985) 233-237; 14:6 (November 1985) 321-323.

KEMPTHORNE, Oscar. 50th anniversary celebration. *The Institute of Mathematical Statistics Bulletin* 14:6 (1985) 327-330.

KEMPTHORNE, Oscar. Reply to Letter to the Editor. *The Institute of Mathematical Statistics Bulletin* 14:6 (1985) 331.

KEMPTHORNE, Oscar. President's report. *The Institute of Mathematical Statistics Bulletin* 14:6 (1985) 352-357.

SHELLEY, Mack. *Party Identification, Political Behavior, and the American Electorate,* by Sheldon Kamieniecki. (Westport, CT: Greenwood Press, 1985. Pp. xiv, 288. $35.00). Reviewed in *The Journal of Politics* 48:2 (1986) 512-515.

STEPHENSON, W. R. Accent on Teaching Materials section—Review of two books: *Probability by Calculator: Solving Probability Problems with the Programmable Calculator,* by Peter W. Zehna, New York: Prentice-Hall, 1982, x + 182 pp., $9.95, and *Statistics by Calculator: Solving Statistics Problems with the Programmable Calculator,* by Peter W. Zehna and Donald R. Barr, New York: Prentice-Hall, 1982, xi + 308 pp., $13.95. Reviewed in *The American Statistician* 40:1 (1986) 45-46.

STEPHENSON, W. Robert. Test bank to accompany *Statistics—Concepts and Applications,* by David R. Anderson, Dennis J. Sweeney, and Thomas A. Williams. West Publishing Company, St. Paul, Minnesota. 1986. vi + 114 pp.

VARDEMAN, Stephen B. Review of two books: *Probability and Statistics for Engineers and Scientists* (3rd ed.), by Ronald E. Walpole and Raymond H. Myers. New York: Macmillan, 1985. xiii + 639 pp. $30.00. *Probability and Statistics for Engineers* (3rd ed.), by Irwin Miller and John E. Freund. Englewood Cliffs, NJ: Prentice-Hall, 1985. x + 530 pp. $34.95. Reviewed in *Journal of the American Statistical Association* 81:393 (1986) 259.

Graduate students Steve Miller, Neerchal Nagaraj, Dale Zimmerman, and Bridget Tirol, left to right.

■ Thesis Abstracts

Anderson, Kevin Karl. Limit theorems for renewal processes in the infinite mean case. Ph.D. thesis, Iowa State University Library. August 1985.

Let $F(\cdot)$ be a cumulative distribution function concentrated on $(0,\infty)$. Let $\{N(t); t \geq 0\}$ and $U(t)$ be the associated renewal process and renewal function, respectively. It is assumed that either $F(\cdot)$ has a regularly varying tail with exponent $-\alpha$, $0 < \alpha \leq 1$, or $m(t) \equiv \int_0^t (1 - F(u))\, du$ is slowly varying at infinity.

Strong renewal theorems of Feller-Smith type are presented. These give the asymptotic behavior of the convolution $(U*Q)(t)$ as $t \to \infty$, under the assumption that $Q(\cdot)$ is regularly varying at infinity with exponent $\beta > -1$.

Weak and strong renewal theorems are given for generalized renewal functions $G(\cdot)$ of the form

$$G(t) \equiv \Sigma_{n=0}^{\infty}\ a(n)F^n(t),$$

where $a(\cdot)$ is regularly varying at infinity with exponent $\beta \geq -1$.

Second order estimates for $U(\cdot)$ are presented for a class of distributions. These are possible through the use of a strong renewal theorem of Feller-Smith type.

Limit theorems for $N(t)$ in the $\alpha = 1$ case are examined in some detail. An application to the extreme value theory of regenerative stochastic processes in the null recurrent case is given.

Callanan, Terrance Patrick. Restricted maximum likelihood estimation of variance components: Computational aspects. Ph.D. thesis, Iowa State University Library. December 1985.

Suppose that y is an $n \times 1$ observable random vector, whose distribution is multivariate normal with mean vector $X\underline{\alpha}$, where X is a known $n \times p$ matrix of rank p^* and $\underline{\alpha}$ is a $p \times 1$ vector of unknown parameters. The covariance matrix of y is taken to be $V = \gamma_{c+1}[I + \Sigma_{i=1}^c \gamma_i Z_i Z_i']$, where $Z_1,...,Z_c$ are known matrices and $\gamma_1,...,\gamma_c,\gamma_{c+1}$ are unknown parameters. The parameter space for the vector $\gamma = (\gamma_1,...,\gamma_c,\gamma_{c+1})'$ is taken to be the set of Ω_1^* of γ-values for which $\gamma_{c+1} > 0$ and the matrix $I_n + \Sigma_{j=1}^i \gamma_j Z_j Z_j'$ is positive definite $(i = 1,...,c)$.

The problem considered is that of computing a restricted maximum likelihood (REML) estimate of γ, that is, a point $\hat{\gamma}$ at which the log-likelihood function $L_1(\gamma;y)$ associated with a set of $n-p^*$ linearly independent error contrasts attains its supremum over Ω_1^*.

Aside from certain special cases, $\hat{\gamma}$ must be computed numerically, generally by some iterative algorithm. Fourteen algorithms are devised, using the following six approaches: 1. Application of the Newton-Raphson method to the log-likelihood function or, equivalently, the application of Newton's root-finding method to the likelihood equations; 2. Application of Newton's method to linearized likelihood

equations, for example (when c = 1), to the equations $\xi_i(\gamma) \, \delta L_1/\delta\gamma_i = 0$ (i = 1,2), where $\xi_i(\gamma)$ is a function of γ chosen so that, in the special case of balanced data, $\xi_i(\gamma) \, \delta L_1/\delta\gamma_i$ (i = 1,2) are linear in γ; 3. Application of the Newton-Raphson method to a "concentrated" log-likelihood function; 4. The method of scoring; 5. The EM algorithm; and 6. The method of successive approximations.

Efficient procedures for computing the iterates of each algorithm are presented, and some techniques for restricting the iterates to the parameter space are discussed. Also, extensions to the case where $V = \gamma_{c+1}$ $[I + \Sigma_{i=1}^c \gamma_i Z_i A_i Z_i']$ for known nonnegative-definite matrices $A_1,...,A_c$ are devised.

Numerical results on the performance of the 14 iterative algorithms are given for each of four data sets. One very effective algorithm is that obtained by applying Newton's method to a set of linearized, concentrated likelihood equations.

Crowder, Lee Ann. Goal programming: Computational solutions for large-scaled models. Ph.D. thesis, Iowa State University Library. May 1986.

The use of linear programming in decision making has been widespread for 20 to 30 years, with its theoretical and solution concepts well documented and explored. In spite of its wide use, one main difficulty in linear programming remains, and that is the fact that linear programming problems are defined with only one objective function. A. Charnes and W. W. Cooper, through continuing research, developed the computational procedure known as goal programming, which enables one to solve linear programming problems with multiple objectives. This dissertation presents computational procedures that will enable one to solve a large-scale linear goal programming problem, as well as its multi-dimensional dual problem. Applications in statistics and industry are explored.

Crowder, Stephen V. Kalman filtering and statistical process control. Ph.D. thesis, Iowa State University Library. May 1986.

