

Is California Entering a Megadrought?

<https://www.climateone.org/audio/california-entering-megadrought>

Recorded on July 14, 2016



Greg Dalton: From the Commonwealth Club of California this is Climate One. I'm Greg Dalton. El Niño has come and gone and La Niña is stirring in the Pacific Ocean. On the show today we will learn what the rains of 2016 did for California's reservoirs and what we can expect next year. We'll hear about new research suggesting that California should expect more dry times ahead. Some scientists suggest California may even be heading into a megadrought that could last for decades, which has happened in the past.

After El Niño sent storms to the state last winter the Brown administration relaxed some water restrictions allowing regional authorities to decide how to manage the worst drought in the state's modern history. The governor also made permanent bans on certain activities such as hosing off sidewalks and washing cars with hoses that don't have shut off valves. Some question if those gestures even matter when 80% of the state's water goes to agriculture, which has a reputation for playing fast and loose with water that it gets on the cheap. Over the next hour, we will discuss the future of water and food in the era of climate disruption. This program is underwritten by our friends at the S. D. Bechtel, Jr. Foundation.

We have three distinguished guests here today to talk about keeping the California economy well hydrated. Noah Diffenbaugh is associate professor in the School of Earth Sciences at Stanford and a senior fellow at the Woods Institute for the Environment. He's a lead author for the intergovernmental panel on climate change, or IPCC and is a former Google science communication fellow. Peter Gleick is one of the world's foremost authorities on freshwater. He's cofounder and now president emeritus of the Pacific Institute, a water think tank based in Oakland. He's a recipient of the MacArthur genius award and the author of many books including *Bottled and Sold: The Story Behind Our Obsession with Bottled Water*. Karen Ross is a California Secretary of Food and Agriculture. She grew up as a 4-H kid on a farm in Nebraska and is now responsible for promoting and protecting California's \$54 billion agricultural economy. She previously was Chief of Staff for US Secretary of Agriculture Tom Vilsack, before that led the California Association of Wine grape Growers. Please welcome them to Climate One.

[Applause]

Welcome all of you. Peter Gleick, let's begin with you. We had a wet year, is the drought over?

Peter Gleick: No. Okay, so we had a wet - we didn't have a wet year actually. To be specific we sort of had an average year. And it's been so long since we've had an average year that everybody kind of

got excited. But rainfall statewide was a tiny bit below average; wet in the North, dry in the South. The snowpack was a little below average, and it melted really fast which we can talk about later perhaps. Some of the big reservoirs filled but not all of them. And our groundwater is still massively over pumped. So by that measure the drought is not over.

Greg Dalton: Karen Ross, how is the agriculture sector being affected? Is it hitting the farms and are we seeing impacts at the grocery store?

Karen Ross: Well yes, it is hitting the farms and we've commissioned economic impact reports to better understand how farmers are managing their way through this. It's fallowing acres; that's what farmers do. Because of the water right system, the water is cut off and so you fallow acres if you don't have access to groundwater. So we know that last year as an example, we were short on surface water deliveries by about 8.7 million acre-feet. We compensated by pumping 6 million acre-feet from the ground.

So we were short 2.7 million acre-feet, which resulted in over two and a half billion dollar economic loss of economic activity that wasn't being generated; 10,500 jobs that were not created as a result of fallowing that kind of acres. So yes, it is hitting the farms and that's starting to be back to back. With regard to the food, I think it would take a much longer sustained drought to really work its way through the food system. We know that food more and more is being sourced from other countries. In the fresh produce aisle we've probably seen the most direct impact. But we're also seeing it when the cost of inputs and the cost of labor have gone up so it would be hard to say and that was a result of the drought. So far food prices have remained fairly stable. But if we continue to have these kinds of situations and we grow less and less, then the things that we specialize in California could in fact see increased food prices at the grocery store.

Greg Dalton: Agriculture is 2% of the California state economy, 80% of water use. Karen Ross, you penned an op-ed last year saying that it's worth it. Do the math for us, how is 80% of the water good for 2% of the economy?

Karen Ross: And of course I know that Peter will appreciate how much my constituents go crazy talking about 80% of the water. It is true that 80% of the developed water in California and on a global basis -

Greg Dalton: Tell us what developed water means.

Karen Ross: Developed water means that water that we capture, manage, put into reservoir system moved to those places of need. As opposed to all of the water that's available from nature in good years that mean increased flows in our streams that benefit our wildlife and just our green landscapes so and that, it's a different statistic. And the 2% I do take exception to because agriculture is like a renewable resource. Every year we plant, we nurture, we harvest that's creating economic activity so that there are many ways that we benefit the economy far beyond that 2%. We're embedded in insurance and finance. We're embedded in marketing. We're embedded in entertainment because we're a big part of our tourism industry here in California. 25% of the hundred billion dollars that's spent by tourists in our state every year is going specifically to culinary tourism restaurants, wine tasting and all those other fun types of activities.

