

**IN THE UNITED STATES DISTRICT COURT FOR
THE NORTHERN DISTRICT OF GEORGIA
ATLANTA DIVISION**

DONNA CURLING, et al.

Plaintiff,

vs.

BRIAN P. KEMP, et al.

Defendant.

**CIVIL ACTION FILE NO.:
1:17-cv-2989-AT**

DECLARATION OF PHILIP B. STARK

PHILIP B. STARK hereby declares as follows:

Qualifications and Background

1. I am Professor of Statistics and Associate Dean of Mathematical and Physical Sciences at the University of California, Berkeley, where I am also a faculty member in the Graduate Program in Computational Data Science and Engineering; a co-investigator at the Berkeley Institute for Data Science; principal investigator of the Consortium for Data Analytics in Risk; director of Berkeley Open Source Food; and affiliated faculty of the Simons Institute for the Theory of Computing, the Theoretical Astrophysics Center, and the Berkeley Food Institute. Previously, I was Chair of the Department of Statistics and Director of the Statistical Computing Facility.
2. I have published more than one hundred and ninety articles and books. I have served on the editorial boards of archival journals in physical science, Applied Mathematics, Computer

Science, and Statistics. I currently serve on four editorial boards. I have lectured at universities, professional societies, and government agencies in thirty countries. I was a Presidential Young Investigator and a Miller Research Professor. I received the U.C. Berkeley Chancellor's Award for Research in the Public Interest, the Leamer-Rosenthal Prize for Open Social Science, and a Velux/Villum Foundation Professorship. I am a member of the Institute for Mathematical Statistics and the Bernoulli Society. I am a Fellow of the American Statistical Association, the Institute of Physics, and the Royal Astronomical Society. I am professionally accredited as a statistician by the American Statistical Association and as a physicist by the Institute of Physics.

3. I have consulted for many government agencies, including the U.S. Department of Justice, the U.S. Department of Agriculture, the U.S. Department of Commerce, the U.S. Department of Housing and Urban Development, the U.S. Department of Veterans Affairs, the Federal Trade Commission, the California Secretary of State, the California Attorney General, the California Highway Patrol, the Colorado Secretary of State, the Georgia Department of Law, and the Illinois State Attorney. I currently serve on the Board of Advisors of the U.S. Election Assistance Commission and on the Board of Directors of Verified Voting Foundation. (The opinions expressed herein are, however, my own: I am not writing as a representative of any entity.)
4. I have testified before the U.S. House of Representatives Subcommittee on the Census; the State of California Senate Committee on Elections, Reapportionment and Constitutional Amendments; the State of California Assembly Committee on Elections and Redistricting; the State of California Senate Committee on Natural Resources; and the State of California Little Hoover Commission.

5. I have been an expert witness or non-testifying expert in a variety of state and federal cases, for plaintiffs and for defendants, in criminal matters and a range of civil matters, including, *inter alia*: truth in advertising, antitrust, construction defects, consumer class actions, credit risk, disaster relief, elections, employment discrimination, environmental protection, equal protection, fairness in lending, federal legislation, First Amendment, import restrictions, insurance, intellectual property, jury selection, mortgage-backed securities, natural resources, product liability class actions, *qui tam*, risk assessment, toxic tort class actions, trade secrets, utilities, and wage and hour class actions. Much of that work concerned statistical sampling and extrapolation.
6. I have been qualified as an expert on statistics in federal courts, including the Central District of California, the District of Maryland, the Southern District of New York, and the Eastern District of Pennsylvania.
7. I have also been qualified as an expert on statistics in state courts.
8. I have used statistics to address a wide range of questions in many fields.¹
9. I served on former California Secretary of State Debra Bowen's Post-Election Audit Standards Working Group in 2007.
10. In 2007, I invented a statistical approach to auditing elections ("risk-limiting audits") that has been incorporated into statutes in California (AB 2023, SB 360, AB 44, AB 2125), Colorado (C.R.S. 1-7-515), and Rhode Island (RI Gen L §17-19-37.4 (2017)), and which were recently

¹ For example, I have used statistics to analyze the Big Bang, the interior structure of the Earth and Sun, the risk of large earthquakes, the reliability of clinical trials, the accuracy of election results, the accuracy of the U.S. Census, the risk of consumer credit default, the causes of geriatric hearing loss, the effectiveness of water treatment, the fragility of ecological food webs, risks to protected species, the effectiveness of Internet content filters, high-energy particle physics data, and the reliability of models of climate, among other things.

proposed in federal legislation (the PAVE Act of 2018). RLAs have been tested in California, Colorado, Indiana, Ohio, Virginia, and Denmark.