Applications of the Kalman filter as a tool in univariate process monitoring and optimal control are studied. Generalized versions of a simple Kalman filter model, the steady model, are used to develop algorithms for recursively estimating a randomly varying process mean and variance.

Under the normal steady model, the unobservable process mean evolves according to a random walk. The Kalman filter estimates the current process mean by a geometric moving average (GMA) of sample means. The weighting factor for the GMA is a function of the known variance terms associated with the steady model. A generalization of the steady model to nonnormal distributions, due to J. Q. Smith [*Journal of the Royal Statistical Society* B, 41 (1979) 378-387], leads to estimation of a randomly changing process variance by a GMA of sample variances.

Again, the weighting factor used is a natural consequence of the model structure.

Properties of the GMA as a process monitoring tool are studied using integral equations for moments of run length distributions. Under an i.i.d. model, L(x), the average run length of a GMA with starting or initial value x, can be expressed as the solution of a Fredholm integral equation of the second kind. The function L(x) is approximated numerically, and tables of average run lengths associated with the GMAs are given. Using these tables, a procedure is given for choosing the parameters of a GMA chart. The GMA control charting procedures are also compared to the standard Shewhart control charting procedures under an i.i.d. model.

The steady model, used above to derive the GMA for a process mean, involves constant variance terms that are assumed to be known. We extend the normal steady model to the case of unknown variance components possibly changing over time. A maximum likelihood approach is used to estimate the unknown variances, which are then used in the algorithm for estimating the process mean, producing what is known as an adaptive Kalman filter. Also, an adaptive version of the algorithm for monitoring a process variance is derived, using a nonnormal generalization of the steady model and a marginal likelihood function. Properties of the resulting adaptive filters are studied via simulation, and are compared to those of corresponding Shewhart control charts under an i.i.d. model.

The Kalman filter is also used as a tool in stochastic control theory. A nonstandard but intuitively appealing cost structure, involving a fixed cost for any process adjustment, is introduced for the optimal control problem. This cost structure and the steady model then lead to optimal policies that, unlike usual optimal control policies, are consistent with Shewhart statistical process control policies. That is, under the new cost structure, process adjustment is called for only when evidence of misadjustment is strong. Tables that allow implementation of these new policies are provided. Expressions for the risk function associated with the finite horizon problem, and the limiting average risk function associated with the infinite horizon problem, are given.

Gan, Fah Fatt. Goodness-of-fit statistics for location-scale distributions. Ph.D. thesis, Iowa State University Library. August 1985.

This dissertation is concerned with the problem of assessing the fit of a hypothesized parametric family of distributions to data. A nontraditional use of the chi-square and likelihood ratio statistics was considered in which the number of cells is allowed to increase as the sample size increases. A new goodness-of-fit statistic k^2, based on the Pearson correlation coefficient of points of a P-P (percent versus percent) probability plot, is developed for testing departures from the normal, Gumbel, and exponential distributions. A statistic r^2 based on the Pearson correlation

coefficient of points on a Q-Q (quantile versus quantile) probability plot is also considered. A new qualitative method based on the P-P probability plot is developed, for assessing the goodness of fit of non-hypothesized probability models to data. This method is not limited to location-scale distributions. Curves were fitted through the Monte Carlo percentiles to obtain formulas for the percentiles of k^2 and r^2 statistics. An extensive Monte Carlo power comparison was performed for the normal, Gumbel, and exponential distributions. The statistics examined included those mentioned earlier, statistics based on the moments, statistics based on the empirical distribution function, and the commonly used Shapiro-Wilk statistic. The results of the power study are summarized, and general recommendations are given for the use of these statistics.

Jeske, Daniel Robert. Prediction intervals for the realization of a random variable under a general mixed linear model. Ph.D. thesis, Iowa State University Library. December 1985.

Let $\underline{y}$ represent an $n \times 1$ observable random vector and w an unobservable random variable, whose joint distribution is of the multivariate normal form with $E(\underline{y}) = X\underline{\beta}$ and $E(w) = \underline{\lambda}'\underline{\beta}$, where X is a given $n \times k$ matrix, $\underline{\lambda}$ is a given $k \times 1$ vector, and $\underline{\beta}$ is a $k \times 1$ vector of unknown parameters. The elements of the variance-covariance matrix of $\underline{y}$ and w are assumed to be known functions of a $q \times 1$ vector $\underline{\theta}$ of unknown parameters.

The problem considered is that of constructing an approximate $100(1 - \alpha)\%$ prediction interval for the realized value of w, that is, an interval $[P_1(\underline{y}), P_2(\underline{y})]$ such that the probability (with respect to the joint distribution of $\underline{y}$ and w) of the event $\{P_1(\underline{y}) < w < P_2(\underline{y})\}$ approximates $1 - \alpha$, for all $\underline{\beta}$ and $\underline{\theta}$.

There exist functions $P_1^*(\cdot;\alpha,\underline{\theta})$ and $P_2^*(\cdot;\alpha,\underline{\theta})$, depending on α and $\underline{\theta}$, such that $P[P_1^*(\underline{y};\alpha,\underline{\theta}) < w < P_2^*(\underline{y};\alpha,\underline{\theta})] = 1 - \alpha$, for all $\underline{\theta}$ and $\underline{\beta}$. If $\underline{\theta}$ were known, $[P_1^*(\underline{y};\alpha,\underline{\theta}), P_2^*(\underline{y};\alpha,\underline{\theta})]$ would be an exact $100(1 - \alpha)\%$ prediction interval for the realization of w. When $\underline{\theta}$ is unknown, an exact $100(1 - \alpha)\%$ prediction interval for the realization of w does not exist (except in relatively simple special cases).

Five types of approximate intervals were investigated: 1. Naive intervals $[P_i^*(\underline{y};\alpha,\hat{\underline{\theta}})]$, where $\hat{\underline{\theta}}$ is an even translation-invariant estimator of $\underline{\theta}$; 2. Modified naive intervals $\eta_B(\underline{y};\hat{\underline{\theta}}) \pm t_{\alpha/2}[v(\hat{\underline{\theta}})][M^*(\hat{\underline{\theta}})]^{1/2}$, where $v(\cdot)$ is a specified function, $t_{\alpha/2}[v(\hat{\underline{\theta}})]$ is the upper $\alpha/2$ point of the t-distribution with $v(\hat{\underline{\theta}})$ degrees of freedom and $M^*(\hat{\underline{\theta}})$ is an approximation to $E[\eta_B(\underline{y};\hat{\underline{\theta}}) - w]^2$; 3. Conservative intervals of the general form $(\min_{\underline{\theta} \in \underline{R}} [P_1^*(\underline{y};\alpha^*,\underline{\theta})], \max_{\underline{\theta} \in \underline{R}} [P_2^*(\underline{y};\alpha^*,\underline{\theta})])$, where $\underline{R}$ represents a confidence set for $\underline{\theta}$; 4. Parametric bootstrap intervals $\eta_B(\underline{y};\hat{\underline{\theta}}_m) \pm k_{\alpha/2}(\hat{\underline{\theta}}_m)[M_m^*(\hat{\underline{\theta}}_m)]^{1/2}$, where $k_{\alpha/2}(\underline{\theta})$ is the upper $\alpha/2$ point of the distribution of $[\eta_B(\underline{y};\hat{\underline{\theta}}_m) - w]/[M^*(\hat{\underline{\theta}}_m)]^{1/2}$ and $\hat{\underline{\theta}}_m$ is the maximum likelihood estimator of $\underline{\theta}$; 5. Bayesian credibility intervals.

