

Special Section

Dive into fun in Santa Cruz. **L1**



Our San Francisco

This city wasn't always a foodie's paradise. **F1**

Sporting Green
Warriors hold off New Orleans in playoff opener. **B1**



San Francisco Chronicle

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Facing drought's hard reality

'New normal': Scientists forecast less rain, more heat in the future

By Kevin Fagan

What's gone wrong with the weather? Ever since California began drying out four years ago, Noah Diffenbaugh and his crew of earth scientists at Stanford University have been working on that question. They're on a mission, like detectives breaking down a psychological profile of a bad guy — only this hunt is done with calculators and computer models.

Their bad guy is the drought, one of the worst in California's recorded history. And one of the most mysterious. What's most clearly known is this: A huge dome of stagnant air has spent much of the past four winters parked off the West Coast, driving the storm path far north of California. In years past, it would periodically slide south, letting in rain to the lowlands and snow to the mountains. Now, it *Scientists continues on A16*

RUNNING DRY

Throughout 2015, *The Chronicle* will report on water growing scarce in California.

- ▶ **Insight:** The state has enacted rate hikes and cutbacks, but is anybody listening? **E5-E7**
- ▶ **Bay Area:** 1977's poster girl for water wasters has done an about-face. **C1**
- ▶ **Online:** More at www.sfchronicle.com/drought.

Mandatory cuts: Water managers issue call for sweeping reductions

By Kurtis Alexander

Dead lawns and dirty cars may be the future for California under mandatory water reductions of up to 36 percent rolled out Saturday by state water officials. The unprecedented regulation, which comes despite concern that the state is overreaching, builds on an earlier proposal that compels heavy water users to make the biggest sacrifices as California

faces a fourth year of drought. Under the new mandate, each of the state's 400 largest water agencies is assigned to one of nine tiers of cuts, with those that have historically consumed more water required to make larger reductions — even more than the initial proposal recommended. A handful of spots in the Bay Area, including Hillsborough, Discovery Bay, Atherton and Woodside, join a roster of *Cuts continues on A14*



The Lexington Club has long been the city's only bar that was a special place for lesbians and transgender people. Preston Gannaway / Special to The Chronicle 2014

Land altered before blast

Pipeline might have been closer to the surface

By Steve Rubenstein and Nanette Asimov

FRESNO — The ground at the site of a natural gas pipeline explosion that injured 12 people has been altered significantly in the two years since Pacific Gas and Electric Co. last surveyed the location of the line, officials said Saturday. Seven people remained hospitalized Saturday, including four in critical condition, said Mary Lisa Russell, a spokesperson for Community Regional Medical Center, where most victims are being treated. Federal, state and local investigators are trying to determine the cause of Friday's fiery explosion from PG&E's pipeline in northwest Fresno. The utility said it last surveyed the location of the pipe in 2013, mapping it at 40 inches below the surface. Both PG&E officials and the sheriff's officials who use the site as a firing range say the land has since been heavily altered, meaning the pipe may have been much *Blast continues on A12*

Storied bar's last round

Closing time at the Lexington, a home, haven and heart in the city's queer community

By Ryan Kost

The Lexington Club is packed, shoulder to shoulder. It's been this way for nearly an hour. All those bodies have made the Mission District bar warm and loud. A pool table has been shoved into a corner and a microphone stand sits on top. A little after 8 p.m., Joey "Cupcake" Stevenson climbs up. She quiets the crowd and makes a few announcements, and the eulogies begin. One after another, people come to the microphone to share their memories — of spin the bottle and bathroom fights, love stories and ghost stories. Stories about community and stories about loss. "I'm scared of how it's going to feel to miss you," somebody says. And everybody gets it: The Lex is closing. San Francisco is full of wakes these days. This one is for its only lesbian bar. At the end of the month, after 18 years, *Lexington continues on A15*



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FROM THE COVER

Historical data prove culprit is climate change

Scientists from page A1

hardly budes.

That's where Diffenbaugh takes up the hunt. What has changed? Why did it change? And is that change permanent?

It's no exaggeration to say the future of California society hinges on the answers. Where we live, what our homes look like, what food we eat, what we build and where we build it — all of these depend on the reliability of water supplies.

State 'in a new climate'

Don't expect any happy dispatches from Diffenbaugh, a senior fellow at Stanford's Woods Institute for the Environment who grew up in the forests above Santa Cruz, and his eclectic crew of a dozen science sleuths — including a 25-year-old who runs one of the nation's most popular weather blogs. They work together as the cumbrously named Climate and Earth System Dynamics Group, and as they help lead the scientific world's investigation into the state's epic dehydration, they're not finding a lot to smile about.

