Post-Election Risk-Limiting Audit Pilot Program 2011-2012
Semi-Annual Progress Report to the Election Assistance Commission
Reporting Period Close: November 30, 2012

Summary

The California Secretary of State's Office (SOS) received a grant from the Elections Assistance Commission (EAC) under HAVA Section 271 to conduct a two-year post-election audit pilot program during 2011-12 to test new risk-limiting audit models. The research problem for this project is how to conduct risk-limiting audits that include individual contests, multiple contests and cross-jurisdictional contests in small and large elections. The SOS is partnering with the University of California, Berkeley (UC Berkeley) Statistics Professor Philip B. Stark, who developed and conducted initial tests of election audit models in California. The SOS is working with up to 20 counties and has so far conducted 10 audits following elections in 2011 and 2012. Grant funds are being used to test and document audit processes and best practices for conducting cost-effective post-election audits using a parallel tally system and the risk-limiting audit methods developed by Professor Stark.

The $230,000 two-year grant from the EAC helps fund:

1) Audits of election results following actual elections in up to 20 counties;

2) Detailed analyses of the efficacy of risk-limiting audits and recommendations on how the current voting systems can be made more auditable; and

3) Creation of auditing tools for elections officials. The pilot program team has developed draft audit rules for selecting the initial sample size and for determining when enough ballots have been audited, methods for ballot-level audits, and user-friendly web-based tools and procedures for conducting and reporting on risk-limiting audits. (A preliminary version is available at statistics.berkeley.edu/~stark/Vote/auditTools.htm)

Risk-limiting post-election audits are audits based on modern statistical principles. The number of ballots initially reviewed in a risk-limiting audit varies based on the margin of victory. The audit escalates – potentially to a full hand count of every ballot cast – if significant differences between the hand tally and the voting system tally are found. Risk-limiting audits are efficient when conducted at the "ballot level," meaning individual ballots (rather than entire precincts) from the voting jurisdiction are subject to the random draw and the audit. This contrasts with California's statutorily mandated 1% manual tally, where only the precincts are subject to the random draw from across the entire election jurisdiction, not the ballots themselves. Put another way, risk-limiting audits generally involve hand counting fewer ballots overall, but those ballots come from across the entire voting jurisdiction, whereas the 1% manual tally generally involves significantly more ballots but only from specific areas of the voting jurisdiction.

Now that a variety of methods for risk-limiting audits have been tested, the SOS believes efficient and effective election auditing requires auditing at the ballot level. Therefore, the audit team's goal is to develop standards, procedures, and tools for conducting post-election risk-limiting audits at the ballot level. This will:

1) Help California and other states develop new, more robust and effective election auditing laws;

2) Inform the design of next generation voting systems;

3) Provide election auditing best practices and procedures that can be used by many jurisdictions in the U.S. using a broad variety of voting systems; and

4) Build public confidence that if there are errors in election results, those errors will be caught and corrected.

Progress

During this phase of the project the pilot program team worked with six counties as follows:

1) Audits of small election contests were successfully conducted in Madera and Napa counties;

2) Large multi-contest audits were prepared and attempted, but not successfully completed, in Marin, Orange, Santa Cruz and Yolo counties;

3) The audit team is collaborating with a separate team of University of California researchers (who are not funded under this grant) to improve the audit software and audit methods used in the pilot program. These improvements will enhance audit preparation efficiency by reducing the time needed to complete a parallel scan and tally of the ballots before the audit can begin.

4) On November 30, 2012, the SOS requested a 24-month no-cost extension of the project period for the California Post-Election Risk-Limiting Audit Pilot Project.

Reason for Delay

As noted above, four counties conducting audits following the June 2012 Presidential Primary Election had to postpone completion of their audits midway through the audit process because the audit team experienced serious difficulties with the parallel tally software. (Note: The software was developed before the project began by University of California experts.) Improvements to the software could not be made in time for audits scheduled to follow the November election. Therefore, several other counties that were scheduled to participate following the November 2012 Presidential General Election had to postpone their participation due to these software difficulties (see chart below).