Results on the properties of these intervals are given for the general case and for the following two special cases: (1) the comparison of the means of two independent normal populations with unknown and unequal variances (the Behrens-Fisher problem), and (2) the prediction of a group mean under the balanced one-way random model. The modified naive intervals, the conservative intervals, and the parametric bootstrap intervals seem to provide satisfactory approximate prediction intervals.

Kim, Byung Hwee. The admissibility of some generalized and stepwise Bayes estimators. Ph.D. thesis, Iowa State University Library, August 1985.

Consider an estimation problem in the one-parameter exponential family with squared error loss. Das Gupta and Sinha [*Technical Report #84-8, Department of Statistics, Purdue University (1984)*] and Meeden and Ghosh gave, using an approach given in Brown and Hwang [in *Statistical Decision Theory and Related Topics III,* Vol. 1, edited by S. S. Gupta and J. O. Berger (1982)] which is in turn based on Blyth's method [*Annals of Mathematical Statistics* 22 (1951) 22-42)], two different sets of sufficient conditions for the admissibility of generalized Bayes estimators of an arbitrary parametric function. These two sets of sufficient conditions are discussed and compared.

Using Karlin's [*Annals of Mathematical Statistics* 29 (1958) 406-436] technique, sufficient conditions are given for generalized Bayes estimators to be admissible under squared error loss for estimating an arbitrary nonnegative, differentiable, strictly increasing or decreasing parametric function in one-parameter nonregular families of distributions. The sufficient conditions involve the behavior of a certain integral in a neighborhood of the endpoints of the parameter space. Some examples are subsequently given.

We also consider estimating an arbitrary parametric function in the case when the parameter and sample spaces are countable and the decision space is arbitrary. Through use of the notions of a stepwise Bayesian procedure introduced by Hsuan [*Annals of Statistics* 4 (1979) 860-868] and finite admissibility introduced by Meeden and Ghosh [*Proceedings of the Indian Statistical Institute Golden Jubilee International Conference on Statistics: Applications and New Directions* (1984) 378-390], a theorem is proved which shows that every finitely admissible estimator is unique stepwise Bayes with respect to a finite or countable sequence of mutually orthogonal priors with finite supports. Under an additional assumption, it is shown that the converse is true as well. An example is considered where every admissible estimator is finitely admissible as well.

McNulty, Mark S. Information usage in the formation of price expectations: Theory and econometric tests. Ph.D. thesis, Iowa State University Library. August 1985.

Assume that economic agents form expectations rationally by forecasting future prices with the stochastic expectation of price, conditional upon an

observed set of information. If information used in forming expectations is considered a scarce resource, profit maximizing agents will acquire additional information until the marginal cost of that activity equals the marginal benefit. Agents engaged in purely productive activities are considered, and it is assumed that there is no opportunity for speculation. The benefits of information usage are shown to depend upon the parameters of the market in which the agent is participating. In certain situations, the information used by one agent may create both positive and negative externalities in the market.

If information is considered a costly resource, then one does not expect agents to use all that is available, even if expectations are formed rationally. The applicability of different econometric tests of the hypothesis of rationality is discussed in light of this fact. Special attention is given to estimation and hypothesis testing when the error in the model is serially correlated.

An empirical analysis of expectation formation in the chicken broiler market is conducted. The results imply that short-run production decisions in this industry do not satisfy the rational expectations model. It is suggested that the value of information to broiler producers is relatively small in the short run because of an inability to make substantial short-run changes in the level of production. A cobweb model of expectation formation performed well in describing producer behavior.

Rogers, Michael Philip. Selection using a dichotomized auxiliary variate. Ph.D. thesis, Iowa State University Library. December 1985.

Consider a random sample of n objects from which we wish to select the k best. Quality will be defined in terms of measurements Y_i ($i = 1,...,n$); the larger the value of Y_i, the more valuable the object. The obvious solution—measure $Y_1,...,Y_n$, and select those objects with the k largest Y_i values—may be impractical, if the Y_i's are difficult to observe. An alternative is to select objects on the basis of an auxiliary variate X_i ($i = 1,...,n$), related to Y_i, but less elusive.

Under the assumption that X_i and Y_i are positively associated, a reasonable procedure is to choose those objects with X_i values exceeding some fixed point x_c. Denote the probability that the subset of items thus selected does indeed include the k best by $_n\Pi_k$. Then, x_c may be chosen so that $_n\Pi_k \geqslant P^*$, where P^* ($0 < P^* < 1$) is researcher-set. Several expressions for $_n\Pi_k$ are found; one particularly convenient form is evaluated, when X and Y are bivariate normal, for many values of n, k, and $\rho = \mathrm{corr}(X,Y)$.

The limiting behavior of $_n\Pi_k$, as $n \to \infty$, is examined when k is either constant or a function of n (that is, $k = k(n) = f \cdot n$ or n^f ($0 < f < 1$)). Briefly, when k is fixed, $_n\Pi_k \to 1$; when k is proportional to n, $_n\Pi_k \to 0$; and when $k = n^f$, the limit is distribution dependent (see text for details).

Yeo and David [*Journal of the American Statistical Association* 79:385 (1984) 399-405] consider a fixed-size subset selection procedure—choosing those objects with the s largest X_i values—and calculate $_n\Pi_{s:k}$, the probability that this subset includes the k best objects. Our approach is contrasted with Yeo and David's, and an alternative derivation of $_n\Pi_{s:k}$ is provided.

Saad-Eldin, Saad-Eldin Mohamed. The split-plot design with covariance. Ph.D. thesis, Iowa State University Library. December 1985.

A split-plot data structure is usually modeled by a linear classificatory model with a {0,1} model matrix and with error consisting additively of independent Gaussian errors. Statistical analysis of such a data structure in the usual mode involves two components of error variance. The usual model is, then, a special case of what is commonly called a mixed linear model. Consequently, the well-known problems of mixed linear models are encountered. However, the standard balanced split-plot data structure has special features of balance that enable progress, as will be explained.

With the presence of a concomitant variable and the assumed error structure, the problem of estimation of the dependence of the observations to be explained on the concomitant variable becomes complicated. The model considered is

$$y_{ijk} = \mu + \alpha_i + \gamma_j + \nu_k + \eta_{ijk} + x_{ijk}c + e_{ij} + s_{ijk}$$

where x_{ijk} is the value of the concomitant variable or the covariate, c is the regression coefficient, e_{ij} and s_{ijk} are errors. The difficulties arise from the existence of the two types of error. The nature of split-plot designs is exposited, along with special features arising from the balance in the structure.

The basic problem considered is estimation of the regression coefficient c, since if this is solved the remainder of the problem of fitting the model seems clear. There is no best way of estimating c because $\mathrm{var}(e_{ij})$ and $\mathrm{var}(s_{ijk})$ are not known. Various methods are discussed.

The problem is simple if the ratio of the two variance components is known. Therefore, attention is turned to estimation of a basic parameter related to this ratio, with various methods, including Bayesian estimation, being considered. The widely used method of maximum likelihood fitting of the model is examined. Also, a method of restricted maximum likelihood estimation is examined.

