

THE STATISTICAL CONSULTANT

Section on Statistical Consulting
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IN THIS ISSUE

- Committee on Outreach Education
- Notes from the Section Chair
- Statistical Consulting In Legal Cases: An Example From A Court Martial
- Activities at JSM 2001
- Notes from the Editor

Committee on Outreach Education

The ASA Committee on Outreach Education needs good people to serve a three-year term beginning in January 2002. The Committee is a relatively new one. Its responsibilities involve advising the ASA on continuing education courses for non-statisticians.

Since there is always considerable overlap between courses that are appropriate for non-statisticians and those geared towards practicing statisticians, ASA is especially interested in finding potential committee members who are involved in applying statistics. Thus, members of the Statistical Consulting Section may be particularly well qualified to serve as members of this committee.

Nominations for membership will be presented to President-Elect Myron Straf, who has the final authority in making these appointments.

If you are interested in being nominated for appointment to this committee, please contact:

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Notes from the Section Chair

Ron Wasserstein, Washburn University*

The most interesting discovery during my first few months as chair of this Section is the number of inquiries that come to ASA from people looking for statistical consultants.

Therefore, I am drafting a proposal for the Section Executive Committee to consider, which I think might be a constructive response to this need as a Section and as an Association. In brief, the proposal will involve a web site

that would provide a place for consultants who are interested in finding new projects to post a resume or announcement regarding availability and specialty, and a place for those who seek a consultant to post a notice.

If you have suggestions or alternative strategies, please share them with me, and I'll pass them along. Drop me a note at ron@washburn.edu.

Statistical Consulting In Legal Cases: An Example From A Court Martial

H. James Norton, Carolinas Medical Center†

While my principal positions are Director of Biostatistics at a large hospital in Charlotte, NC, and Adjunct Associate Professor of Mathematics at the University of North Carolina at Charlotte, I have also been retained as a consultant on eight legal cases. This article describes some aspects of statistical consulting as they apply to the legal field.

My goals are to discuss the types of knowledge and skills that a statistical legal consultant should possess; describe, as a practical example, the statistical issues that arose in an Air Force court martial; and introduce you to some useful publications in the areas of statistics and law.

My involvement in legal consulting began when Dr. Ron Ostrowski, a professor of biology at the University of North Carolina at Charlotte, asked me to critique several articles on the statistical analysis of DNA evidence. I subsequently worked with him as a consultant or expert witness on six cases. In each case, the defendant was accused of rape.

Dr. Ostrowski and I also consulted on an

Air Force court martial. In this case, a psychiatrist, who was a colonel in the Air Force, was accused of having sexual relations with a patient. Dr. Ostrowski and I were asked by the defense to evaluate the DNA evidence from stains on the patient's underwear and on the colonel's office couch. Subsequently, the Air Force defense lawyer for this case recommended me to an attorney colleague also involved in a court martial. I describe this case in more detail below.

Knowledge and Skill Required

Statistical issues that present themselves in legal cases include sampling techniques, probability, variability, the appropriate choice of a statistical model or test, assessing whether the assumptions of the model or test have been met, statistical independence, confounding variables, and interpretation of quantitative results.

In addition to a general knowledge of statistics, a legal consultant needs other

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knowledge, skills, and traits. Knowledge of particular subject matter may be needed. For example, the three courses in genetics I took as a graduate student in biostatistics turned out to be very useful in cases involving DNA evidence. On occasion, some knowledge of the law as it applies to the particular case can be useful. I will present an example of legal knowledge being helpful in connection with the court martial described below.

One important skill for legal consulting is teaching. First, the consultant has to explain (that is, teach) the statistical issues to the attorney. If an attorney is not able to become comfortable with the statistical issues, he or she may decide not to use such material in the trial, which may affect the quality of the defense he or she is able to put on. Without a statistics coach, an attorney will not be able to ask cogent questions of a statistical consultant when the consultant testifies. Similarly, he or she may not be able convincingly to interrogate a statistical expert working for the opposing side.

The statistical consultant may be called upon to testify. In this role, the consultant is in the position of educating the judge and jury not only in respect to expert conclusions but also about the statistical methods that lead to these conclusions. The statistician may also have to explain the statistical evidence to the defendant.