As a result, the large audits scheduled for 2012 were not completed. Some California counties will hold special elections in 2013 and at least two of them will be multi-jurisdictional. While the number of ballots cast will not be as high as in a normal, regularly scheduled statewide election, the SOS audit team envisions being able to use these special elections to conduct multi-jurisdictional audits.

Counties

Twenty counties volunteered to participate in the pilot program. To date, the audit team has conducted audits in ten California counties following actual elections. Eight of the audits were conducted following small local elections held in 2011 and two audits were conducted in small counties, Madera and Napa, following the June 2012 Presidential Primary Election. Below is a chart showing the status in each participating county.

County	Election	Audit
Alameda	Nov. 8, 2011	Dec. 5, 2011
Alpine	Nov. 6, 2012	Postponed
Colusa	Nov. 6, 2012	Postponed
El Dorado	Nov. 6, 2012	Postponed
Humboldt	Nov. 8, 2011	Dec. 16, 2011
Madera	June 5, 2012	Sept. 20, 2012
Marin	June 5, 2012	Postponed mid-audit
Merced	Nov. 8, 2011	Dec. 12, 2011
Monterey	May 3, 2011	May 6, 2011
Napa	June 5, 2012	July 20, 2012
Orange (2011)	Mar. 8, 2011	Mar. 14, 2011
Orange (2012)	June 5, 2012	Postponed mid-audit
Sacramento	Nov. 6, 2012	Postponed
San Luis Obispo	Aug. 30, 2011	Sept. 12, 2011
Santa Cruz	June 5, 2012	Postponed mid-audit
Stanislaus	Nov. 8, 2011	Dec. 2, 2011
Sutter	Nov. 6, 2012	Postponed
Ventura	Nov. 8, 2011	Nov. 29, 2011
Yolo	June 5, 2012	Postponed mid-audit
Yuba	Nov. 6, 2012	Postponed

University of California

The SOS is under contract with the University of California for the purpose of engaging Professor Philip Stark as lead researcher for the project.

Advisory Panel

At the outset of the pilot program, the SOS established an advisory panel, which is comprised of the following experts, advocates, and community activists in the field of election auditing and reform:

>Dean Logan
>Registrar-Recorder/County Clerk, Los Angeles County
>
>Pam Smith
>President, Verified Voting
>
>Joseph Lorenzo Hall
>Postdoctoral Research Fellow, New York University Department of Media, Culture and Communication
>
>Hovav Shacham
>Assistant Professor, University of California, San Diego, Department of Computer Science and Engineering
>
>Mark Halvorson
>Director and Founder, Citizens for Election Integrity Minnesota
>
>Susannah Goodman
>Director, Common Cause National Campaign for Election Reform
>
>Margaret MacAlpine
>Research Associate, SafelyLocked, LLC

Conducting Ballot-Level Risk-Limiting Audits Using a Parallel Scan and Tally

For most election audits, the results of a hand tally are compared to the results recorded by the voting system. For California's 1% manual tally, elections officials hand tally entire precincts of ballots and compare those hand tally totals to the machine-tallied totals generated by the voting system.

In order for risk-limiting audits to be efficient, they must be conducted at the individual ballot level, not at the precinct level. A ballot-level audit compares the result tallied by the voting system for a given ballot to a hand tally of the same ballot. To conduct a risk-

limiting audit at the ballot level, two things are necessary: 1) the voting system must have a cast vote record (CVR) for each ballot. A CVR is a line of data that shows how the votes on a given ballot were actually tallied by the voting system; and 2) elections officials must be able to match a CVR to the corresponding physical ballot, which requires keeping ballots and CVRs in identical order.

Earlier in the program, the pilot project team conducted a series of conference calls with voting system vendors to determine the capabilities of existing voting systems. Through these calls and discussions with participating counties, the team determined that none of the voting systems in use in California is currently capable of exporting CVRs that can be associated with corresponding physical ballots.