11. RLAs are widely viewed as the best way to check the accuracy of vote tabulation. They have been endorsed by the Presidential Commission on Election Administration, the National Academy of Sciences report “Securing the Vote: Protecting American Democracy,” the American Statistical Association, the League of Women Voters, Verified Voting Foundation, Citizens for Election Integrity Minnesota, and other groups concerned with election integrity.
12. I have worked closely with state and local election officials in California and Colorado to pilot and deploy RLAs. The software Colorado uses to conduct RLAs is based on software I wrote.
13. I worked with Travis County, Texas, on the design of STAR-Vote, an auditable and end-to-end cryptographically verifiable voting system.
14. I testified as an expert witness in the general area of election integrity, including the reliability of voting equipment, in 2016 presidential candidate Jill Stein’s recount suit in Wisconsin, and filed a report in her suit in Michigan.
15. I have testified as an expert in election auditing and the accuracy of election results in two election-related lawsuits in California.
16. I have testified to both houses of the California legislature regarding election integrity and election audits. I have testified to the California Little Hoover Commission about election integrity, voting equipment, and election audits.
17. Since 1988, I have taught statistics at the University of California, Berkeley, one of the top two statistics departments in the world (see, e.g., QS World University Rankings, 2014) and the nation (US News and World Reports, 2014). I teach statistics regularly at the

undergraduate and graduate levels. I have created five new statistics courses at Berkeley. I developed and taught U.C. Berkeley's first online course in any subject, and among the first approved for credit throughout the ten campuses of the University of California system. I also developed and co-taught online statistics courses to over 52,000 students, using an online textbook and other pedagogical materials I wrote and programmed.

18. Appendix 1 is my current *curriculum vitae*, which includes my publications for the last ten years and all cases in the last four years in which I gave deposition or trial testimony.

Opinions

19. I am offering my opinion with respect to the need and feasibility for Georgia to conduct the 2018 mid-term election using paper ballots and to verify the outcomes of the election using a risk-limiting audit conducted affordably using current voting equipment.
20. The September 6, 2018 National Academy of Sciences, Engineering and Medicine report, *Securing the Vote: Protecting American Democracy*² ("the NAS report"), echoes the opinions of leading voting system scientists and the election integrity community: to ensure that reported election results reflect the will of voters, public elections should be conducted with hand-marked paper ballots or systems with a voter-verifiable paper trail.
21. The NAS report recommended that "every effort should be made to use human-readable paper ballots in the 2018 federal election." NAS Report, at 7.

² <https://www.nap.edu/read/25120/chapter/1> Last accessed 9 September 2018.

22. The Board of Advisors of the U.S. Election Assistance Commission (EAC) passed a resolution in 2018 recommending that the EAC “not certify any system that does not use voter-verifiable paper as the official record of voter intent.”³
23. Merely using paper ballots to conduct an election does not ensure that results are correct. The paper must actually be used in an appropriate way to check the reported results and to correct the results if they are wrong. Suitable “post-election audits” that manually inspect random samples of paper ballots can detect and correct incorrect electoral outcomes.
24. The NAS report states, “each state should require a comprehensive system of post-election audits of processes and outcomes.” NAS Report, at 8. “Audits of election outcomes should include manual examination of statistically appropriate samples of paper ballots cast.” NAS Report, at 9.
25. Elections should be conducted in a way that gives the public convincing evidence that reported election outcomes are correct. This is the principle of “evidence-based elections.”⁴
26. It is my understanding that since the security breach of the Kennesaw State University Center for Election Systems server, there has been no forensic examination or remediation of voting system components, including many thousands of pieces of computerized election equipment indirectly connected to that server. As a result, in Georgia, the accuracy and trustworthiness of election results are in particular peril compared to most states: the need for paper ballots and rigorous post-election audits is urgent. The paperless systems currently deployed in Georgia simply cannot provide trustworthy evidence that reported election outcomes are correct.