Residual problems such as attaching "reasonable" standard errors to estimates are not solved. It seems that understanding those problems can be achieved only by simulation.

Tveite, Michael David. Statistical aspects of L_1 regression. Ph.D. thesis, Iowa State University Library. December 1985.

Consider the linear model $\underline{Y} = X\underline{\beta} + \underline{\varepsilon}$, where $\underline{Y}$ is an $n \times 1$ vector of response variables; X is an $n \times p$ matrix of values of concomitant variables with entries $x_{i,j}$, $i = 1,2,...,n; j = 0,1,...,p-1$; $\underline{\beta}$ is a $p \times 1$ vector of parameters $(\beta_0,\beta_1,...,\beta_{p-1})$; and $\underline{\varepsilon}$ is an $n \times 1$ vector of random disturbances, assumed to be independent

and identically distributed, each following some distribution function F.

Historically, the residuals (ε) have been assumed to be independent and identically distributed normal random variables with mean zero and variance σ^2. This assumption has led to almost exclusive use of the least squares criterion for estimating β. However, the assumption of normally distributed residuals is currently being questioned for many applications; when the normality of residuals is in doubt, so is use of the least squares regression criterion. There are many possible alternatives to least squares, and this dissertation addresses one of these: the L_1 regression criterion, also frequently referred to as minimum absolute deviations (MAD) or least absolute values (LAV) regression. L_1 regression consists of finding estimates $\widetilde{\beta}$ of β such that

$$\min_{\beta_j \in R} \Sigma_{i=1}^{n} \left| y_i - \Sigma_{j=0}^{p-1} x_{ij} \beta_j \right| = \Sigma_{i=1}^{n} \left| y_i - \Sigma_{j=0}^{p-1} x_{ij} \widetilde{\beta}_j \right|.$$

Techniques for obtaining L_1 estimates have been the subject of a great deal of research and are only summarized in this dissertation. However, there has not been much done to develop inference techniques for L_1 regression; this dissertation tries to develop such techniques. The inferences developed here are for β_1, the slope of the simple regression line (the linear model given above, with p = 2). Three different strategies are employed to provide prospective inferences: in Chapter 2, nonparametric techniques arising from L_1 estimation are explored; in Chapter 3, the asymptotic distribution of $\widetilde{\beta}_1$, the L_1 estimator of β_1, is used to generate inferences; in Chapter 4, likelihood ratio statistics are derived assuming residuals are distributed double exponential, and inferences based on these statistics are developed.

The 1986 spring breakfast featured made-to-order omelets. Roy Hickman is shown, left, preparing a special one for the Bill Meeker family, while Doug Andrews, right, adds a quick shake and a handful of chopped (your choice) green pepper, onion, cheese, mushroom, and ham. At Andrews' right are Carol Francisco and Mark Reiser.

Department of Statistics

The Department of Statistics offers 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. This curriculum was reorganized to offer two options beginning with the 1985-86 year. The biostatistics option stresses the application of statistical techniques to designed experiments and sample surveys. The new information management option places greater emphasis on efficient storage and rapid retrieval of large data sets that are useful in inventory control, optimum use of resources, and management decision-making. Degree candidates in statistics or biometry may choose to receive the degree jointly with another department. This is not a frequent choice but represents a way to add depth in areas of application. The most common graduate co-major is industrial engineering or engineering valuation for a joint emphasis on operations research.

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 engineering statistics. 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. More information appears in the departmental brochure, "Iowa State University—Graduate Program in Statistics, August 1986," available upon request.

D. F. Cox taught Stat 593, Statistical Methods, in Cherokee, Iowa, from November 6 to December 4, 1985. This one-credit course meets for five three-hour sessions and is part of the off-campus program for the degree Master of Agriculture. The objective of the course is to teach the basic role of statistics in designing, executing, and interpreting experiments.

Kenneth J. Koehler offered a new three-credit course on statistical methods for analyzing categorical data, as Stat 590B in fall 1985.

Under Stat 590A, two one-credit special topics courses in statistical theory were offered by B. K. Kale. The course given in the fall dealt with theory of

unbiased statistical estimation functions (USEF) that are functions of observations and the parameters in the model. The motivation for USEF is provided by estimating equations, such as likelihood equations, which are established by equating a USEF to zero. Several open problems were mentioned, and a set of lecture notes was prepared for reference purposes since no text is available.

Kale's second course, Outliers, dealt with the problem of statistical inference in the presence of outlier observations. Various procedures for detection and identification of outliers for univariate data were discussed along with the estimation of parameters of interest. Maximum likelihood estimation theory for different outliers generating models was discussed. Classical real-life data sets such as Darwin's data (Fisher), Cushny-Peebles data (Student), and Newcomb's data (Stigler) were used to illustrate the theory.

The Department of Statistics has over the past few years placed great emphasis on activities relating to engineering and industrial statistics. Faculty members have worked summers at leading U.S. companies, developed and published new theory in the area, participated in important meetings and conferences on the subject, supervised theses and creative components applicable to industrial problems, consulted and offered industrial short courses privately, and completely revamped ISU's graduate courses in industrial statistics to reflect current best theory and practice.

In response to needs perceived through the new ISU Industry/University Affiliate Program in Productivity, Quality, and Reliability, a one-week short course was developed for presentation in March 1986, in cooperation with ISU Engineering Extension. This course dealt with advanced statistical methods for process control and improvement. It was taught by W. Robert Stephenson and Stephen Vardeman from the Department of Statistics and Roger Berger from the Department of Industrial Engineering, with Stephen Crowder providing instruction on the use of the course software. The short course was favorably received by 13 people representing both affiliate and nonaffiliate companies. It appears that this will lead to further interaction with Bandag, Inc., an eastern Iowa company, with Stephenson teaching a course there in July 1986. Preparations are underway for presentation of a reliability statistics short course at another affiliate's site.

Several years ago the Statistical Laboratory and the Department of Statistics entered into a cooperative rotating internship arrangement with Weyerhaeuser Company, Hot Springs, Arkansas. This has made it possible for a graduate or advanced undergraduate student to gain experience working as a trainee with the company for a semester or longer. The program has been quite successful and continues.

In February 1986 an agreement was arranged between the Department of Statistics and Process Management Institute, Inc., Bloomington, Minnesota, for another internship. This provides for sending to PMI, for a semester or longer on a rotating basis, a statistics graduate or undergraduate student interested in quality control applications in industry. PMI engages in consulting and training in the field of industrial management and quality improvement, as a proponent of W. Edwards Deming's ideas and the Japanese management style.

Richard Groeneveld presented a portion of the Computer Science/Engineering/Statistics Symposium during the ISU Science and Mathematics Teachers Short Course held on campus March 14, 1986. The MINITAB computing package was described so that the high school science teachers were able to use programs in the package operating from computer terminals to solve demonstration problems. The annual short course is sponsored by the university in cooperation with a section of the Iowa Academy of Science and the Iowa Council of Teachers of Mathematics.

The main thrust of undergraduate teaching in statistics continues to be the provision of service courses. Since the early 1970s enrollments have roughly doubled in the 100-300 level courses. (The great bulk of such enrollments is in the introductory courses—2,844 students for fall and spring 1985-86.) In comparison, the percentage of enrollments in 100-300 level courses among *all* statistics course enrollments has been relatively stable. For 1985-86, not counting summer, 70.4 percent of all enrollments in statistics courses are at the 100-300 level. (This compares with 63.4 percent 10 years ago.) Many programs throughout the university require a statistics course for their majors. In the last five years enrollments rose dramatically in the introductory business statistics course, but may now have leveled off.