"California is in a new climate," Diffenbaugh said. "And that's a climate where droughts have already become much more likely, and will continue to be so in the coming years."

Note the word "likely": It's used often by this group, which couches its fact-based descriptions as carefully as a monk scrapes sand grains.

"You're ultimately trying to figure out how the world works, and a lot of what we do as scientists is fail," Diffenbaugh said. "We wrestle with all the tiny micro-challenges to try to get some answers, and that takes time and a lot of very careful work."

"It's a really chaotic system we have to study."

Meticulous crew

To make sense of the chaos, Diffenbaugh works with a dozen graduate and postdoctoral researchers carrying a wide gamut of strengths, from a specialist on Indian monsoon characteristics to a snowpack expert and Daniel Swain, the young weather blogger who gave a name to that huge, storm-diverting dome of high pressure that has now become known worldwide. He dubbed it the Ridiculously Resilient Ridge.

A boyishly fit man who seems younger than his 40 years, Diffenbaugh runs his team with an easy, collaborative manner. "Some people show their intelligence by talking about themselves; Noah shows his by asking really great questions," said graduate student Justin Mankin.

But there's nothing easy about what this crew does. The work is so painstaking and deliberate it can give dull a new meaning — to nonscientists, that is. To those paying close attention, it's academic dynamite.

In two key reports, released in September and March, the Stanford team argued that the drought isn't simply a one-off event that will soon revert to the old norm. More likely, the researchers said, it will be repeated in varying degrees of severity on a regular basis from now on.

What's changed

This drought hasn't been marked simply by a dearth of rain, but also by unusual heat, the team noted. That warmth — the average temperature in California in 2014 was 61.5 degrees, a record — points to human-caused climate change as one big reason for the drying out of California, the researchers believe.

They based their contention on weather records dating back to 1895. Combining through decades of statistics, graphic modeling and raw data from organizations including the National Oceanic and Atmospheric Administration, they



Leah Millis / The Chronicle



Michael Macor / The Chronicle

Above: Polly and Noah Diffenbaugh pick out vegetables with daughters Lulu, 10, and Ela, 13, at the Palo Alto farmers' market.

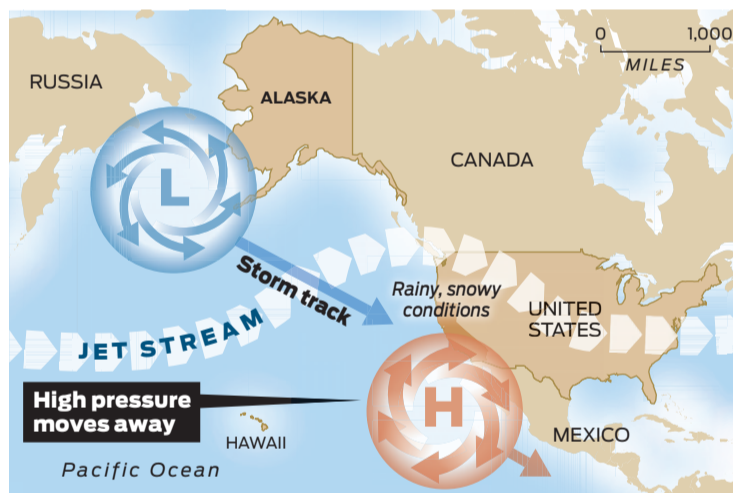
Left: Diffenbaugh attends a lab meeting at Stanford.

Right: Daniel Swain, the blogger on the team, checks out a rare thunderstorm as it rolls across the sky during a UC Davis conference Swain spoke at called "Water Scarcity in the West: Past, Present, Future."



The Ridiculously Resilient Ridge

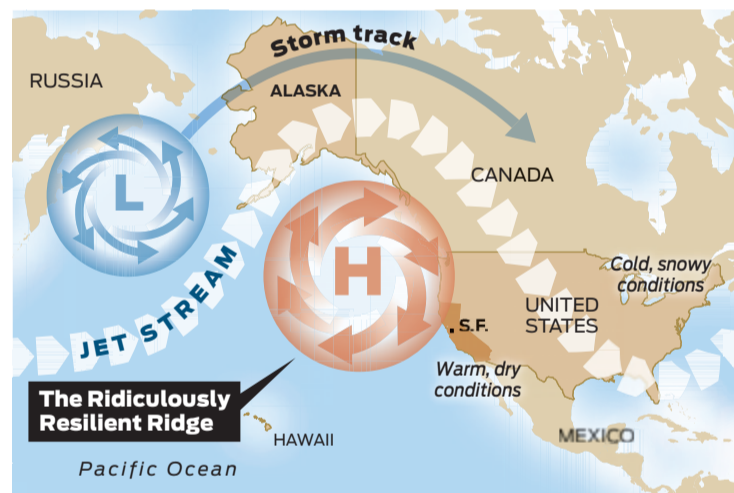
The term was coined by Stanford graduate student Daniel Swain to describe the atmospheric pattern that's behind California's recent warm and dry winters. The graphic shows what has changed compared with how typical winter storms move across the Eastern Pacific.