³ <https://www.eac.gov/documents/2018/04/27/resolution-2018-03-auditability-of-voter-intent-passed-10-8-4-advisors-resolution-page/> Last accessed 9 September 2018.

⁴ Stark, P.B., and D.A. Wagner, 2012. Evidence-Based Elections. *IEEE Security and Privacy*, 10, 33–41. Preprint: <https://www.stat.berkeley.edu/~stark/Preprints/evidenceVote12.pdf>

27. A “risk-limiting audit” (RLA)⁵ is a particular approach to catching and correcting incorrect election outcomes before they become official. A RLA is any post-election procedure that offers the following statistical guarantee: If a full manual tally of the complete voter-verifiable paper trail would show a different electoral outcome, there is a known, pre-determined minimum chance that the procedure will lead to a full manual tally.
28. If the procedure does lead to a full manual tally, the result of that manual tally replaces the reported outcome, thereby correcting it.
29. Here, “outcome” means the political result: the candidate(s) or position that won, or the determination that a run-off is needed, not the exact vote totals.
30. The maximum chance that the procedure will not lead to a full manual tally if that tally would show a different outcome is called the *risk limit*. Equivalently, the risk limit is the largest chance that the audit will fail to correct an outcome that is incorrect, where “incorrect” means that a full manual tally of the voter-verifiable paper trail would find different winner(s).
31. For instance, a RLA with a risk limit of 5% has at least a 95% chance of requiring a full manual tally, if that tally would show an outcome that differs from the reported outcome.
32. The NAS Report recommends RLAs: “States should mandate risk-limiting audits prior to the certification of election results.” NAS Report, at 9. “Risk-limiting audits can efficiently establish high confidence in the correctness of election outcomes—even if the equipment

⁵ Risk-limiting audits have been endorsed by the Presidential Commission on Election Administration, the American Statistical Association, the League of Women Voters, Common Cause, Verified Voting Foundation, and many other organizations concerned with election integrity. They are required by law in Colorado and Rhode Island, and have been tested in California, Ohio, and Denmark. They were developed in 2007; the first publication is Stark, P.B., 2008. Conservative Statistical Post-Election Audits, *Ann. Appl. Statistics*, 2, 550–581. Reprint. Since then, there have been extensions for other social choice functions (e.g., proportional representation, see Stark, P.B., and V. Teague, 2014. Verifiable European Elections: Risk-limiting Audits for D’Hondt and Its Relatives, *JETS: USENIX Journal of Election Technology and Systems*, 3, 18–39. https://www.usenix.org/system/files/jets/issues/0301/overview/jets_0301_stark_update_9-10-15.pdf), for auditing any number of contests simultaneously, for different types of voting equipment, etc. For a general but still somewhat technical introduction, see Stark, P.B., and M. Lindeman, A Gentle Introduction to Risk-Limiting Audits, *IEEE Security and Privacy*, 10, 42–49, doi:10.1109/MSP.2012.56

used to cast, collect, and tabulate ballots to produce the initial reported outcome is faulty.”

NAS Report, at 100.