If the case goes to trial, the consultant will need to be able to think quickly during the trial. This is especially true if the consultant is called to testify under cross-examination. In addition, the statistician may be called upon while the trial is in session to consult with the lawyer or legal staff about testimony by the opposing experts.

An agreement regarding compensation needs to be made at the outset. It is preferable for the statistician to be paid directly by the government (prosecution) or the law firm (defense), rather than by the client. A losing client may not have as a top priority the payment of bills to the consultant.

In my opinion, the statistician should not accept a contingency fee arrangement, in which payment is conditional on the verdict. One reason for this is credibility. The opposing attorney may ask the consultant about the financial arrangements, and could argue that pay for opinions contingent on the outcome is a reason for the jury to suspect the consultant's motives and opinions.

This also seems to me to be an ethical issue, although I have not found an exactly applicable statement in the current ASA Ethical Guidelines for Statistical Practice (www.tcnj.edu/~ethcstat/-start.html). The 1985 International Statistical Institute's Declaration on Professional Ethics (www.cbs.nl/-isi/-ethics.htm) includes a statement that comes the closest I've seen to an ethical concern over the terms of payment for services. It states, "Statisticians should not accept contractual conditions that are contingent upon a particular outcome from a proposed statistical inquiry." I would think that a financial arrangement that depends upon a certain verdict might indirectly violate this tenet.

Consulting in a Court Martial

I served as a consultant to the defense on a court martial titled U.S. v. Burton. I will use events in this court martial to illustrate several statistical issues.

There are several criteria for promotion in the Air Force. One is the score on a written multiple-choice test. The test is administered worldwide on the same day, with a different test given for each rank. The tests are carefully guarded so that personnel have no prior knowledge of the test they will be taking. However, the information the test covers is published in a 120-page manual to which everyone taking the test has access and which they are encouraged to study.

Despite the tight security, the Air Force became aware that a test was stolen and that some personnel studied a stolen copy. Several

Air Force personnel were found to have copies of the test prior to administration of the exam. However, the Air Force was not able to pinpoint the details of the theft. Possession of the exam and using the copy to prepare for the exam are separate crimes.

The defendant in this case, Sergeant Burton, was accused both of having a copy of the exam and of using it as study material. He was also a whistle-blower in another case in which another sergeant, whom I will identify as Sergeant X, was accused of defrauding the Air Force of a large sum of money.

Sergeant Burton was one of several people that reported the fraud to a supervisor, which led to prosecution of Sergeant X. Seeking a reduced sentence, Sergeant X stated that he would supply evidence of cheating on the Air Force promotion exams. He testified that Sergeant Burton had supplied him with a copy of the exam and that they studied together. This testimony led to an investigation of Sergeant Burton.

In contrast to several other cases, no copy of the exam was found on Sergeant Burton, at his home, or at his workplace. The circumstantial evidence in the case included:

- The testimony of Sergeant X.
- The fact that Sergeant Burton was a friend of another Air Force sergeant at the Pentagon who had access to the exam. No charges were brought against this person.
- Sergeant Burton scored high on the test, approximately at the 95th percentile.
- This was not Sergeant Burton's first attempt to pass the exam. In two previous tries, Sergeant Burton's score improved from the 40th percentile to the 85th percentile. There was no evidence that he had cheated in previous attempts.

In preparation for a previous court martial involving the same accusation the prosecution

had asked a colonel in the Science and Mathematics Department at the Air Force Academy to develop a statistical procedure that could be used as evidence that a soldier had studied a copy of the exam. The prosecution had already used the procedure he developed in four previous courts martial. The prosecution planned to introduce evidence based on this procedure in this case also.

The statistical procedure developed by the colonel was the following. First, for each wrong answer by Sergeant Burton, the percent of soldiers choosing this answer was found. For example, if Sergeant Burton answered question #1 incorrectly by choosing answer B when answer A was correct, and 20% of the soldiers answered B, then 0.20 was recorded. This was done for each of his 11 incorrect answers. Second, these probabilities were multiplied together to obtain the "joint probability" of this pattern of incorrect responses.

The prosecution's argument was that since the resulting probability was very small, Sergeant Burton chose an unusual set of incorrect answers. They argued that this implied he had a copy of the test prior to the exam session.