TYPICAL WINTER STORM PATTERN

Pacific storms usually approach the West Coast from the north and west, bringing rain and high-elevation snow. The storm track wobbles north and south many times over the course of each winter, bringing periodic storminess to California. This results in rain and colder conditions along the West Coast.

Source: Daniel Swain, Stanford University



WARM AND DRY WINTERS

The Ridiculously Resilient Ridge is a region of unusually persistent high pressure, which has pushed the Pacific storm track to the north of its typical position along the West Coast. This has prevented typical winter storms from reaching California.

John Blanchard / The Chronicle

compiled one set of scenarios based on weather patterns reflecting global warming — commonly pegged as a 1.6-degree rise in Earth's average temperature over the past century. The other set reflected patterns that would have occurred if that heating had not happened.

They came to the conclusion that during the early and mid-20th century, big swings in temperature and precipitation occurred independently of each other, and only about a quarter of the time did California get a warm and dry year at the same time. But suddenly in the past two decades, 80 percent of the years have been warmer than average — coinciding with an unusually frequent surge of hot air across the Pacific toward the Western United States.

The Stanford team projects this trend to continue from here on out — translating into what Diffenbaugh says is the "new normal," a future filled with warm and dry years about half the time, instead of a quarter. A big culprit in all this, the team says: global warming.

"No matter how you look at it, global warming is occurring, and this is increasing the risk of extreme events," Diffenbaugh said. "We have to deal with the reality that we are in a new climate."

In the state capital and much of the scientific community, the contention that human-caused climate change is helping drive

the drought is not a revolutionary conclusion. But there are about two dozen climate-change and earth science groups around the country doing vigorous research on the drought, and not all think global warming is as big a factor as Diffenbaugh does.

Alternative analysis

In November, for example, a NOAA report concluded that variable ocean temperatures — not a warming atmosphere — were encouraging the persistence of storm-blocking high pressure off the West Coast. The lead author of that report, researcher Richard Seager of New York, said in an interview that ridge or no ridge, the atypical warming trend in the West doesn't play a core role in the drought.

"My view is that the drought is really a precipitation-driven drought, and that when they look at the contribution of greenhouse gas-driven warming trends, they are looking at a rather second-order effect," said Seager, a climate scientist at Columbia University's Lamont-Doherty Earth Observatory.

"They're not totally off the mark, but I think the temperature is a secondary part of this drought."

Diffenbaugh's analysis, however, holds greater sway in Sacramento.

"In some scientific reports you look for one point where there is a definitive statement,

and it's hard to find one," said state Natural Resources Secretary John Laird, one of the most influential figures for shaping California's environmental policy. "The trouble is, that kind of statement is always helpful to me to get people's attention, because my job is to make sure the rank and file and the water decision makers all understand the science of what's going on."

"I find it very handy that Noah's papers are so clear. He helps people understand the science of the drought, and that is no easy thing."

In popular perception, probably the biggest contribution the Stanford team has made to drought study has been the naming of that stubborn high-pressure system off the coast: the Ridiculously Resilient Ridge, or, for short, the Triple R.

Swain coined the name on his California Weather blog in 2013. On a site where each of Swain's biweekly or so posts draws thousands of comments — he says his metrics show a million annual readers — it didn't take long for the label to stick, and to spread like one of the jet streams he writes about.

The Triple R deflects winter storm systems north, where they then rush over Canada and pour south to dump rain and snow on the East Coast. Global warming, again, is probably stoking the Triple R's resiliency, the Stanford group says

— though nobody has figured out precisely why the ridge has parked off the coast like a stalled bus.

"The features in the atmosphere are usually transient, but this ridge has been particularly persistent," Swain said recently, cobbling up animation on his computer showing the latest flow pattern of warm and cold fronts shoved around by the Triple R. "There probably isn't a single answer to why the Triple R is here, but we keep looking into it. It's pretty weird."

Warm, dry future

The Triple R will in all likelihood dissipate at some point, the team contends — but that doesn't mean everything will go back to normal.