For this reason, the team has conducted some of the audits for this pilot program by means of a parallel scan and tally of the votes. A parallel scan and tally is a second tally of the ballots, using commercial-off-the-shelf (COTS) scanners and open source tally software, which was developed during spring and summer 2011 for the pilot program.

County elections officials scanned the ballots using a COTS scanner and either marked the ballots or kept the ballots in order to permit each physical ballot to be paired with its scanned ballot image. This method allowed auditing of the machine's interpretation of individual ballots rather than auditing vote subtotals for entire precincts. Making individual ballots auditable – i.e., creating auditable "batches" of one ballot each – brings very significant efficiency, as described above. The hand counting workload for a ballot level audit can be smaller than the workload of a precinct level audit by a factor of 1,000 or more. Since the parallel tally for each audit showed the same results (winners and losers) as the official voting system, the audit was able to confirm the official results *transitively* (i.e., If A = B, and B is correct, then A is correct).

Web-Based Tools and Instructions

The pilot program team, led by Stark, has honed the audit models and developed a set of web-based tools (statistics.berkeley.edu/~stark/Vote/auditTools.htm) and instructions (attached) designed for elections officials to use to conduct risk-limiting audits. The tools explain how the audits work and show the math that the tools implement, so elections officials and the public can understand risk-limiting audits. These tools are continually being refined and improved as a part of the pilot program.

Audits Conducted Between June 1, 2011, and November 30, 2012

The pilot program team conducted successful risk-limiting audits in two counties, Napa and Madera, prior to the November 30, 2012, close of the EAC's semi-annual reporting period. For each audit, the audit team worked with participating counties to plan and help prepare for the audits.

Stark traveled to Napa County and provided on-site assistance in carrying out the audit, including performing all computations and helping with finding and reviewing individual ballots in the audit sample. Madera County conducted its audit – with remote help for the parallel tally and sample size calculations from Stark – and reported results to the SOS audit team. The attached in-depth ArsTechnica article and press release on the Napa County audit and summary from Madera County provide additional detail.

Cost-Efficiency Analysis: Risk-Limiting Audits Compared to the 1% Manual Tally

As with the 2011 audits, the time it took to conduct the 2012 audits was minimal – a few minutes to a few hours – compared to the time it takes to conduct the 1% manual tally. However, counties participating in the pilot audits had to spend a considerable amount of time *preparing* for the audits by scanning the ballots and conducting a parallel tally of the vote totals for the contest(s) to be audited. While the counties used high-speed scanners in this year's audits, this only somewhat minimized the time spent scanning ballots in preparation for the audits.

Larger audits must be conducted to show the efficiency and effectiveness that can be created with risk-limiting audits of multi-contest elections in large jurisdictions compared to California's 1% manual tally law.

Plans for Use of Remaining Grant Funds if an Extension is Granted

The audit team and participating counties plan to use the remaining grant funds on the following unfinished components of the project:

Cross-Jurisdictional Auditing. To date, a risk-limiting audit of a contest that crosses jurisdictional boundaries has never been conducted in the United States. Some California counties will hold special elections in 2013 and at least two of them will be multi-jurisdictional. While the number of ballots cast will not be as high as in a normal, regularly scheduled statewide election, the SOS audit team envisions being able to use these special elections to conduct multi-jurisdictional audits.

Auditing in Large Jurisdictions with Multiple Contests. A viable auditing model must be usable in any election – whether large or small. While the SOS has successfully tested risk-limiting audits in small elections, the team needs more time to successfully test risk-limiting audit methods in multi-jurisdictional elections. The SOS will spend 2013 improving auditing procedures, including ballot accounting, ballot scanning and parallel tally procedures and coordinating with the University of California as it works to improve the parallel tally software being used for the audit pilot program.