The number of undergraduate statistics majors remains modest but stable, ranging from 40 to 50. Although the major in statistics is a relatively small program within the College of Sciences and Humanities, it is among the larger undergraduate programs administered by a statistics department in the United States.

In the fall semester, 41 undergraduate majors in statistics, 3 students in biometry, and 95 graduate majors in statistics were enrolled.

Course offerings for the 1985-86 academic year and the 1986 summer session are listed below.

■ 1985-1986 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 Andrews Erland Gotway	Kortge Shelley Stephenson	
104	Introduction to Statistics	3	F,S,SS Beasley C. P. Cox Grau	Hotchkiss G. Morel Sukhatme	
105	Introduction to Statistics	2	F,S	Isaacson Melander Sukhatme	

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227	Introduction to Business Statistics	4	F,S,SS	Christman, Farmer, Kortge, Liedtke, J-S. Lin, Meeker, Moore	Moy, Murphy, Nanayak-kara, Roesler, Vander Wiel
231	Probability and Statistical Inference for Engineers	4	F,S	Homblé, Kale, Meeden	Nanayak-kara, Vardeman
305	Engineering Statistics	3	S	Vardeman	
328	Applied Business	3	F,S	Groeneveld, Meeker, Silvis	
341	Introduction to Theory of Probability and Statistics	3	F,S	Groeneveld, Pollak, 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, Carriquiry, C. P. Cox, D. F. Cox, Hotchkiss	Lorenz, McGovern, Roberts, Shelley, Stephenson
402	Statistical Design and the Analysis of Experiments	3	F,S	D. F. Cox & Hinz, Hotchkiss	Marasinghe, Wolins
404	Statistics for the Social Sciences	3	F	Roberts	
405	Applied Econometric Statistics	3	S	Hickman	
407	Methods of Multivariate Analysis	2	F	Koehler	
421	Survey Sampling Techniques	3	S	Reiser	
432	Applied Probability Models	3	F	Groeneveld	
436	Genetic Statistics for Research Workers	3	F	Bailey	
447	Statistical Theory for Research Workers	4	S,SS	Amemiya, Kale	
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	F,S	Stephenson	

Courses Primarily for Graduate Students, Major or Minor

500	Statistical Methods	4	F	Hinz
501	Multivariate Statistical Methods	3	S	Koehler
511	Theory and Application of Linear Models	3	S	Harville
512	Design of Experiments	3	F	Kempthorne
521	Theory of Sample Surveys I	3	S	Sukhatme
533	Reliability	3	S	H. T. David & Meeker
536	Genetic Statistics	2	F	Pollak
537	Genetic Statistics	2	S	Pollak
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	Athreya
543	Theory of Probability and Statistics	3	S	H. A. David
544	Bayesian Decision Theory	3	SS	Meeden
579	Introduction to Computer Hardware and Software Systems for Statistical Computing	1	F	Kennedy & Marasinghe
580	Statistical Computing	3	F	Kennedy
590	Special Topics	Arr		
	A. Theory		F	Meeden
	B. Methods		S	Meeker
	C. Design of Experiments		F	Hotchkiss, Sacks
590A	Estimation Functions	1	F	Kale
590A	Outliers Theory and Methodology	1	S	Kale
590B	Frequency Data	3	F	Koehler
593x	Statistical Methods	1	F	D. F. Cox
599	Creative Component	Var	F,S,SS	C. P. Cox, Cressie, H. A. David, H. T. David, Harville, Hinz, Kennedy, Koehler, Lorenz, Marasinghe, Meeden, Meeker, Reiser, Sacks, Stephenson, Vardeman

Courses for Graduate Students, Major or Minor

601	Advanced Statistical Methods	3	F	C. P. Cox
606	Spatial Statistics	3	S	Cressie
611	Advanced Linear Model Theory	3	F	Harville

612	Advanced Experimental Design	3	S	Kempthorne
642	Measure Theory and Probability	3	S	Isaacson
643	Theory of Estimation and Testing of Hypotheses	3	F	Meeden
645	Order Statistics	3	F	H. A. David
651	Time Series	3	S	Fuller
680	Advanced Statistical Computing	3	S	Kennedy
699	Research	Var	F,S,SS	Athreya Koehler Cressie Marasinghe H. A. David Meeden H. T. David Meeker Fuller Sposito Harville Vardeman Isaacson

▪ Graduate Students

Eleven Ph.D. degrees and 34 M.S. degrees were completed in the Department of Statistics during the fiscal year. Two of the doctorates were awarded for joint majors.

Kevin Anderson, Daniel Jeske, and Stephen Crowder received Graduate College Research Excellence Awards at graduation in recognition of research accomplishments demonstrated by completion of outstanding dissertations. Each award consisted of $300, a letter of commendation from President Parks, a certificate of achievement, and special recognition.

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

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

M.S. Recipients

*Douglas Martin Andrews (Spring 1986; H. A. David).

Patti Ann Beasley (Spring 1986; Kenneth J. Koehler) joined Hoffman/LaRoche in Nutley, New Jersey, in June.

Stephen Dale Boeh (Summer 1985; Stephen B. Vardeman) is a process analysis specialist with Corning Medical, Medfield, Massachusetts.

Thomas Arthur Borders (Summer 1985; Noel Cressie) joined the Human Factors Group, General Dynamics, Fort Worth Division, in Fort Worth, Texas, to work on design of experiments.

*Mark Frederick Bryan (Fall 1985; Noel Cressie).

José A. Calcaño-Collazo (Fall 1985; W. Robert Stephenson) resumed his position as assistant professor, Department of Mathematics, Inter American University, in Hato Rey, Puerto Rico.

Terry Eugene Caliste (Spring 1986; William Q. Meeker, Jr.) has been working at Bell Communications Research, Red Bank,

New Jersey, as a member of the Technical Staff, Quality Assurance Department, since January.

Seong-San Chae (Fall 1985; Paul Hinz) is working on his doctorate in statistics at Oklahoma State University.

I-Shang Jackson Chow (Spring 1986; William Q. Meeker, Jr.) began work toward a Ph.D. degree in the Department of Biostatistics, University of California at Los Angeles, in June.

Jeffrey David Christman (Spring 1986; Mervyn Marasinghe) has accepted a position as statistician with International Technology Corporation, Monroeville, Pennsylvania.

John Robert Cook (Fall 1985; Frederick O. Lorenz) has continued graduate study in the Department of Statistics, North Carolina State University.

Da Yang (Summer 1985; Edward Pollak) went to the University of Illinois Department of Animal Science to work toward a doctorate.

Mamadou Lamine Diedhiou (Spring 1986; Jerome Sacks) has returned to Senegal to engage in research as an agricultural statistician in the Institute of Agricultural Research, Dakar.

Gloriana Giacobello (Fall 1985; Mark Reiser) returned to Rome, Italy, and is employed by Procter & Gamble, Inc.

Mark Lee Gunderson (Summer 1985; Paul Hinz) is a statistical analyst in the Product Engineering Department, Hydra-matic Division of General Motors, in Ypsilanti, Michigan.

*In Hye Ha (Summer 1985; H. A. David).