Greg Dalton: Noah Diffenbaugh, does Ag get a disproportionate use of water compared to its contribution to the economy?

Noah Diffenbaugh: Well, I think what I would add is that food is more than 2% of what we eat. Close to a hundred.

[Laughs]

Karen Ross: I love this guy.

Greg Dalton: Don't need to go to Stanford to get that math, yeah, okay.

Noah Diffenbaugh: And I think, you know, it's not controversial to say that California's agriculture is, you know, critical for the US agriculture and for the globe. And, you know, for a lot of what we eat beyond the economic value we rely on California for that agriculture. So I think the real challenge that we're seeing in this drought is that we have a lot of really worthwhile demands on our water. And when we face shortfalls we really see the stress on across those demands. And I think it's not, it's less a question of which of these should we get rid of and more a question of in the context of a changing climate where we know that these kinds of conditions are becoming more frequent, and will continue to become more frequent, how do we manage those different priorities in a way that manages those climate risks and meets the needs of the people and ecosystems.

Greg Dalton: So Peter Gleick, do environmentalists and others unfairly criticize agriculture for its perceived high water use?

Peter Gleick: So I think we're thinking about this the wrong way. California is a great place to grow food. The soils are incredible. The climate at the moment is incredible. There's typically a lot of water. I think will always be a big agricultural economy. During the drought, the agricultural sector has done remarkably well. Some economic impact, perhaps some employment impact. Farm prices have been high, food prices have been high. Revenues have been pretty good. But partly, that's because we're unsustainably overdrafting groundwater. You made the point that as we increase groundwater pumping to 6 million acre-feet. Well that's completely unsustainable. We're seeing groundwater levels drop. We're seeing subsidence in the Central Valley in the southern San Joaquin. That can't continue.

If the drought were to continue, we're going to see fundamental changes in agriculture. We may see some land come out of production permanently. We're already seeing changes in crop type. We're going to see more tension between cities and farms and ecosystems. We can't leave ecosystems out here. There have been enormous ecosystem impacts of the drought and that's part of the equation. So the long-term question is how we're going to balance all of the things we want to do with water with how much water we have?

Greg Dalton: You've mentioned subsidence. I want to roll a clip from KQED. This is Michelle Sneed, a geologist with the US Geological Survey interviewed on KQED about subsidence which is the sinking of land in the Central Valley as a result of pumping out groundwater. Let's listen to this clip.

[CLIP]

Michelle Sneed: *I've been studying land subsidence throughout the last for 20 years. And I've never measured rates like this before.*

Male Speaker: *Over the past two decades the ground in one area has sunk from Sneed's head to her feet. According to NASA, some parts of the Central Valley are now sinking more than 2 inches a month.*

Michelle Sneed: *We saw that the area being affected by subsidence was enormous. Stretching all the way from I-5 to 99. About 1,200 square miles have been affected by subsidence.*

Male Speaker: *That's an area the size of Rhode Island.*

[END CLIP]

Greg Dalton: That's Michelle Sneed, a geologist with the US Geological Survey. Karen Ross, the size, an area the size of Rhode Island sinking as much as 2 inches a month from the pumping of groundwater.

Karen Ross: Sure. So there's a couple things I want to say. First, historically over time we have and it's not just farmers that depend on groundwater. We also have some cities that are a hundred percent dependent on groundwater. We have historically in agriculture relied on groundwater for about 30% of our total needs which is more sustainable. It's just that in drought time that is our reservoir, that is supposed to be our buffer to carry us through disastrous drought conditions. And the last few years we're pumping as high as 60% of our water is coming from that groundwater. I think everyone will acknowledge that is not sustainable which is why I was also very engaged in helping to pass a Sustainable Groundwater Management Act. We cannot continue to do that. And we cannot waste time in putting our basins back into balance and doing that in a very thoughtful kind of way to make sure we have that buffer for future generations.

Karen Ross: It's interesting to note our history that one of the reasons we went into the State water Project, the Central Valley water project is because subsidence was not new. And we knew that we need to have surface water to make sure that we wouldn't do permanent harm to our basins. So this is being repeated and that's why we have to take it as an alarm call.

Greg Dalton: So Peter Gleick, sinking lands and pumping too much groundwater.

Peter Gleick: So Karen is exactly right. I mean there is sort of a little bit of optimism in the sense that we now have for the first time a Sustainable Groundwater Management Act. We have some laws that are trying to slowly bring these over drafted basins back into balance. I would note though, this isn't just a drought problem. Even during a good year we overdraft groundwater. We use more groundwater than nature recharges and that can't continue. It's drawing down your bank account without recharging it.

And so part of the Sustainable Groundwater Management Act conversation is how to bring those basins back into balance. How maybe in dry years we draft overdraft groundwater and then that's okay if in wet years we can recharge those basins again. And we're not there yet that's the conversation that's happening.