No questions concerning the validity of this procedure were raised during the previous trials. A major in the Science and Mathematics Department at the Air Force Academy was brought in as an expert witness for the prosecution to introduce and defend the procedure developed by his colleague on the same faculty.

I met with the defense lawyers before they took a pretrial deposition from the major who had served as an expert witness. I brought up the following in our discussion:

- The method employed seemed to have nothing to do with proving cheating or even with choosing unusual answers. Was there any published reference that justified this procedure?
- There was a paradox in the procedure, as the more questions one got incorrect, the smaller the probability. Did it make

sense that the more questions one got wrong the stronger the evidence of cheating?

- The simple product rule for probability requires independence. What evidence was there that the questions were independent?
- How many soldiers had a lower product than Sergeant Burton?
- The case of *People v. Collins* appeared to provide a precedent for challenging use of probabilities of behavior.

In *People v. Collins*, a woman's purse was stolen from her. The witnesses agreed that the robber was an African American male with a mustache who escaped in a yellow car and who was accompanied by a woman with blond hair in a ponytail style. The defendant was an African American male with a mustache, who owned a yellow car and had a girl friend with yellow hair styled as a ponytail.

During summation to the jury, the prosecutor wrote down "probabilities" for each of these events (having a yellow car, having a mustache, etc). The prosecutor multiplied these "probabilities" together and obtained a very small number. He then claimed that this was the likelihood of choosing someone at random with all the attributes, and that this likelihood was so small that the robber must be this defendant.

The appeals court overruled the conviction in *People v. Collins* on the grounds that it was not appropriate for the prosecutor to make up the individual probabilities without any evidence to support them and that the prosecutor had a burden to prove whether the assumption of independence was reasonable.

From the major's deposition we learned that the only peer review of the colonel's method was at a "brown bag" luncheon attended by five people. They had not calculated the "probability" for any other person and had not attempted to prove that the answers to the exam questions were independent.

At the request of the defense, the major had the Air Force's computer personnel calculate the "probability" for the other 120 people who, like Sergeant Burton, got 11 incorrect answers. It was later revealed to us that 20 out of these 120 people got a lower "probability" than Sergeant Burton. The major promised to provide some evidence that the questions were independent.

The defense lawyers decided to contest the major's testimony and the colonel's statistical procedure on the basis that the procedure did not meet the standard for admitting expert scientific testimony. We reviewed the standards suggested by rulings in previous cases. In *Frye v. United States*, the court states that expert opinion based on a scientific technique is inadmissible unless the technique is "generally accepted" as reliable in the relevant scientific community.

The appeal in another case (*Daubert v. Merrell Dow Pharmaceuticals*) expanded on *Frye v. United States*. While the ruling in *Daubert* does not supply a set of criteria that should be used to decide whether the technique is "generally accepted", the court states that the following issues could be considered:

1. Has the theory or technique been tested?
2. Has the technique been subjected to peer review and publication?
3. What is the known or potential rate of error of the method?
4. Is there widespread acceptance or only minimal support within the scientific community?

During the pretrial motion to suppress the "statistical evidence", the major presented an ad hoc method to show independence of the test questions. On cross-examination, he was asked if he had done any chi-square tests for independence and he stated he had not. The judge ordered him to present some chi-square test results at the trial.

While the trial judge seemed skeptical about this method, he made what I thought was an unusual ruling. Military law states that, "the test for determining whether to admit expert scientific testimony does not apply to admissibility of expert testimony based on technical or other specialized knowledge." He then ruled that statistics was not a science but technical or other specialized knowledge. This ruling brought to mind the saying that "military justice is to justice what military music is to music." So the trial went forward.

The major was rigorously cross-examined at the trial concerning the validity of this statistical procedure. The judge chastised the major in the presence of the jury when he failed to provide the promised chi-square tests. The defense called only three witnesses. They all testified to Sergeant X's lack of veracity. The jury deliberated for only forty minutes and returned a not-guilty verdict.

Publications on Law and Statistics

Two interesting texts on this topic are *Statistics and the Law* (1994) edited by DeGroot, Fienberg, and Kadane, and *Statistics in the Evaluation of Evidence for Forensic Scientists* (1995) by C.G.G. Aitken. The former principally concerns civil cases and the later focuses on criminal cases. Types of civil cases discussed in *Statistics and the Law* include employment discrimination, antitrust, price fixing, environmental regulations, and paternity cases. It also addresses cases that are not easily categorized, such as, "Does electronic poker require skill?" Statisticians have been used as a consultant on each of these types of cases.