*Chong Sun Hong (Spring 1986; Herbert T. David).

Chihho Hsieh (Fall 1985; Stephen B. Vardeman) is working in quality control as a statistician with Metpath Inc., Peterboro, New Jersey.

*Frederick Landis Hulting (Fall 1985; W. Robert Stephenson).

Ching-Chang Hwang (Fall 1985; Mervyn Marasinghe) went to Kansas State University in August 1985 to begin work toward a Ph.D. in statistics.

Brenda Kirsten Ihle (Spring 1986; Kenneth J. Koehler), after marrying Mark Gunderson (M.S. Summer 1985), was employed during the summer as a statistical consultant in the Reliability Section, Hydra-matic Division, General Motors. She begins work toward a doctorate in statistics at the University of Michigan in September.

*Karen Lorraine Jensen (Fall 1985; William Q. Meeker, Jr.).

*Yoou-Jen Kang (Summer 1985; Yasuo Amemiya).

Mohammad Inayat Khan (Fall 1985; Jerome Sacks) began studies toward a Ph.D. in statistics at Oklahoma State last January.

Kenneth James Kortge (Spring 1986; C. Philip Cox) has joined General Motors Milford Proving Ground in Michigan as a statistical analyst in the Current Product Engineering Division.

*Jyh-Shiun Lin (Summer 1985; W. Robert Stephenson).

Douglas Edwin McCoy (Summer 1985; William Q. Meeker, Jr.) is a statistical analyst in the Analytical Services Department, Hydra-matic Division, General Motors, in Ypsilanti, Michigan.

Karen Louise Moore (Spring 1986; W. Robert Stephenson) accepted a position as research statistician with A. C. Nielsen Co., Northbrook, Illinois.

Juan Esteban Ramírez Cid (Spring 1986; Herbert T. David) continues as assistant professor in the Department of Mathematics, Universidad de Santiago, in Chile.

Narayan Swami Shankar (Fall 1985; Krishna Athreya) is working toward a Ph.D. in mathematics at the University of Illinois, Urbana.

Yan-Ling Tsay (Summer 1985; William J. Kennedy) accepted an appointment as researcher, Applied Statistics & Computing Section, Battelle Memorial Institute, Columbus, Ohio.

Steven Paul Vilendrer (Fall 1985; Kenneth J. Koehler) has been with Minnesota Mining and Manufacturing in St. Paul since July 1985; he is an advanced quality engineer in its Decorative Products Division.

Peh-Jen Jenny Wu (Summer 1985; V. A. Sposito), who is married to Anthony Lui (M.S. ISU in statistics, Summer 1984), began studies at Ohio State University in September and hopes to complete a second master's degree in computer science.

Min-Shih Chang Yang (Summer 1985; Ronaldo Iachan) joined her husband in Endicott, New York.

Ph.D. Recipients

Kevin Karl Anderson (Summer 1985; Krishna Athreya) joined the Thomas J. Watson Research Center, IBM Corporation, Yorktown Heights, New York, for one year as an IBM postdoctoral research fellow in the Department of Mathematical Sciences.

Terrance Patrick Callanan (Fall 1985; David A. Harville) is an applied statistician in the Management Services Division, Applied Statistics Group, at Eastman Kodak, Rochester, New York.

Lee Ann Josvanger Crowder (Spring 1986, in statistics and industrial engineering; Vincent A. Sposito and Keith McRoberts) is a senior statistical engineer in the Manufacturing and Engineering Division, Corning Glass Works, Corning, New York.

Stephen Vernon Crowder (Spring 1986; Stephen B. Vardeman) also is a senior statistical engineer in the same division of Corning Glass.

Fah Fatt Gan (Summer 1985; Kenneth J. Koehler) joined the Department of Statistics, University of Central Florida, as assistant professor.

Daniel Robert Jeske (Fall 1985; David A. Harville) is a member of the Technical Staff, Microwave Department, AT&T Bell Laboratories, in Holmdel, New Jersey.

Byung Hwee Kim (Summer 1985; Glen Meeden) returned to Seoul, Korea, to join the Department of Mathematics, Hanyang University, as assistant professor.

Mark Steven McNulty (Summer 1985, in economics and statistics; Wallace Huffman and Wayne A. Fuller), who had been an assistant professor in the Department of Economics, University of North Carolina at Greensboro, joined the Department of Statistics, Kansas State University, with the same rank.

Michael Philip Rogers (Fall 1985; H. A. David) began work at Regenstrief Institute, Indianapolis, as statistical consultant in September 1985, with the position of assistant professor in the Biostatistics Section of the Indiana University Medical Center.

Saad Eldin Mohamed Saad Eldin (Fall 1985; Oscar Kempthorne) returned to the University of Gezira, Sudan, to become a lecturer in the Department of Statistics.

Michael David Tveite (Fall 1985; Vincent A. Sposito) completed his third year as assistant professor in the Department of Mathematics, St. Olaf College. Then in June 1986 he joined Process Management Institute, Bloomington, Minnesota, a consulting and training company in the field of management and quality improvement.

M.S. Candidates

bin Abdul Malik, Danyal
Al-Mahmoud, Ahmad M. A.
Andrews, Douglas M.
Beasley, Patti Ann
Benlemrid, Driss
Boeh, Stephen D.
Brescia, Victor P.
Bullock, Scott E.
Busch, Donna E.
Cai, Yilin
Calcaño-Collazo, José
Caliste, Terry E.
Carley, Michael R.
Chae, Seong-San
Chisolm, Barbara A.
Chow, I-Shang Jackson
Christman, Jeffrey D.
Cook, John R. (in absentia)
Diedhiou, Mamadou L.
Da Yang
Dombek, C. Janelle
Erland, Kimberly
Fagih, Abdullah Y. A. K.
Fan, Kaisheng
Giacobello, Gloriana
Gotway, Carol A.
Graf, Deanna L.
Grau, Eric A.
Grondona, Martín
Guo, Renkuan
Han, Geun Shik
Hong, Chong Sun
Hsieh, Chihho
Hwang, Ching-Chang

Ihle, Brenda
Johnson, Jane M.
Khan, Mohammad I.
Kim, Joo-Hwan
Kortge, Kenneth J.
Lay, Alice S.
Liedtke, Charles A.
Lin, Chiou-Hua
Melander, Todd
Moore, Karen L.
Morel, Grecia F.
Moy, Terry
Murphy, Dennis J.
Nusser, Sarah M.
Park, Heon Jin
Rathbun, Stephen L.
Roesler, Jill L.
Schroeder, Darrell
Shamsuddin, Hussein
Shankar, Narayan
Su, Shiowlin
Sullivan, Gary R.
Symanowski, James T.
Taylor, Kathleen M.
Thompson, John C.
Vander Wiel, Scott
Vasconcelos, M. Katheleen
Vilendrer, Steven P.
Wan Ismail, Wan Azah
Wang, Kui-Jang
Wang (Chu), Shaw-Ling
White, Susan E.
Winters, Franklin
Wu, Peh-Jen Jenny