Greg Dalton: But doesn't each individual farmer have an incentive to suck out as much as they can, because if I don't get it, Karen's farm will. And if Karen's farm doesn't, Peter's farm will, so.

Peter Gleick: Well, at the moment that's right. At the moment it's a free-for-all. But the Sustainable Groundwater Management Act is designed to let the local basins develop plans to bring their basins into balance. If they don't, the state can step in. But there's a local incentive at the moment over the next decade to slowly bring these basins back into balance.

Greg Dalton: Noah Diffenbaugh, some recent research came out of Stanford. Rob Jackson saying that there could be three times the amount of groundwater on the Central Valley. That headline might say the farmers are okay, let's open up the tap, keep pumping.

Noah Diffenbaugh: Yeah, I mean I think it's, you know, the message that I take from that paper and I've heard from Rob and Peter can speak more about it because he's involved with the Journal. You know, the message I've taken is that if we look deep which Rob and his colleagues were able to do with the well access that they had in terms of the data that they had access to. If we look deep

there's a lot of water there. How exactly how fresh it is, exactly how much energy it would take to get it up to the surface, exactly how much energy it would take to make it more fresh if it's not sufficiently fresh. I think those are open questions. I think the main message is that in California where we have a portfolio of water sources. We have a portfolio of water uses and we're not totally aligned. So as my high school daughter has said, why are we flushing our toilet with water that's just as good as the water we drink? Why are we flushing this clean water down the toilet?

And that's one example one very local example of our uses not totally being aligned with the quality of our supply. So I think the main message from that paper more generally, is that we do have opportunities in California to look at where we using water. What level of quality do we need, what are the costs and benefits of aligning those more optimally?

Greg Dalton: Karen Ross, we're drilling deeper for oil. Why not drill deeper for water especially if it gets more scarce?

Karen Ross: Well, one is just the cost of doing that. The energy of doing that, these are huge factors in all of these. And really reconciling the value of that we put on water for the value that it brings us back which is why we've seen the crop shifts that we've seen is that we're generating more efficient economic use of every drop by matching it to higher value crops. They can't be duplicated across the country, or in some places around the world. So it becomes a question of economics as well as we do have in this state a very strong environmental ethic from farmers all the way to every citizen of the state. And doing those kinds of decisions and the impact it has on communities and neighbors gets factored in and especially with the Sustainable Groundwater Management Act. We will see very hard decisions being made that will affect people's livelihoods. The ability to continue the kind of lifestyle we have. But it comes down to the value of water for the value it brings to us. And we all have a role to play in using every drop as efficiently as we possibly can.

Greg Dalton: So what are you saying, are you saying that there'll be less of cotton, alfalfa, almonds, that sort of thing?

Karen Ross: There is already a lot less cotton. When I moved to the state almost 30 years ago we had over a million acres of cotton in the Central Valley. Last year, I don't think we'll have even 220,000 acres of cotton. That's just one example of crop shifts that are happening.

Farmers in the state respond very rapidly to markets. And we are shifting more and more into those kinds of produce crops, tree nut crops, processing tomato crops. We still have a lot of cows in the state and that's what the alfalfa is used for but we're really matching where the highest value is. And for the value add, and like milk turns into a lot of different things.

Greg Dalton: Peter Gleick, is the market working to shift those crops to where they ought to be, so the highest value away from cotton to other things?

Peter Gleick: Sure markets work but no - my economist friends like to say let the markets work. Let the free market set the price of water and then people will be efficient. I'm not an economist, but there is no such thing as a free market. We don't have perfect markets. Water is allocated not on a market system in California with a few exceptions. It's given out by water rights and those water rights are 100 years old or more. And that's part of the complication. We don't really have a market system. But farmers are shifting, we're growing less cotton, we're growing more almonds for a reason. The price of almonds is really high. Farmers can make \$1000 an acre whereas an alfalfa farmer might make \$100 an acre. So economics drives some of this, markets drive some of it, but policy drives some of it too.

Greg Dalton: Karen Ross, you mentioned cows, you know, there's what, 600 gallons of water in a hamburger. Some people really question the water input embedded water in a hamburger and other beef. Other people say cows can be part of the solution, that if they're grazed properly certain grasslands, which are all over beautiful California golden hills, can sequester water and carbon. So how do you see it?

Karen Ross: We really do need to account for all of the benefits that come from well-managed farmland. From really thinking in an ecosystem holistic kind of way about how management practices can be a part of making sure that any water that comes off the land is useful.

And clean quality that we can help reduce air emissions that we can be a part of sequestering carbon to reduce greenhouse gas emissions. So we really have to think more comprehensively about the public good that comes from well-managed stewardship practices on our farmland, including with our cattle. And then at the end of the day, each one of us as consumers make very powerful decisions both at the grocery store aisles and at the ballot box with the policies that we support and what we choose to buy. I think at the end of the day, we still in this country value choice and we want to be able to make our own choices but we need to be informed consumers and understand the impact of our own decisions.