County Clerk - Recorder
and Registrar of Voters

200 West 4th Street, Madera CA 93637

Clerk (559) 675-7721; Recorder (559) 675-7724; Elections (559) 675-7720; or Toll Free 1-800-435-0509; Fax (559) 675-7870

Rebecca Martinez, County Clerk-Recorder & Registrar of Voters

September 20, 2012

MEMO TO: Jennie Bretschneider, Assistant Chief Deputy and Counsel

FROM: Rebecca Martinez, County Clerk-Recorder

SUBJECT: Post-Election Audit – Madera County

Madera County participated in an experimental post-election audit following the June 2012 primary election. The contest audited was for County Supervisor, District 3.

Madera County's ballots are comprised of multiple cards, on which votes are marked with either a #2 pencil (for vote by mail) or a fiber-tipped pen (at the polls). For the audit, the local contest appeared on the "C" card of the ballot, in one ballot style only.
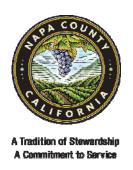
The cards were scanned, using a scanner rented for this use only, and the images were sent to U.C. Berkeley where the marked votes were tabulated. A random formula selected the ballot card to which the results were to be compared. Upon comparing the ballot cards to the random selection, we were able to verify that the marked votes were the same as those compiled from the scanned images. We did note, however, that some images were duplicated, and those were discounted; also, that some images were not exactly in the same order as the ballot cards, which could have been a scanning error or a processing error. At any rate, we were able to locate almost every vote cast.

It was noted by David Wagner of U.C. Berkeley that our statement of the vote reflected more ballots cast than ballot cards scanned. We verified that we had scanned every "C" card in each precinct/batch; there are no "missing" ballot cards. However, in reviewing our processes in tabulating the ballot cards during the canvass (prior to certification of the results), we were able to determine that the difference was due to the manner in which we run the cards through our card readers and, during that process, creating <u>duplicate</u> ballot cards to replace some cards that the card reader sees as <u>blank</u>. The duplicated cards are re-read by the reader, resulting in the ballot passing through two times (the original "blank" card, and then the duplicate card which actually records the vote cast). Our vendor confirms that assessment. While no additional votes were tabulated, it <u>appeared</u> that more ballots were cast than there actually were;

however, the discrepancy was minimal.   In the future, we will change our processes to eliminate such differences.

Unfortunately, the differences between "ballots cast" on our statement of the vote and the actual ballot cards sampled resulted in a large random sample that required visual inspection/comparison. Even in this relatively small contest, the comparison took a good four hours to complete, spread between two work days.

In retrospect, I remain very much in favor of the random, <u>hand</u> tally that is prescribed by law at this time.

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NEWS RELEASE

CONTACT: REGISTRAR OF VOTERS JOHN TUTEUR 707.253.4459 john.tuteur@countyofnapa.org

DATE: July 13, 2012

PUBLIC INVITED TO OBSERVE PILOT PROJECT RANDOM SAMPLE OF BALLOTS

The Napa County Election Division is inviting the public and the media to observe a pilot project random sample of ballots cast in the 2nd Supervisor District to be conducted on Friday, July 20, 2012 at 9 a.m. The 2nd Supervisor District contest was proposed for the study several months ago because there was the possibility of a close election. "We volunteered to participate in this pilot project that is testing new ways to assure the integrity of future elections," Registrar of Voters John Tuteur announced. The statewide pilot project is funded by a grant from the Federal Election Assistance Commission at the request of the California Secretary of State. More information is available at http://www.sos.ca.gov/voting-systems/oversight/risk-limiting-pilot.htm The grant will also reimburse Napa County's expenses.

The pilot project is separate from the mandated manual tally process California counties use to certify the final results of the June 5, 2012 Presidential Primary Election. The certified results of the 2nd Supervisor District contest will not be impacted by the project. Scanned images of the paper ballots have been sent to a research team at the University of California Computer Science Lab who will create a tally from the scanned images which is independent of the paper ballots counted by the Election Division. On July 20 at the Napa County Election Division approximately 600 of the paper ballots that were scanned will be selected by a random process to confirm that the votes tabulated from the scanned image at UC Berkeley match the tally of the sampled ballots made by human eyes. "Professor Philip B. Stark, Chair of Statistics at UC Berkeley, who is leading this effort will be here on July 20 to assist with the random sample process," Tuteur added.