Ph. D. Candidates

Abdurachman, Edi
Anderson, Kevin K.
Biele, Jonathan
Bryan, Mark F.
Callanan, Terrance P.
Carriquiry, Alicia
   (joint animal science-
   statistics)
Cranford, Brian Keith
Crowder, Lee Ann
   (joint statistics-
   industrial engineering)
Crowder, Stephen V.
Eltinge, John L.
Farmer, Charles M.
Francisco, Carol A.
Freire, Clarice
Fuh, Cheng-Der
   (joint mathematics-
   statistics)
Funo, Eiichiro
Gan, Fah Fatt
Ha, In Hye
Hasab-El-Naby, Nancy Eyink
Homblé, Patrick R.
Hulting, Frederick
Jensen, Karen L.
Jeske, Daniel R.
Kang, Yoou-Jen
Kim, Byung Hwee
Kim, Song-Ho
Lasack, Paula M.
   (joint entomology-
   statistics)
Lee, Mong-Kong

Lemke, Klaus
Lin, Jyh-Shiun
Lin, Tsung-Hua (Thomas)
Loubert, Sharon K.
Lu, Chi-hsien Joseph
McNulty, Mark (in absentia)
   (joint agricultural
   economics-statistics)
Miller, Stephen M.
Mingoti, Sueli A.
Morel, Jorge G.
Muththiah, Thilagawathy
Nagaraj, Neerchal K.
Nanayakkara, Nuwan
Ramírez C., Juan Esteban
Rogers, Michael P.
Saad Eldin, Saad Eldin M.
Schnell, Daniel J.
Silvis, David L.
Sung, Nae Kyung
Tirol, Miriam Bridget
   (joint industrial
   engineering-statistics)
Tollefson, Margot H.
Tveite, Michael (in absentia)
Wolfgram, Danny A.
Wong, Peter Sze-Yan
   (joint mathematics-
   statistics)
Yoon, Byoung Chang
Zakaria, Rahmat Syahni
   (joint statistics-
   industrial engineering)
Zimmerman, Dale L.

Frederick Hulting completed his internship with Weyerhaeuser Company, Forest Paper Products, Hot

Springs, Arkansas, in July 1985, under the cooperative Statistical Laboratory-Weyerhaeuser agreement. Kim Erland interned there from July through December, and Terry Moy started on a similar program in mid-June 1986. Scott Vander Wiel began a cooperative education and training program with Process Management Institute, Inc., in Bloomington, Minnesota, in June 1986.

Mark Bryan served as parliamentarian for the Iowa State University Graduate Student Senate Executive Council during the academic year. Mong-Hong Lee received a certificate of recognition from the ISU Student Affairs Human Relations Committee at a May 29th presentation.

Paula Lasack and Heon Jin Park were initiated into Phi Kappa Phi Honor Society in March.

◼ Mu Sigma Rho
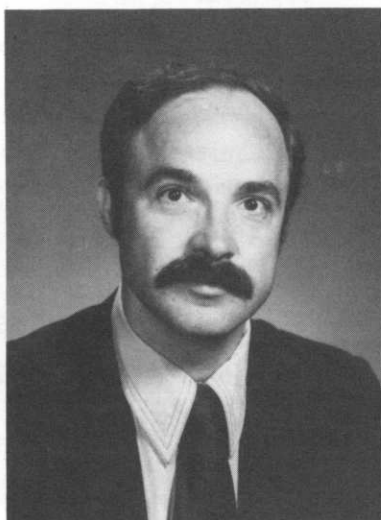
Mu Sigma Rho lecturer Gary G. Koch, has been president of the Biometric Society (ENAR) and is a recent editor of *The American Statistician*.

The Iowa Alpha chapter of Mu Sigma Rho invited Gary G. Koch, professor in the Department of Biostatistics at the University of North Carolina-Chapel Hill, to present its annual lecture this year. His talk, entitled "General strategies for the analysis of categorical data" and cosponsored by Iowa STAT-ers, the Department of Statistics, the university Committee on Lectures, and a number of other areas of the university, was well received by the interdisciplinary audience of students and faculty.

Koch's major research interests are in analysis of categorical data, nonparametric multivariate inference, and random-effects multivariate models and components of variance. He is author or coauthor of over 120 publications concerned with statistical methodology and practice.

Preceding the lecture on April 29th, 34 members were initiated into Mu Sigma Rho at the chapter's annual banquet. The new members were graduate and undergraduate students selected from the Department of Statistics and other departments.

Serving as faculty adviser for Mu Sigma Rho this year was W. Robert Stephenson. Officers elected for the 1986-87 academic year are Karen Jensen, president; John Eltinge, vice president; and Craig Kollman, secretary-treasurer.

◼ George Zyskind Memorial Lecture

Berkeley professor Peter J. Bickel, a former IMS president, presented this year's Zyskind lecture.

The eleventh Zyskind Memorial Lecture was presented by Peter J. Bickel, who spoke on the topic "At least how many are there?" on November 19. Bickel, a professor of statistics at the University of California-Berkeley, has also been dean of physical sciences there since 1980. He is co-author of *Mathematical Statistics* and a former president of the Institute of Mathematical Statistics.

The Zyskind lecture series honors the late George Zyskind, professor of statistics at ISU from 1959 to 1974. While here, Bickel also gave a seminar talk sponsored by the Statistical Laboratory and the Iowa chapter of the American Statistical Association.

◼ Iowa STAT-ers

This past year was one of rejuvenation for the Iowa STAT-ers as the organization continued to take a more active role. Its major accomplishment was the reformation and expansion of a seminar series aimed at the statistics graduate students. The seminars have featured statistics professors and students, as well as two speakers from outside the university. Response has been very good, with high attendance and departmental encouragement in the form of additional funding for next year's series. Plans are to continue the series with more student involvement and more outside speakers.

A group of students traveled to the Iowa City meetings of the Iowa chapter of the American Statistical Association. Plans are underway for a group to travel to the national meetings in August to be held in Chicago.

In additional to these professional activities, several social activities were organized by the Iowa STAT-ers. Among these were beginning- and end-of-the-year pizza parties and a January skating party. These events were planned to encourage camaraderie among the graduate students. Plans are to have more of such activities in the future.

Officers for the year were Keith Cranford, president; James Symanowski, vice president; Brenda

Ihle, secretary; Karen Moore, treasurer; and Alicia Carriquiry, seminar chair. John Eltinge was the student representative at faculty meetings for the academic year. Kenneth Koehler serves as faculty adviser to Iowa STAT-ers.

◼ Snedecor and Bancroft Awards

John Lamont Eltinge was chosen to receive the 1986 George W. Snedecor Award, as the most outstanding Ph.D. candidate in the Department of Statistics. Established in 1954, the award honors the late founder and first director of the Statistical Laboratory, an internationally recognized pioneer in applied statistics. Eltinge was given a year's membership in the Royal Statistical Society and a cash prize.

He received a B.S. degree in mathematics, magna cum laude, at Vanderbilt in 1982 and an M.S. in statistics at Purdue in 1984, where he was a university fellow and a National Science Foundation fellow. At Iowa State his doctoral research interests are in time series and measurement error models. He began the third year of his NSF fellowship June 1, 1986 after two years as a research assistant in statistics.

The 1986 T. A. Bancroft Award was presented to Paul Michael Van Raden, a graduate student in animal science, for outstanding performance as a doctoral candidate minoring in statistics. Van Raden completed a B.S. degree in dairy science at the University of Illinois in 1981 and an M.S. in animal breeding at Iowa State in 1984. He is author or coauthor of four published research papers and in 1985 received the HOLCO award as the most outstanding graduate student in animal science here. The Bancroft award consists of a cash prize and a subscription to a statistically-oriented journal. It honors T. A. Bancroft, professor emeritus and former director and head of the Statistical Laboratory and Department of Statistics.