Greg Dalton: Karen Ross is California Secretary of Food and Agriculture. If you're just joining us, we're talking at Climate One about the drought and our water future. Our other guests are Peter Gleick from the Pacific Institute and Noah Diffenbaugh from Stanford. I'm Greg Dalton.

Noah Diffenbaugh, help us a little bit to understand the drought. Is this drought influence amplified by the climate, by climate disruption, climate change?

Noah Diffenbaugh: So, a substantial number of scientists have asked that question during the drought over the last four years. And that's - our peer review and publication process is fast enough that we now have certainly a hill coming up to a mountain of papers asking that question. And the preponderance of evidence from those papers from a number of different independent groups is clearly that yes, global warming is influencing what we're experiencing here in California. The primary influence is through temperature, you know, the more heat there is in the atmosphere, the more that draws water out of soils and out of plants. The faster that it melts snowpack the more that it pushes precipitation towards rain rather than snow particularly at lower elevations. And we've seen all of those during this drought.

And the work that's come out of my lab at Stanford, what we found is that it used to be in California that we pretty much got half wet years and half dry years. We got half warm years and half cool years. And what's happened with the long-term warming of California is pretty similar to the global warming. Is now we're getting a warm year, pretty much year after year. Eighty percent of the years in the last two decades have been warmer than the long-term average. And what that means is that it's like flipping two coins except we got a precipitation coin that's pretty 50-50 half heads, half tails. And now we've got a temperature coin that's really loaded towards warm conditions, right. Eight out of ten flips are coming out tails and that means we get two tails more often. And what that means when we have low precipitation and high temperature is we're much more likely to get drought. And that's what we're likely to see going forward into the future more and more.

Greg Dalton: So Karen Ross, how is the agricultural sector getting ready for a hotter and drier future?

Karen Ross: Well, certainly some crops have taken longer-term views on climate change and impact to the quality of their product and the wine sector has been one of the first in doing that. But more

and more of that commodities are looking at what does this mean for crop choices, for varieties, and really there's a whole new level of reinvestment and plant breeders. And really understanding what we need to do to try to find those crops that will be salinity tolerant, drought tolerant, cold hardiness, you know, because we're going to go through all of those kinds of things. But the most immediate change has been what's happening on the farm as far as improving the efficiency of our water use. And the adoption of precision irrigation technology primarily in the state because we have trees and orchard crops that lend themselves very nicely to drip irrigation and subsurface drip irrigation. But subsurface drip irrigation completely transformed the processing tomato sector. It improves quality, it lowers other inputs, it reduces nitrogen runoff from fertilizer in addition to being the most efficient way of using water trying to minimize evaporation off of those fields.

So we have about 50% close to 50% of the acreage that's using that kind of technology. There are several barriers to why we're not getting further down the road. And one of the big ones is that 46% of our land is rented, so you can't go to the bank and use your land as collateral to make those kinds of capital investments. And then the state with the governor's leadership and the support of the legislature we have been offering incentive dollars to try to help, especially a lot of the smaller midsize farmers that just need that incentive dollar to take the next step to implement drip technology, we're doing that. But our whole infrastructure in California needs to be modernized. We still deliver water in parts of the state where you're getting your water delivery on Tuesday and that doesn't lend itself to real time water management on the farm. So we really need to marry up this technology.

Greg Dalton: Peter Gleick, is Ag doing enough?

Peter Gleick: So none of us are doing enough. I don't mean to be glib about that but none of us are doing enough. There are probably people, well-meaning people in the audience who still have top loading washing machines, or 6 gallons per flush toilets in your homes or leaks that you don't even know about. Agriculture is doing a lot, but agriculture as Karen says could be doing a lot more. Every one of our orchards should probably be on drip or precision sprinklers. And there are disincentives and incentives and we need to do a better job. We could grow more food with less water. We could do all the things we want with less water and that's the inevitable future for us. There's not enough water for all of us to do what we want. I've said this a lot maybe you've heard me but as badly as we're doing it now as inefficiently as we're doing it. And that's the drip irrigation question; it's the efficient washing machine and the efficient toilet. It's the leak detection. We're using too much water at the moment to do the things we want. And it's true during a drought, but it's true during a normal year as well.

Greg Dalton: We're talking about the drought at Climate One. I'm Greg Dalton. My guests are Noah Diffenbaugh from Stanford, Peter Gleick from the Pacific Institute and Karen Ross, Secretary of Food and Ag in California. We're going to go to our lightning round. Which is a series of brisk yes or no, truth or false questions. This is designed to inform and humor our audience and make them squirm just a little bit up here. Peter Gleick, in the last five years Orange County has made more progress than San Francisco in using water more efficiently, true or false?