The random draw and ballot review will take place at the Napa County Election Division, 900 Coombs St, Rm 256, in downtown Napa. All-day free parking is available at the Pearl and Coombs Street garage. The garage is approximately one block from the office. The entrance to the office is in the alleyway between the 2nd Street parking garage and the adjacent building. Observers should enter the alley from Coombs Street between 1st and 2nd Streets.

Those who wish to observe the audit process should call the election office at (707) 253-4321 or toll free (Upvalley and American Canyon) 1-888-494-8356, or send an e-mail to elections@countyofnapa.org Observers will sign in and receive appropriate identification when they arrive on Friday July 20, 2012.

END

ArsTechnica

Law & Disorder / Civilization & Discontents

Saving throw: securing democracy with stats, spreadsheets, and 10-sided dice

"Risk-limiting audits" use sound math to make sure the right candidate won.

by Cyrus Farivar - July 24 2012, 5:00pm PDT

Philip Stark with his boxes of ballots
Cyrus Farivar

NAPA, CALIFORNIA—Armed with a set of 10-sided dice (we'll get to those in a moment), an online Web tool, and a stack of hundreds of ballots, University of California-Berkeley statistics professor Philip Stark spent last Friday unleashing both science and technology upon a recent California election. He wanted to answer a very simple question—had the vote counting produced the proper result?—and he had developed a stats-based system to find out.

On June 2, 6,573 citizens went to the polls in Napa County and cast primary ballots for supervisor of the 2nd District in one of California's most famous wine-producing regions, on the northern edge of the San Francisco Bay Area. The three candidates—Juliana Inman, Mark van Gorder, and Mark Luce—would all have liked to come in first, but they *really* didn't want to be third. That's because only the two top vote-getters in the primary would proceed to the runoff election in November; number three was out.

Napa County officials announced the official results a few days later: Luce, the incumbent, took in 2,806 votes, van Gorder got 1,911 votes, and Inman received 1,856 votes—a difference between second and third place of just 55 votes. Given the close result, even a small number of counting errors could have swung the election.

Vote counting can go wrong in any number of ways, and even the auditing processes designed to ensure the integrity of close races can be a mess (did someone say "hanging, dimpled, or pregnant chads"?). Measuring human intent at the ballot box can be tricky. To take just one example, in California, many ballots are cast by completing an arrow, which is then optically read. While voters are instructed to fully complete the thickness of the arrow, in practice some only draw a line. The vote tabulation system used by counties sometimes do not always count those as votes.

So Napa County invited Philip Stark to look more closely at their results. Stark has been on a four-year mission to encourage more elections officials to use statistical tools to ensure that the announced victor is indeed correct. He first described his method back in 2008, in a paper called "Conservative statistical post-election audits," but he generally uses a catchier name for the process: "risk-limiting auditing."

Napa County had no reason to believe that the results in this particular election were wrong, explained John Tuteur, the County Assessor, when I showed up to watch. But, anticipating that the election would be close, Tuteur had asked that Napa County be the latest participant in a state-sponsored pilot project to audit various elections across the Golden State.

While American public policy, particularly since the 2000 *Bush v. Gore* debacle, has focused on voting technology, not as much attention has been paid to vote audits. If things continue to move forward, Stark could have an outsized effect on how election audits are conducted in California, and perhaps the country, for years to come.

"What this new auditing method does is count enough to have high confidence that [a full recount] wouldn't change the answer," Stark explained to me. "You can think of this as an intelligent recount. It stops as soon as it becomes clear that it's pointless to continue. It gives stronger evidence that the outcome is right."

The process has been endorsed by numerous academics and voting officials, and by the American Statistical Association (PDF), the League of Women Voters (PDF), the Brennan Center for Justice (PDF) and many others in recent years.