33. The US Election Assistance Commission (EAC) recently issued a white paper on the history, importance, and conduct of RLAs.⁶
34. It is crucial to base post-election audits on voter-verifiable paper records; to ensure that those records include every validly cast vote exactly once, and no others (checking the determination of eligibility, in particular); to ensure that those records remain complete and intact from the moment they are cast through the audit; and to assess the evidence that they are trustworthy. Absent affirmative evidence that the paper trail is a trustworthy record of voter intent—that it accurately reflects the intent of every voter who legitimately cast a ballot in the contests under audit, and no others—the audit might simply confirm the incorrect outcome. The process of assessing the trustworthiness of the paper trail is called a *compliance audit*.
35. There are many methods for conducting risk-limiting audits, involving different ways of drawing samples of ballots and different demands on the voting system and on auditors. For instance, a full handcount is a risk-limiting audit, with a risk limit of zero. But by inspecting randomly selected ballots and using appropriate statistical methods, it is possible to conduct risk-limiting audits much more efficiently—when the electoral outcome is correct. Below, I discuss *ballot-polling* RLAs, a particular approach that Georgia could implement in time for the 2018 mid-term elections.
36. RLAs require manually inspecting voter-verifiable paper ballots. In particular, digital images of ballots are not a trustworthy record of voter intent.

⁶ https://www.eac.gov/assets/1/6/Risk-Limiting_Audits_-_Practical_Application_Jerome_Lovato.pdf Last accessed 9 September 2018.

37. Ballot-polling is a particularly simple method for conducting RLAs. It involves selecting and manually inspecting randomly selected cast ballots. If a sufficiently large random sample of ballots shows a sufficiently large margin for the reported winner, that is strong statistical evidence that the reported winner really won.
38. A ballot-polling RLA is similar to an exit poll, but instead of asking a random sample of voters what their preferences were, the audit looks at a random sample individual ballots to see what preferences those ballots show.
39. In contrast to exit polls, the sample size for a ballot-polling RLA is not fixed in advance. A ballot-polling RLA stops if and when the sample shows that it is implausible that anyone other than the reported winner really won. The calculations to determine whether and when the audit can stop are simple enough to be done with a pencil and paper. They involve nothing more complicated than multiplication.
40. The first ballot-polling RLA was conducted in Monterey County, California, in 2011.⁷ Since then, they have been used in pilot RLAs in California, Colorado, and Virginia. The first academic papers on ballot-polling RLAs were published in 2012.⁸
41. A free, open-source tool that implements all the calculations for ballot-polling RLAs, including the random selection of ballots and the calculation of when the audit can stop, is available at the URL <https://www.stat.berkeley.edu/~stark/Vote/ballotPollTools.htm> (last accessed 9 September 2018). That tool is the basis of the software Colorado uses for RLAs in some counties. It has been used in pilot audits in several California and Colorado counties.

⁷ See <http://www.montereycountyelections.us/AB2023.html>, last accessed 9 September 2018.

⁸ Lindeman, M., P.B. Stark, and V.S. Yates, 2012. BRAVO: Ballot-polling Risk-Limiting Audits to Verify Outcomes. *2012 Electronic Voting Technology Workshop/Workshop on Trustworthy Elections (EVT/WOTE '12)*. Reprint: <https://www.usenix.org/system/files/conference/ewtwote12/ewtwote12-final27.pdf>. Lindeman, M. and P.B. Stark, 2012. A Gentle Introduction to Risk-Limiting Audits. *IEEE Security and Privacy*, 10, 42–49. Preprint: <https://www.stat.berkeley.edu/~stark/Preprints/gentle12.pdf>.

42. Georgia could use ballot-polling RLAs to confirm electoral outcomes if it conducted elections using paper ballots counted by Accu-Vote optical scanners.
43. There are other approaches to RLAs that generally involve inspecting fewer ballots, but that require more data from voting systems and have higher set-up costs than ballot-polling RLAs. For instance, *ballot-level comparison* RLAs are currently the most efficient approach, as measured by the number of ballots that must be audited when the electoral outcome is correct. Georgia should explore other approaches to RLAs in the future, but the easiest RLA method to implement by the mid-term elections is ballot polling.
44. I understand that audit guidelines might need to be established by the Georgia State Election Board in a public process. Because there is now considerable experience conducting RLAs, a great deal of public information, free software, and model legislation, the work could be done in time to audit the 2018 mid-term elections. The fact that Georgia uses a uniform voting system employing the Accu-Vote optical scanner will simplify the process. However, there is no time to waste: work should start immediately.
45. The audit guidelines should embody a number of principles, including requiring serious checks of the integrity of the paper trail, specifying risk limits, specifying how contests subject to RLAs are to be selected, ensuring that the audit cannot be subverted, and providing the public enough information to verify that the audit did not stop prematurely. The guidelines also need to specify how to interpret voter intent from hand-marked ballots.⁹