Noah Diffenbaugh: It's lightning.

[Laughter]

Peter Gleick: Do I really have to? Yes or no? Okay, false.

Greg Dalton: Karen Ross, true or false. Citizens should be wary of municipal water systems being operated by for-profit companies?

Karen Ross: False.

Greg Dalton: Noah Diffenbaugh, in the next five years people in California will start to sell and move their homes due to water shortages?

Noah Diffenbaugh: True.

Greg Dalton: It's happened in some cases already. Peter Gleick, suppose you are writing a movie about water shenanigans in California with Kevin Spacey playing the villain. Would that villain come from the agricultural industry or the Metropolitan Water District of Southern California?

[Laughter]

Peter Gleick: Yes.

[Laughter]

Greg Dalton: Kevin Spacey in two roles.

Peter Gleick: That movie has been made already.

Greg Dalton: With Jack Nicholson. Noah Diffenbaugh, fracking for natural gas may have serious impacts on water quality and human health, yes or no?

Noah Diffenbaugh: Yes, because you said may.

Greg Dalton: Karen Ross, the rise of fracking, a water intensive practice is putting agricultural and oil industries in conflict in some cases over water?

Karen Ross: True. In some cases, yes.

Greg Dalton: Karen Ross, senior water rights in California probably will be changed if the current drought continues? Australia did that, will it happen here?

Karen Ross: No. Well, see I can't give you context.

[Laughter]

Like the governance structure there is so completely different that that's hard to imagine so.

Greg Dalton: Peter Gleick, reform of California water rights could result in a more equitable distribution of water in the state?

Peter Gleick: Oh sure.

Greg Dalton: Karen Ross. Nothing big happens in California water without the blessing of US Sen. Dianne Feinstein?

Karen Ross: True.

[Laughter]

Of course I'm pandering, I'm sorry!

Greg Dalton: Peter Gleick, one day you will drink recycled pee water as part of your normal life?

Peter Gleick: True.

Greg Dalton: Noah Diffenbaugh, almonds get a bad rap. They actually deliver a reasonable amount of protein per drop of water compared to other protein sources.

Noah Diffenbaugh: That's true and I will declare a conflict I keep a bag of almonds in my office. I eat them every day.

Greg Dalton: We actually had the head of the sustainability person from the almond board here a few weeks ago talking about water. You can listen to that podcast. I also have a bag of almonds next to my desk. Karen Ross, what crop is the biggest water hog in California? I know you love all your 400 commodities, but. Water intensive.

Karen Ross: Okay, water intensive I have to say alfalfa. Because we do seven cuttings a year, alfalfa.

Greg Dalton: And we export a lot to Japan for the cows. Peter Gleick, what crop is the biggest water hog in California?

Peter Gleick: The largest single user of water is alfalfa in terms of acre-feet per year. But that's not necessarily the best measure. Is it dollars per gallon is it yield per gallon? That's a tough, tough one.

Greg Dalton: Noah Diffenbaugh, as a former farm Stanford is a bigger water hog than UC Berkeley where people shower like Europeans?

Noah Diffenbaugh: I don't know the data on that.

[Laughter]

Greg Dalton: Okay then maybe you know data on this one. Noah Diffenbaugh, last question. One way to save water is to shower with a friend?

[Laughter]

Noah Diffenbaugh: Depends how long the shower lasts.

[Laughter]

Greg Dalton: Alright, we have to end it there. How they do on the lightning round?

[Applause]

[CLIMATE ONE MINUTE]

Announcer: And now, here's a Climate One Minute.

This drought has gone on longer than many anticipated - we're currently in our fifth year. Two years ago, Californians approved a seven billion dollar water bond to help get us through dry times. But is it enough? In 2014, John Coleman of the Association of California Water Agencies looked into his crystal ball to predict what might happen if the drought continued.

John Coleman: *It's going to be dire in many parts of the State. Some parts of the State now you're*

only allocated 50 gallons of water per house per day regardless of the number of people living in them. We don't want to get back to that, but if it's a dire year again, you're going to see agencies that are going to, in most cases, ban outdoor water use entirely because that's in summertime upwards of 70% of your water usage. You're going to see - hopefully the State Water Board moving quickly with regulatory reform to deal with recycled water. You're going to see more de-sal plants. There's 10 on the drawing board now in the State that will be sped up. Things that people may have opposed in the past are going to fall to the side to some degree and it's just - it will kill our economy. We need to remember that water is the lifeblood of this State and if we don't have the water resources available, we're not going to produce the widget, we're not going to grow whatever and those are jobs, and even if you don't see it here it's your job, you're going to pay for it one way or the other and it's going to have an impact.

Announcer: John Coleman, president of the Association of California Water Agencies, in October of 2014. 2015 went down as one of California's warmest and driest years on record - and things just keep heating up. For more on the megadrought, let's join Greg Dalton and his guests at the Commonwealth Club.