By 2040, Diffenbaugh's numbers predict, low-rain years in California will consistently be warmer than the winters we've been used to. Even in years that get more precipitation than 2015, soil will become parched more quickly, snow will melt faster, and less water will be available in streams, lakes and the ground than in earlier eras.

In other words, more extraneous droughts are in our future. With some sloppy relief in between.

But weather science isn't straightforward. On one hand, Diffenbaugh says, global warming has indeed increased the probability of more hot years in conjunction with little rain. On

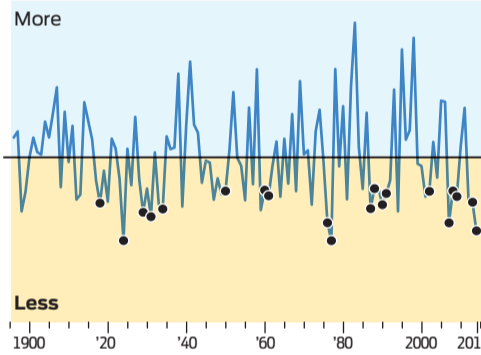


Leah Millis / The Chronicle

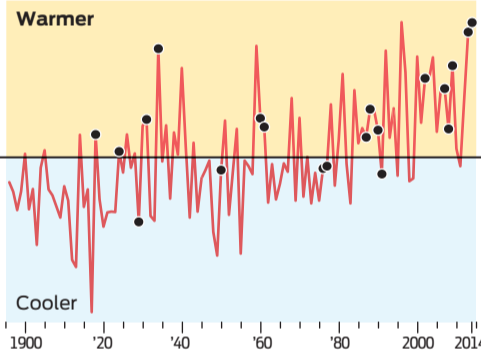
Disturbing trends

When coupled, less precipitation and warmer temperatures mean less moisture in the ground — and less water available in California.

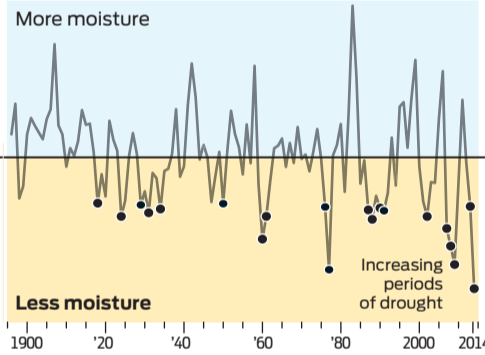
Precipitation (Rain and snow)



Temperature



Soil moisture index



The charts above are calculated from records beginning in 1895. The lines represent anomalies from the average. The black dots represent periods of drought
Source: Noah Diffenbaugh, Stanford University
John Blanchard / The Chronicle

the other, global warming also increases the chances of extremely wet years now and then.

“We’re not saying California will become a desert,” he said. “We just say the risk of drought in future years is increasing.”

“And though I don’t study economics or policy, I do know this: We are in a different climate than we were when our current infrastructure for water was built. And decisions on how to handle our water need to be made on the current climate, not the old climate.”

From forest to fellow

The idea that Diffenbaugh would one day be a computer-modeling scientist making such pronouncements wasn’t exactly in the cards when he was a child.

He was raised at Mount Madonna, a Santa Cruz Mountains community based around the spiritual discipline of Ash-tanga Yoga, which holds paramount the pursuit of peace and selfless service. His parents are both educators in the area, and growing up included trips to India to work with the underprivileged.

“I did not grow up with computers,” Diffenbaugh said. “I grew up in the mountains, in touch with my physical surroundings, and was 9 when the first TV came to my house.”

But being more in tune with nature did not mean his education was shorted. He got into Stanford to study medicine — though that didn’t last long.

“I was premed right up until I took my first chemistry midterm,” he said. “Not for me. Then I discovered earth system science, and that really unlocked things for me.” He was hooked.

He also got hooked on his soon-to-be wife, Polly, a fellow Stanford science student who now is a clinical associate at the university. They married 18 years ago, and en route to Diffenbaugh’s doctorate in earth sciences at UC Santa Cruz and his professorship at Purdue University, they had two daughters, now 11 and 13, and a son, now 16.

Today, they live in a tidy, spacious house overlooking the Stanford campus, surrounded by trees and little noise other than birds. Posted prominently inside the front entrance on a table is a statuette of Hanuman, an Indian icon of selfless service.

The typical family conversation flows from the makeup of neuroscience and drinking water needs in the Third World to the merits of “Lord of the Rings” with the ease of a downhill stream. There’s no shortage of good-natured ribbing of Dad — they’re used to seeing him on national TV, at public appearances and on the Internet, where a geeky climate change music video shows him sitting alongside an artificially singing Al Gore.