Both statistics awards were presented at a seminar January 29.

◼ Undergraduates

A diversity of recognitions, awards, and activities highlighted this year for undergraduate majors in statistics. Craig Kollman, Jae McKeown, Ellen Merfeld, Rosli Bin Othman, Steven Wallrichs, and Ellen Winey were initiated as members of Mu Sigma Rho at the annual banquet on April 29. Kollman will serve as secretary-treasurer for the statistics honorary during the 1986-87 academic year. Jae McKeown is currently president of the Sciences and Humanities Council. As president, he also serves on the Executive Committee of the Sciences and Humanities Representative Assembly and the GSB Executive Council. Kollman will be the recipient of the Eastern Iowa American Society for Quality Control Scholarship for 1986-87.

Ten students received B.S. degrees in statistics or biometry during the period July 1, 1985 to June 30, 1986—six with single majors in statistics, three with joint majors or double degrees, and one with a major in biometry. Names and employment or study plans, when definite, follow.

Islahuddin Abu-Hassan (Fall 1985, statistics)

Jooi-Tow Goh (Fall 1985, statistics, and B.A. in economics) is currently a graduate student in statistics at Iowa State.

Holly Marie Gundacker (Fall 1985, statistics) is working as a statistician for Dewey & Almy Chemical Division of W. R. Grace & Co., Lexington, Massachusetts.

Susan Buehler McCann (Spring 1986, statistics and political science) took a position as mathematical statistician with the U.S. Bureau of Labor Statistics, Washington, D.C., in June.

Jay W. Meyer (Spring 1986, statistics) has been accepted into the graduate program in statistics at the University of Florida with an assistantship in biostatistics.

Daniel John Moellenbeck (Spring 1986, biometry) has taken a position as computer analyst with Garst Seed Company, Slater, Iowa—a subsidiary of Imperial Chemical Industries.

Rosli Bin Othman (Spring 1986, statistics and mathematics) will be attending graduate school in statistics at the University of Minnesota starting fall 1986.

Jill Anne Redmond (Spring 1986, statistics)

Mary Catherine Sullivan (Fall 1985, statistics) is working in the accounting department at Webster City Products, Webster City, Iowa.

Jean Ann Wells (Fall 1985, statistics) is an intermediate evaluations analyst for Principal Financial Group (formerly Bankers Life), Des Moines, Iowa.

Craig Kollman, a junior, is working during the summer 1986 with A. C. Nielsen Company in Northbrook, Illinois.

Continuing as academic advisers for undergraduate students were Richard Groeneveld, Donald Hotchkiss, William Meeker, W. Robert Stephenson, and Shashikala Sukhatme.

◼ Statistics Club

The aim of the Statistics Club is to promote interest among undergraduates in the field of statistics. The 1985-86 club activities began with a get-together and barbecue at the home of faculty member Donald Hotchkiss. There was a better turnout this year due

The Statistics Open House during Veishea 1986 was staged on central campus under a canopy. Here visitors discuss the odds in roulette and other games of chance with Jim Markowski (seated) and Tom Owens (standing).

The Statistics Club. Top row: Judy Schaffer, Jeff Larson-Keller, Jean Wells, Randy Bartlett, Robert Plager, and Craig Kollman. Middle row: David Steenhard, Jim Markowski, Diane Hamilton, Holly Gundacker, Jill Redmond, and Sue McCann. Front row: Mary Anne Dellva, Jae McKeown, Julie Haubrich, Jay Meyer, Scott Groth, and faculty advisor Bob Stephenson.

to better weather and the success of last year's barbecue.

In September, representatives of Procter & Gamble—one a former Statistics Club member, Carolyn Conner—gave an informal slide presentation and talked about job prospects with P&G. This presentation was in conjunction with a prerecruiting trip to Iowa State.

The club heard about summer employment at the October meeting. Jay Meyer, club president, talked about his job with the U.S. Bureau of the Census in the Washington, D.C. area. Jean Wells had worked a little closer to home—for the Iowa Department of Public Safety in Des Moines, on a project dealing with fire safety and prevention.

Mark Movic of Bankers Life (Principal Financial Group) spoke to the club in November. He discussed the pros and cons of a career as an actuary.

Spring semester was just as active as the fall, starting with a January meeting to plan spring events. In February, Linda Burtch of Smith Hanley Associates spoke to undergraduates and graduate students about career planning for the statistics professional. She was very optimistic about job prospects for statisticians at all levels. The March meeting was held at the Cyclone Community Center, where members enjoyed ice skating.

April was taken up with plans for Veishea's Open House. This year the Statistics Club moved outdoors. The display "What's your best bet?" was on central campus under a canopy. Visitors had a chance to play one of several casino games and learn the odds of their winning.

Several new initiatives made the club more visible this year. The Statistics Club picture appeared in the *Bomb,* the Iowa State yearbook. Also a newsletter was published regularly to keep members informed of club activities.

Elections were held in April. The 1986-87 officers are:

president: Julie Haubrich
vice president: Jae McKeown
treasurer: Teresa Testroet
secretary: Diane Hamilton

Scott Groth and Jae McKeown will be co-recipients of the 1986-87 Statistics Club Scholarship. W. Robert Stephenson serves as faculty adviser to the club.

■ Seminars

The program of regular weekly noncredit seminars offered by the Statistical Laboratory and the Department of Statistics for the 1985-86 year was planned by Wayne Fuller and Noel Cressie.

Statistical Laboratory Seminars

Summer 1985

July 24	The split-plot design with covariance, Saad Eldin M. Saad Eldin
31	Prediction intervals for the realization of a random variable under a general mixed linear model, Daniel R. Jeske

Fall 1985

August 30	Outliers in educational research: Cultural bias, diagnostic testing, and program evaluation, James R. Veale, California State University at Hayward, and statistical consultant, Berkeley, California
September 4	Graduate students in statistics: Where they come from and where they go, Dean L. Isaacson
11	Restricted maximum likelihood estimation of variance components: Computational aspects, Terrance P. Callanan
18	Optimal inference in curved and nonexponential families, with applications, Ashish Sen Gupta, University of Wisconsin-Madison and Indian Statistical Institute-Calcutta
25	Software for life data analysis, William Q. Meeker, Jr.
October 2	On sampling procedures with inclusion probability proportional to size, A. K. Srivastava,

In Memoriam

Theodore A. Bancroft, 1907-1986

T. A. Bancroft, professor emeritus and former director and head of the ISU statistical center, died at home in Ames in late July 1986. A full-length article about his contributions to statistics and the Statistical Laboratory will appear in the next annual report. Our sympathies go to his daughters, their families, and relatives.

Photo Credits

The photo of David Cox on p. 1 was taken by Barbara Plakens, editor of *Grad News and Notes*, ISU. Bud Meador took the photo of colleague Shelley on p. 7. Photos on p. 22 were taken by the university Photo Service. Photos of Bickel and Koch on p. 41 were provided by courtesy of the speakers. The Statistics Club photo on p. 43 is derived from a color original taken for the ISU *Bomb* yearbook. The remaining photos and the layout design are by Jauvanta Walker.