[END CLIMATE ONE MINUTE]

Greg Dalton: Noah Diffenbaugh, explain to us why we should care about the Arctic and how the Arctic is related to our lawns.

Noah Diffenbaugh: Yes, this area of really active research including my research group and elsewhere. Yeah, so you know the weather and climate that we experience in any location on the planet is really a result of the energy imbalance of the planet. So just to give you like the brief sort of planetary energy balance 101. The tropics get more energy in total than the high latitudes. And so there's too much energy from the sun at the tropics and there's not enough at the poles, essentially. And so the circulation, the atmosphere and ocean is really working out of that energy imbalance. And what's happening globally is that the Arctic is warming faster than the tropics. So the gradient between the tropics and the poles is changing. And we know that that's something that was predicted from theory of global warming a long time ago is something we're absolutely seeing in observation.

And so the question is because the atmospheric circulation is really a result of that gradient as that gradient changes, what are we likely to see in the weather and climate that we experience anywhere in particular on earth. So that's the primer. In terms of California we know that because we get most of our precipitation from kind of this train of storms that comes across the Pacific during our rainy season. We get most of our water from just a handful of storms actually and anything that disrupts that, we're going to be sensitive to. And what we've seen during this drought is this area of really high atmospheric pressure called the Ridiculously Resilient Ridge. And there are a lot of hypotheses about how changes in the Arctic could affect that kind of feature. And so one of the hypotheses is that we could see more frequent blocking, more frequent Ridiculously Resilient Ridging as a result of that loss of Arctic sea ice. And certainly this year, we had a really strong El Niño. We had record low winter sea ice in the Arctic and something we're trying to chase down is what's the interplay between those factors.

Greg Dalton: And what can we expect with La Niña which is typically a dryer, the predictions about specific water years in California are difficult. But Noah Diffenbaugh, what we can look to in 2017 with La Niña, is that going to trend more dry, warm?

Noah Diffenbaugh: So I think you'll hear two answers about this. One answer is here look at this graph of history you can see that we've had all kinds of precipitation years in California with all

kinds of combinations of El Niño and La Niña and it's totally noisy. So that's one answer you'll get. The other answer is that even though it's noisy, if you could have one piece of information to make a guess about what California precipitation will be like in the coming year, you would want to know whether it was an El Niño year or La Niña year or neutral year.

So it won't give you perfect predictability, but if you could only have one piece of information that's the piece of information you'd want to know. And in general, if it's an El Niño year that'll tip the odds towards a wet year and if it's a La Niña year, that'll tip the odds toward dry year. So part of the concern right now as we're seeing indications of La Niña developing is that it will potentially be a dry year. And that's within the context of what's almost certainly going to be the warmest year on record globally.

Greg Dalton: And that beats 2015 which beat 2014, is that right?

Noah Diffenbaugh: Yes, so 2014 was the record, 2015 beat 2014; we're now well on track for 2016 to beat 2015.

Greg Dalton: Peter Gleick, there is a bill in this California State Senate regarding disclosure of big water users kind of name and shame. Some of the cities, Palo Alto has secrecy laws around water usage. Do you think name and shame is a good tool for putting, you know, Billy Beane's name in the paper that he uses lots of water?

Peter Gleick: I think data on who's using how much water to do what is valuable. You know, name and shame maybe helps in some circumstances maybe it doesn't. But in general, if we had better data on who is using water and what they were using it for, we would have a better tool for figuring out how to use it better or how to price it differently, or how to offer incentives for improving efficiency. And part of the problem in California, you know, we're a big state we're technologically savvy. We're rich economically, we're rich academically and yet it's astounding how bad we are at collecting water data. It's really astounding, and in every sector; urban, industrial use all those things. And so I like the idea of open source data on water.

Greg Dalton: Karen Ross, would farmers agree with that?

Karen Ross: Yes. You can't manage it if you can't measure it. I mean if you really want to improve your management you have to be able to measure and know what's your benchmark is and have that to compare to. And it's the same with our household use. Those companies that have done, doing some pilots of giving you real information about your water use how it compares to your neighborhood and here are some incentive programs that are offered for doing that XYZ. It helps everything. That's one of the positives that have come out of the drought, A, is that we have all worked together and we have done remarkable things in conservation. And we've made strides to do a much better job of collecting information, doing measurement, collecting the data, making it user-friendly. And that's a big part of what the governor's executive order was in May of this year. Really taking a look at and we are working on that to have a report to the governor on improvements in measurement, efficiency standards all across the board. So we've made strides because we do know this is not isolated, it's not something that's going to happen in 10 years from now. We'll re-create the playbook. We're trying to capture these lessons learned and improving data collection and making it more useful is a big part of what we're working on right now.

Greg Dalton: Noah Diffenbaugh.