The primary focus of Aitken's work is DNA profiling. He also covers quantitative assessment and the evaluation of evidence. The evidence he focuses on includes blood groups and glass fragments. Three other books that explain DNA technology, genetics, and statistics are, *DNA Technology in Forensic Science* (1992), *The Evaluation of Forensic DNA Evidence* (1996), and *Human Identification: The*

Use of DNA Markers (1995).

Conclusions

1. Statistical legal consulting can be very interesting.
2. The statistical consultant can provide important scientific expertise in some court cases.
3. Specific types of knowledge and skills may be required.
4. The statistician's role as teacher can be very important.
5. The government or the legal firm should pay the statistical consultant.
6. I believe that for ethical reasons, the statistical consultant should not be paid in any manner contingent on the verdict in the case.

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Activities at JSM 2001

Business Meeting and Member Reception

The Statistical Consulting Section will hold its Business Meeting and Member Reception Tuesday evening, August 7, at the 2001 JSM in Atlanta. Please join us to find out about how the Section is serving the needs of consulting statisticians, and use this opportunity to help shape the future of the Section. Light refreshments will be furnished at the meeting, and door prizes donated by various exhibitors will be given out. We look forward to seeing you there!

Travel Awards

Three travel awards (\$500 plus registration fee waiver) were handed out this year to JSM 2001 session organizers for their efforts in developing excellent topic contributed sessions. The winners are: David Daniel from New Mexico State University, Kaine Bondari from The University of Georgia, and Laura Bond from Boise State University. Congratulations!

Roundtable Luncheons

The Statistical Consulting Section of the American Statistical Association, through the leadership of the Section's 2002 Program Chair, Brenda Gaydos, has set up four very interesting roundtable luncheon discussions for JSM 2001. From 12:30 a.m. to 2:00 p.m. on Tuesday, August 7, you have the opportunity to enjoy a wonderful lunch and participate in an engaging discussion on your choice of a number of statistical consulting issues. Please be sure to register your first and second choice on the registration form, just in case your first choice is already filled. A maximum of 10 registrants will be allowed to participate in any roundtable so be sure to register early! The discussion topic codes (required for registration) as well as titles, the discussion leaders, and the description of the discussion are given below.

T-13: "Involving Undergraduates in Statistical Consulting"

Discussion Leader: Beth Chance, California Polytechnical State University

This discussion will examine the feasibility of involving undergraduates in statistical consulting. Topics to be considered include: determining the primary goals of such experiences, how these can be best accomplished (e.g. through a capstone course or a consulting practicum, through student experiences, or video illustrations), what resources are needed, and how to optimally combine study of "human factors" issues with statistical ones. Participants will be asked to share their experiences if they have taught such a course or their goals if they are considering such an offering.

T-14: "How Can Statisticians and Their Clients Improve the Way They Work Together"

Discussion Leaders: Janice Derr, Food and Drug Administration, and Thomas Loughin, Kansas State University

If you are a statistician, then chances are that you work closely with people in other professions and disciplines. This can be challenging and frustrating, but it can also be highly rewarding. In this roundtable, we will discuss questions such as "What are the barriers to good statistician-client

interactions in your workplace?”, “What would you like your clients to know about what you do?” and “What can you learn from your clients?”

T-15: “Some Observations on the Practice of Statistics in Legal Proceedings”

Discussion Leader: Dennis Gilliland, Michigan State University

Experiences are discussed involving the questionable use of statistics in a variety of legal proceedings. These experiences illustrate the vulnerable nature of statistics and the great care that must be exercised in its application.

T-16: “Checklists to Consider in a Private Consulting Practice”

Discussion Leader: George Milliken, Kansas State University

Establishing a successful statistical consulting practice involves being able to find clients and then keep them satisfied with your work products. The discussion will center on those items that must be checked in order to stay in business. Each practice is different from another and there will be differing opinions as to the importance of various items.