Daughter his ‘coach’

“I’m coaching him on the importance of speaking with his head high, and smiling,” Ela, the 13-year-old, said as the family headed to a local farmers’ market one recent Sunday — a weekly tradition. “I see constant upward improvement.”

Diffenbaugh raised an eyebrow and tried on one of the suggested smiles.

“I’m not sure what people think of when they look at a scientist — maybe they’d assume he’d be a total nerd with

nerd-nation glasses, sitting in a dark room somewhere all day,” said Jeffrey Koseff, director of the Stanford Woods Institute for the Environment. “But that’s not Noah.”

“It doesn’t surprise me that someone raised like he was is curious and willing to ask hard questions.”

Clever with a quip

If you’re looking for a lot of good news from Diffenbaugh’s group, don’t. Those conclusions state officials find so useful are usually grim. But finding the nitty-gritty of that within the body of the reports, which have succinct conclusions but come in densely worded packages of statistics and hyper-referenced contentions, can be tough sledding.

This is where Swain has come in particularly handy. His ability to coin a phrase and couch trends in lively language make him more user-friendly than most scientists.

“Daniel’s got a passion for the subject, for sure, but he’s also got a knack for a phrase,” said Geoff McGhee, creative director for media at Stanford’s Bill Lane Center for the American West. “That Triple R name, his blog — he came along just at the right time for studying the drought.”

Given the depth of his research, most people are surprised when they get their first look at Swain. He is the youngest in Diffenbaugh’s group, looking more like a slightly shy, gawky teenager than a man set to earn his doctorate next year.

Born to a social worker mom and a schoolteacher dad, as a schoolboy in San Rafael he was scolded by instructors for sneaking onto school computers to study weather. The scold-

ing eased up when he put his obsession to use, building a weather station on his parents’ roof and creating his blog.

He expanded the blog as he earned a bachelor’s degree in atmospheric science at UC Davis in 2011 before moving to Stanford, where he has been working on a doctorate in earth system science. Today, he gets a steady stream of correspondence from his blog readers — everyone from researchers in Europe to a contingent that thinks aliens are concocting the drought. The volume got so huge he had to go to larger computer servers to handle the load.

His explication of the Triple R name — to which he’s added “Redux,” since it came back this past winter — gets the same carefully parsed treatment reserved for describing, say, a variation in temperature degrees across meridians.

“The Triple R is arguably an accurate description of a fairly complex geophysical phenomenon,” Swain said. “It is a ridge. It’s not permanent, it’s resilient. And then of course, it is anomalous and not something you’d expect to see — so it’s ridiculous.”

“Hey, it’s the age of the Internet,” he said with a shrug. “You’ve gotta have some kind of hook now and then.”

Dead serious in the lab

Knacks and hooks come only at the tail end of the research, though. During the heavy lifting, it’s all a dead serious process of relentless tweaking, refining, fact-finding, and then tweaking again.

At least once a week, the Stanford crew gathers in a brightly lit conference room to go over slides of data, mapping

and charts. One recent afternoon found the team staring hard at a projection screen and slicing fractions with even-toned debate — nobody ever raises a voice, nobody looks at a phone, every word is precise.

One chart showed extreme heat between 1975 and 2015 in California spiking so high at times it left the screen. Seemed clear enough, but just where the baseline figures should start to give the best representation year by year wasn’t quite settled.

“We could use a varying number of statistical inputs,” Swain suggested.

“Trends reflective of trends,” Diffenbaugh added.

Deepti Singh, the graduate student presenting the latest figures, noted that the median temperatures year by year would be useful, as well as “calculating spatial averages.”

Critical to understand

“Yes, that is the kind of thing that could be calculated,” Diffenbaugh said, leaning back in his seat and looking mock-serious. The team laughed. It was the kind of joke only a batch of scientists who spend most of their waking hours doing calculations could understand, let alone appreciate. Of course they can calculate it: They calculate literally *everything*.

“The most crucial thing we have to understand next is the intersection between our physical climate system — heat, rain, wind — and people and other living things, and how they interact,” Diffenbaugh said. “I always make it clear that politically, I don’t have a horse in the race. My role is to be objective about the evidence.”

“But I do know this,” he said. “We really do have relevant information to decisions being made right now. Actionable decisions can well be different if our paper is right. If people understand that we do have a different climate now, and this drought is not just an anomalous event, they can make better decisions.”

“That’s our job. To help people understand so they can make decisions on risk going forward. To always keep trying to get it right. It doesn’t end.”

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