Noah Diffenbaugh: There are groups that are not enthusiastic about collecting and yeah -

Karen Ross: I'll be the first one to acknowledge that.

Noah Diffenbaugh: - and revealing the data on their water use. I would just point that out.

Greg Dalton: Yeah, we can't imagine all farmers, yeah sure, because for the first time California has and this is only happening because government mandate.

Karen Ross: But not having that information is going to make a really hard job of implementing the Sustainable Groundwater Management Act even more difficult and so the value is being able to come together to make those decisions collectively as that community. And without the data it's going to make their job so much more difficult. So much more difficult.

Greg Dalton: That's a ten or twenty year thing, right?

Karen Ross: Well, they have to have the plans in place in the next five years. There'll be five-year progress reports and at the end of 20 years or if you've missed your marks on what looks like you're going to achieve sustainability, then the state will step in. So there's lots of opportunities.

Greg Dalton: We might get punished in 20 years, okay. Noah Diffenbaugh.

Noah Diffenbaugh: Just on the data and the importance of data and visibility just to give the obligatory promotion for the importance of research. We do have a project at Stanford in the, it's in basically the data science initiative. And Phil Levis who runs the secure internet of things so, you know, internet of things we hear about we're now trying to do this with water and water data. And figure out a system for monitoring and keeping anonymous. So that the information is secure, but that we know, we don't know who it is, necessarily, but everyone would know what theirs was. And so we are working on that now. And that's in the domestic space so that people have more visibility on what their own domestic use is.

Greg Dalton: Peter Gleick, one area where there isn't water data because it's in the gray economy is marijuana cultivation up in the Emerald Triangle. There's a ballot initiative in California this year to legalize marijuana. Is that a significant water issue, will legalization help California's water situation?

Peter Gleick: Why would you think that I know lots about marijuana -

[Laughter]

- water use? Any water use ought to be monitored and measured and managed. If we're moving toward an economy, a legal economy where marijuana is a big part of our agricultural sector. Are you going to include it in the agricultural economy?

Karen Ross: Well, I already have medical cannabis, so yes, yes.

Peter Gleick: Then we better include it in understanding where the water is coming from and what the consequences of its use are.

Karen Ross: And Greg, there was a trailer bill following the budget this year to give specific charge to the state water board on measuring those diversions to make sure that if the diversions are happening. There's real water, not impacting flows.

So just putting the framework around the medical cannabis, growing part of our existing marijuana picture has already set up that framework to be that big.

Peter Gleick: It's been a big problem. The illegal marijuana piece of this had been a big problem for water use in the northern part of the state and for water quality and for ecosystem flows.

Karen Ross: Yes. Yes.

Greg Dalton: And a lot of energy because it's indoor growing some of it. So if it's legalized it might come outdoors and use the sun rather than lights to grow that. I want to get to some of the top lessons or tips from the drought. Where we're at, five years into the worst drought. What are some of the real lessons Karen Ross from this drought and thinking if, you know, what are the takeaways from this drought?

Karen Ross: Well, just the remarkable progress we've made on showing what we can do with conservation and not have an impact to our economy to dramatically as well as our lifestyles. I think we're all still enjoying a pretty darn good quality of life. But it really underscored our disadvantaged communities. We have almost 2000 wells that did go dry over this drought and that's impacting some of our poorest communities who already had some water quality problems. So it's really raised the visibility of what we need to do as Californians to make sure that every Californian has access to safe, clean drinking water.

Greg Dalton: Peter Gleick, lessons so far in this what five year of this, year five of this most severe drought in 1,200 years?

Peter Gleick: Yeah, I agree with Karen's lesson. Some other things are ecosystems are often underappreciated and suffer more during droughts than human uses in agriculture with the groundwater and that's been a buffer. But ecosystems have really been hammered. Our energy system is partly dependent on water. We get hydropower and when we have a drought we don't get as much. And when we don't get as much we burn more natural gas and that produces greenhouse gases and that's a climate challenge. Another lesson is if the drought's bad enough sometimes the politics open the door to cooperation and groundwater law and some new opportunities. And so I think none of us are hoping the drought continues much longer.

But it is an opportunity to do things a little differently. To have some of the conversations that maybe we don't have when people forget that there's a problem. So that maybe is a positive lesson.

Greg Dalton: Noah Diffenbaugh, takeaways from the drought.

Noah Diffenbaugh: I think the biggest lesson is that California is in a new climate. We have a water right systems we've heard that's more than a century old. We have water infrastructure and management system for that infrastructure that's half a century old and more. And those are all designed and built in an old climate. And we're in a new climate, it's already here. It's going to intensify as global warming continues. And if we want to have a water system that's prepared for the climate of the present and the climate of the future, then we need to acknowledge that we're in the new climate. We don't have the climate from a century or half-century ago.