The JSM 2001 Program:

Sessions Organized by the Section on Statistical Consulting

Rob Tempelman, Program Chair

This year’s JSM theme is “Statistical Science for the Information Age.” Many of our Section’s invited and contributed sessions fall directly into that theme and several touch on important emerging issues that have not been considered in recent JSM. Furthermore, there will be a great deal of diversity in the statistical methods considered and in their application areas, matching the diversity of interests and work environments that exist within our Section. A brief description of the sessions directly organized within our Section is given below. For further details on these sessions, including abstracts, refer to the online program

<http://www.amstat.org/meetings/jsm/2001/onlineprogram/index.cfm>.

You will also at that site find many other interesting sessions organized by other sections or societies, some of which have been co-sponsored by our Section.

“The Impact of the Internet and Technology on Consulting Practice”

Time: Sunday, August 5, 4:00 p.m.

Organizer: John Schuenemeyer

Panel Discussants: Roger Hoerl, Mark Johnson, Janice Derr, and Ronald Snee

The discussion explores the impact of technology, especially the Internet, on statistical consulting. Technology is transforming the way that we learn and work. Will this same technology affect statistical consulting, and if so, how? For better or worse? Can it reduce or eliminate the need for face-to-face contact? Can many of the questions that statistical consultants typically ask be automated? Can we use human and material resources more effectively? How? What is the impact on training? We will explore these and other questions with the experienced statistical consultants from business, university and government who constitute this panel and provide some time for discussion with members of the audience.

"Applications of Bayes Methodology in Statistical Consulting"

Time: Monday, August 6, 8:30 a.m.

Organizer: Laura Bond

The talks in this session will present the use of Bayesian methods to solve statistical questions in specific disciplines. These talks will show that these methods are used widely to solve applied problems, and are proving successful in areas where their use is still limited.

8:35 Wildlifers Discover Bayes – Douglas Johnson, William Link and Steven Sheriff

8:55 Application of Robust Bayesian Methods in Fisheries Stock Assessment – Yong Chen and Margaret Hunter

9:15 Application of Bayesian Methods for Assessing Detection Accuracy in Remote Sensing – Bahman Shafii and

William Price

9:35 Seamlessly Expanding a Randomized Phase II Trial to Phase III – Peter Thall, Lurdes Inoue and Donald Berry

9:55 Bayesian Incidence Analyses From Cross-Sectional Data with Multiple Markers of Disease Severity – David Dunson

"Contemporary Issues in Statistical Consulting and Collaboration"

Time: Monday, August 6, 2:00 p.m.

Chair: Sarah Kogut

This session features some important perspectives and timely topics in statistical consulting and collaboration.

2:05 Some Current Statistical Issues of Agricultural/Biology Researchers – Ted Bailey

2:20 Statistical Methods and Issues in the Analysis of Microarray Gene Expression Studies – Mei-Ling Lee and G.A. Whitmore

2:35 Sample Size Determination for Analysis of Covariance – Negasi Beyene and Lui Kung-Jong

2:50 Examining the Relationship Between Different R_2 Measures Using Bootstrap-

ping in Linear Regression – Dennis Goodman and Bill Seaver

3:05 Selection Of Prognostic Factors Using A Bootstrap Method – Qin Liu, Pihuan Jin, Er-sheng Gao and Chung-cheng Hsieh

3:20 Testing Level and Trend Changes in Interrupted Time-Series Analysis – Patricia Ramsey and Philip Ramsey

3:35 Factor Analysis and Sample Size – Daniel Mundfrom, Dale Shaw and Tian Lu Ke

"Spatial Design and Statistical Analysis Issues in Agronomy"

Time: Tuesday, August 8, 10:30 a.m.

Organizer: Robert Tempelman

The purpose of this session is to discuss the integration and application of recently developed statistical methodologies to the increasingly complex spatial inferential issues that currently face

agronomy researchers. The first talk (Stroup) involves a discussion of power assessment and computations with respect to various spatial sampling designs within a mixed effects model framework. The second talk (Besag and Higdon), illustrates the flexibility of hierarchical Bayesian modeling in terms of the assessment of alternative distributional assumptions and spatial fertility gradients. The third talk (Bullock) provides an overview of the inferential challenges in precision agriculture with case studies illustrating the utility of various data mining and multivariate techniques.