And it begins with those 10-sided dice.

Audit day

To kick off the process, all 6,573 votes tallied in the 2nd District supervisor contest were re-scanned by county elections officials in the City of Napa. They sent the scans to a separate computer science team at Berkeley, led by Professor David Wagner. Along with a group of graduate students, Wagner has developed software meant to read voter intent from ballots. His system, for instance, will flag even ballots where the arrow was not filled in according to the instructions, and it takes a different approach to filtering out stray marks. The Wagner team created a spreadsheet containing each ballot (they also created a numbering system to identify and locate individual ballots) and how that person cast his or her vote.

One problem that cropped up early on was the discrepancy between the number of ballots cast and the number of ballots scanned. While 6,573 total votes were recorded in this particular contest, the Wagner team scanned a total of 6,809 ballots, while Napa County recorded 7,116 votes cast in the election as whole. (Not every voter in the election chose to vote in this particular contest.) In short, there were over 300 ballots missing. While that seems problematic, the margins stayed more or less the same.

"If both systems say 'Abraham Lincoln won' then if the unofficial system is right, so is the official system, even if their total votes differ and even if they interpreted every vote differently," wrote Stark in an e-mail on Tuesday. "That's the transitive idea. A transitive audit is really only checking who won, not checking whether the official voting system counted any particular ballot correctly. That said, we do compare the precinct totals for the two systems to make sure they (approximately) agree, which they did here."

A ballot from the audit; note the use of a thin connecting line.
Cyrus Farivar

He added that to deal with the missing ballots, to confirm the winner, he treated them as if they were votes for the runner-up—so even with 300 additional votes, Luce still was the victor.

"To confirm the runner-up, we could not do that; instead, I treated them two different ways, neither completely rigorous," he added. "In other audits, I've been able to deal with any mismatches between the ballot counts completely rigorously, so that the chance of a full hand count if the reported result was wrong remained over 90 percent."

With that out of the way, the first step in the actual audit was to randomly select a seed number that would be used to feed a pseudo-random number generator found on a website that Stark created. For this, Stark had some high-level help in the form of Ron Rivest, one of America's foremost experts on cryptography and voting systems, a professor of computer science at MIT who had also helped create the RSA crypto algorithm. Using 20 store-bought ten-sided dice, Rivest and Stark rolled out a 20-digit number. (73567556725160627585, for those keeping score at home.)

Risk-limiting auditing relies on a published statistical formula, based on an accepted risk limit, and on the margin of victory to determine how many randomly selected ballots should be manually checked.

"The risk limit is not the chance that the outcome (after auditing) is wrong," Stark wrote in a paper (PDF) published in March 2012. "A risk-limiting audit amends the outcome if and only if it leads to a full hand tally that disagrees with the original outcome. Hence, a risk-limiting audit cannot harm correct outcomes. But if the original outcome is wrong, there is a chance the audit will not correct it. The risk limit is the largest such chance. If the risk limit is 10 percent and the outcome is wrong, there is at most a 10 percent chance (and typically much less) that the audit will not correct the outcome—at least a 90 percent chance (and typically much more) that the audit will correct the outcome."

Ron Rivest, an MIT cryptographer, helped Stark use 10-sided dice to produce a random seed.
Cyrus Farivar

To decide how many ballots should be sampled in the Napa County audit, Stark used his own online tools and calculated that it should be 559. With that number in hand, Napa County's John Tuteur supervised a team of temporary ballot counters in another room. They sorted through stacks of ballots in numbered boxes, affixing a sticky note to the individual ballots in question, preserving the order in which all ballots were kept.

After locating the individual ballots, the team delivered the boxes containing them back to Stark, Rivest, and a few observers (including me). Each marked ballot was then pulled from its box and displayed to the room. Once everyone agreed that the ballot showed a vote for a particular candidate, an undervote (e.g., no vote at all), or an overvote (an uncounted and unauthorized vote for multiple candidates), the result was tallied on Wagner's spreadsheet. After a given set of ballots, those results were then compared to what the Wagner image-scanning team had recorded.