⁹ For instance, if a voter makes a write-in vote for a candidate who is also listed on the ballot, is that a valid vote? If a voter marks a vote for a listed candidate and also writes in that candidate's name, is that a valid vote? If a voter marks a vote for a candidate, crosses through the mark, and marks a vote for a second candidate, is that a valid vote for the second candidate? If a voter makes a stray mark on the ballot that is distinctive enough to identify the ballot, is the ballot valid? Experience in recounts in Minnesota suggests that the percentage of hand-marked ballots that are marked ambiguously is quite small: in the 2008 Minnesota statewide recount, only 845 ballots were challenged. <http://minnesota.publicradio.org/collections/special/2008/campaign/results/mn/recount/ballots/> Last visited 9 September 2018. See http://minnesota.publicradio.org/features/2008/11/19_challenged_ballots/ (last visited 9 September 2018) for specific examples.

46. The largest hurdle is to establish procedures that ensure that the paper ballots are physically secured and organized well enough to draw a random sample.
47. In particular, a key ingredient of ballot-polling RLAs is a *ballot manifest* that describes, for each jurisdiction, how many ballots were cast in that jurisdiction and how the ballots are organized.
48. For instance, a ballot manifest might say, “the county has 913 boxes of ballots, numbered 1 through 913. Box 1 contains 301 ballots. Box 2 contains 199 ballots. . . . and Box 913 contains 247 ballots.”
49. Ballot manifests should be constructed without reliance on the system that is used to tabulate the votes, because they are used to check the tabulation system.
50. It is reasonable to require local election officials to construct ballot manifests routinely: if an election official cannot keep track of ballots, the official is not doing his or her job.
51. All contests should receive some scrutiny. However, it may be impractical to audit every contest to a pre-specified risk limit. If the guidelines do not require every contest to be audited to a pre-specified risk limit, the selection of contests to audit to a risk limit should involve a random element so that every contest has some chance of being selected and a malicious opponent cannot predict whether any particular contest will be audited.
52. For every ballot selected for audit, votes on that ballot in contests that are not required to be audited to a risk limit should nonetheless be recorded (and reported) to provide evidence about whether the results of those contests are accurate. Collecting such data opportunistically from ballots that are manually inspected enables “risk-measuring audits,” which report the strength of evidence that the outcomes of those contests are correct, in light of what the audit finds.

53. The audit sample must not be predictable before the audit starts. Public trust in audits may be increased if the public participates in generating “seed” for selecting the sample. In Colorado, for instance, the “seed” is generated in a broadcast, public ceremony in which 10-sided dice are rolled 20 times, with public participation.
54. Auditing cross-jurisdictional contests requires contest-level results (not merely county-level results) to be known before the audit can conclude. It also requires coordinating the sampling in different counties, so that each county knows when its portion of the audit can stop.
55. I recommend that starting with the 2018 mid-term election, Georgia conduct ballot-polling RLAs of all countywide, statewide, and federal contests, using a risk limit no larger than 5 percent. I recommend that other contests be audited “opportunistically” as described in paragraph 52, *supra*. I believe this is feasible and affordable, but there is no time to waste: the process for establishing the guidelines and procedures must start immediately.
56. A number of non-partisan, non-profit organizations are ready and able to assist Georgia in implementing post-election audits, including Verified Voting Foundation. The U.S. Election Assistance Commission also has staff with extensive experience with RLAs.
57. Although ballot-polling RLAs are not particularly costly, I understand that federal HAVA funds recently granted to Georgia could be used to implement post-election audits, presumably including the cost of monitoring the audits and reporting the results to this Court.

I declare under penalty of perjury, in accordance with 28 U.S.C. § 1746, that the foregoing is true and correct.

Executed on this date, 9 September 2018.

Philip B. Stark