10:35 Power Analyses Based on Spatial Mixed Effects Models – Walter Stroup

11:05 Bayesian Analysis of Agricultural Field Experiments – Julian Besag and

David Higdon

11:35 Data Mining Issues in Precision Agriculture – Don Bullock, German Bollero and Sally Officer

“Statistical Analysis of Genotype-Environment Interaction”

Time: Tuesday, August 7, 2:00 p.m.

Organizer: Kaine Bondari

The objective of this session is to explore the statistical methodologies (e.g., factorial/joint regression methods, partial least-squares regression, two-way ANOVA, the Additive Main Effects and Multiplicative Interaction known as AMMI model, variance components, etc.) used to analyze genotype-environment interaction.

2:05 An Introduction to AMMI Models Used in G X E Experiments – Dallas Johnson

2:25 Contributions to Multiplicative Model Analysis of Genotype-Environment Data – Paul Cornelius, Jose Crossa, Mahmoud Seyedsadr, Genzhou Liu and Kurt Viele

2:45 Mixed Modelling for Genotype-by-Environment Data – Hans-Peter Piepho

3:05 Linear, Bilinear and Linear-Bilinear Models for Analyzing Genotype X Environment Interaction – Jose Crossa, Fred vanEeuwijk, Mateo Vargas, and Paul Cornelius

3:25 Bayesian Analysis of the AMMI Model – Kurt Viele, C. Srinivasan, and Genzhou Liu

“Improving Statistical Consultation Using Recent Advances and Applications of Statistics Methods in Biomedical Research”

Time: Wednesday, August 8, 10:30 a.m.

Organizer: Yu Shyr

This invited session is prepared for those involved in statistical consulting research and who (especially the graduate students) may need a guide to help demystify some of the recently developed statistical methods in the biological and health sciences. The session consists of three topics from three speakers with the following themes: problems, methods of analysis, and interpretation of the results. The statistical approaches will be based on empirical use of methodologies, the emphasis on understanding what the procedures do and applications to data analysis. Many of the examples of these talks will be based on actual biomedical research data that the speakers have analyzed. Our hope is that the method of the statistical analysis aspects of the examples would provide a springboard for the motivated audience.

10:35 Some Statistical Issues in Cancer Clinical Trials – KyungMann Kim

Lisa Wiessfeld

11:05 Applying Time-Varying Coefficient Models to Censored Data –

11:35 Case Studies in DNA/RNA and Protein Data Analysis – Yu Shyr

“Practical Applications of Nonparametric Regression”

Time: Thursday, August 9, 10:30 a.m.

Organizer: David Daniel

Various practical applications of nonparametric regression will be presented using a wide variety of implementations in a diversity of contexts.

10:35 Nonparametric Regression Analysis of Differential Thermal Analysis Data – Patrick Gerard

11:15 Smooth Collaboration in Statistical Genomics – Brian Yandell

10:55 A Similarity Analysis of Curves: A Comparison of the Distribution of Gangliosides in Brains of Young and Old Rats – Yolanda Muñoz Maldonado and Joan Staniswalis

11:35 Smoothing-Based Tests of Function Fit – Jeffrey Hart

11:55 Non-Parametric Regression Approach to Estimating Level Response to Atmospheric Pressure – Paul Whitney

Notes from the Editor

Christina M. Gullion, Editor

As I write this, I am surrounded by piles of boxes (mostly empty), as I prepare to move to a new job. By July I will be at the new address below, looking forward to a cool summer after years of (not) tolerating Texas heat!

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Consulting related aspects of the JSM 2001 program are printed in this issue of *The Statistical Consultant*. I hope these will excite your interest in attending the meeting. If you do, please come to the business meeting—it is a lively affair, with opportunities to shape future activities of the Section, as well as network with other consultants. You might even pick up some free software when the door prizes are handed out.

This issue also contains a description of one consultant’s experience providing statistical advice to the defense in a court martial. Note there will be a round table luncheon on courtroom use of statistics. If you consult in this area, these are opportunities to learn more from colleagues.

Analysis of the survey of Section members is underway. About one-third of the members (N=526) responded. Many thanks to those who took time to fill out the questionnaire. We expect to report preliminary results at the Section business meeting during JSM 2001.

Once again, thanks to Karla Genter for her excellent work in doing the L^AT_EX 2_ε markup for this issue.

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