"You want cast as intended, and counted as cast, and verified," Stark said.

Statistically significant audits

Over a dozen counties have now participated in a California-wide pilot project to provide a real-world test of what had previously been an academic theory. The pilot was authorized under California Assembly Bill 2023, which passed in 2010. Including audits conducted before the bill's passage, 23 contests have been audited across several county-level elections in the state in recent users, and other counties, including Orange, Marin, and Yolo, will have additional audits in the coming weeks.

California already has a mandatory audit law, which stipulates that a public manual tally of 1 percent of the precincts, chosen at random, must take place. But in Stark's view, this is the wrong way to proceed.

"There is no statistical justification for the 1 percent tally," Stark explained. "It is a check on the accuracy of the system, but it is not well tied to ensuring that outcomes are right. It doesn't require more counting for small margins than for large ones, and it does not require a full hand count, even if something is obviously wrong."

"In a contest I audited in Orange County," Stark added, "the chance the 1 percent count might not find any errors at all even if the outcome had been wrong could have been as large as 88 percent." Risk-limiting auditing, by contrast, takes into account the margin of victory. A wider margin of victory means there's less risk that something went wrong, so the system requires fewer votes to audit—sometimes dramatically fewer.

Temporary elections workers sifted through stacks of voted ballots to locate which ones needed to be audited.
Cyrus Farivar

Some vote registrars appreciate the new system. "Academics like Professor Stark bring an unbiased, fact-based approach to solving problems, unlike some election reform activists that promote changes based on superstition and emotion," said Marin County's registrar of voters, Elaine Ginnold, in a 2010 UC Berkeley news release. "It is the more objective approach that will result in meaningful election reform such as the proposal in this election audit bill."

Rivest, who has published academic papers with Stark on this issue, also lauded the process, which until last week he had not witnessed in person.

"Post-election auditing is a great way of making sure that the voting system is working as it should," he said. "Given the difficulty of checking the election outcome by looking at the paper ballots, I'd like to see a lot more post-election auditing. The work here is based [on] having a foundation in paper ballots. Assuming you have a solid paper trail, you can confirm the election outcome with the process that we're seeing today."

And the impact of Stark's work is spreading. Around the country, counties in Colorado and Ohio have used Stark's methods to conduct similar audits, though he has not participated in them. Starting in 2014, all elections in Colorado will use risk-limited auditing. As for California's pilot project, its audits will continue through the November 2012 election.

Stark's spreadsheet compared the scanned vote (right-hand name column) with the votes as human-read on each audited ballot (left).
Cyrus Farivar

The results are in

But risk-limiting auditing does have one real downside: time. A full recount can sometimes take days, of course, but even doing a risk-limiting audit on a relatively small Napa County contest of around 5,000 votes took four hours (including a lunch break) and collectively involved around 15 people, to say nothing of the prep work required to set up the process.

"At the moment, I think that until and unless we get [officials] to report [votes] at the ballot level, it is going to be a lot of trouble to do it this way," Stark said. "For large jurisdictions, it's just hard—it's hard to do quickly enough." He has ideas for speeding up the process, but they don't align well with the current crop of voting machines, which don't record their per-ballot vote interpretations.

The Napa recount encountered a few minor discrepancies, such as when a numbered ballot (for example, Ballot 32 from a stack of 50) was not properly marked because the human worker mis-counted. Those glitches, however, were all corrected by the Stark and Rivest team. In the end, all 559 audited votes the team examined matched the votes as they were recorded by the Wagner scanning software.

As the day wound down, the original results stood—and Napa County could have confidence in its election.

"I am committed to having the right count," Napa County's Tuteur said on Friday. "My goal is to make sure that the people of Napa County, those who voted and those who didn't, have full confidence in our system."

http://arstechnica.com/tech-policy/2012/07/saving-american-elections-with-10-sided-dice-one-stats-profs-quest/2/