Greg Dalton: Earlier this year there was a research, opinion poll from the Hoover Institute conservative think tank in Stanford, and they found that actually water convinced people more than rising temperature, more than weird weather, that climate is happening. Water was more salient in convincing people than other more abstract issues. People get water in a visceral way. Peter Gleick, we haven't talked much about recycling, reuse. We've started that but are we going to see more of that in California and how are we going to pay for it?

Peter Gleick: Absolutely. So a lot of the work we do at the Institute of the Pacific Institute is to look

at new models for how to manage water more sustainably. And we've talked quite a bit already about conservation and efficiency, doing more with the water we already have. That's the demand side of the equation, which is been under addressed forever in water management. But on the supply side because there really is no more new water, we're not going to build any more dams, you know, maybe one or two and we'll still be in the same situation we are now I would argue. But there are new supply options and water reuse and recycling is one of them. Better stormwater capturing is another. And the institute has looked at the potential for those as well.

And the truth is we spend a lot of money collecting wastewater, treating it to a very high standard typically and throwing it away. That's an asset; we talked about this a little bit earlier we don't need to call wastewater treatment plants. We need to call them water recovery plants or something like that. And there's enormous potential for capturing and treating and reusing water for flushing toilets or landscapes or irrigation or all the way up to potentially potable reuse. I don't think that'll happen soon, but we're seeing more and more recycled water already. More and more water districts, especially in the coast when we throw that stuff into the ocean are starting to do that and that's inevitable. I think we're going to see a lot more of that.

Greg Dalton: And that's where Southern California which growing up in Northern California I always bash Southern California for what they did with our water. But they've done a lot in the last couple of decades. LA has a million more people than 20 years ago and they're using the same amount of water.

Peter Gleick: So you asked me the question in the lightning round about Orange County and I froze up in part because Orange County has done wonderful things about water recycling for a long time for groundwater replenishment. They've been a real leader in that. That's a good example of a group that's really been working hard for a long time on that piece of the puzzle.

Greg Dalton: I want to ask Peter to share a story with us from your book about Bottled and Sold about a stadium, sports stadium that was built in Florida and tell us that story it's quite indicative of a, it's an interesting story.

Peter Gleick: So this is in part reflective of the way we think about or ought to be thinking about water. This was about 10 years ago now. A big football stadium was built I think it was Central Florida University, a big football university. Opening day very hot it was September they had 100,000 people in the stadium approximately.

It turned out they had built a stadium with zero water fountains which I think was a violation of the Florida building code. And it was a very hot day they had 30,000 bottles, of bottled water at the concession stand they sold out. And by the end of the day dozens of people had heatstroke and went to the hospital because there was not enough water for people. It led to a conversation at the University about water fountains. The University very quickly retrofitted that stadium with 40 or 50 water fountains. But it was reflective of the disappearance of public water and the shift toward private water which is a bigger problem than we think.

Greg Dalton: We're talking about groundwater and the drought at Climate One. I'm Greg Dalton. My guests are Noah Diffenbaugh from Stanford, Karen Ross, you just heard, Secretary of Agriculture and Food in California. And Peter Gleick, President Emeritus of the Pacific Institute.

We're going to go to audience questions and invite your participation with one, one-part comment or question.

Male Participant: Noah, you said that the climate has changed as if it's changed into a static

position. And I see climate change, rising and rising and rising and rising. And I'm concerned that we'll have as I once mentioned to you, Peter a thousand year drought.

Greg Dalton: Thank you. So fair point, megadrought. Noah Diffenbaugh.

Noah Diffenbaugh: I agree, the best evidence that we have and again this is partly research that I've been involved in partly from other research groups. The best evidence we have is that California has entered a regime in which we have warmer temperatures. And what that means is that when there's low precipitation, we're more likely to enter drought and those droughts are likely to be more intense and to last longer. And that those periods are likely to continue to be punctuated by wet years. And all the evidence suggests that both from looking at historical record, looking at theoretical understanding of the climate system, looking at climate model projections, that we are likely to continue to have a climate that is punctuated by wet conditions.

Greg Dalton: Peter Gleick.

Peter Gleick: I would note there are different definitions of drought. There's, we've sort of been talking about meteorological drought; that is how much water nature delivers to us in our wet season. There's hydrologic drought, which is how much water is in the system.

And then there's economic drought, which is how much water we humans want. And if there's not enough water to do all the things that we want, even if meteorologically there's no change or hydrologically there's no change, then maybe we are in a drought anyway. And so there's some nuances there that suggests that we're already in a water short condition.

Greg Dalton: Thank you. Let's go to our next question at Climate One.

Female Participant: Given the disparity between 80% of the water being used by the agricultural sector, it's true that not all of us are doing what we could be doing and some of us are eating almonds and using top loading washing machines. Are there any other initiatives beside the Sustainable Groundwater Management Act that's either in our Congress or being written up that would address this 80% that is going to the agricultural sector?

Karen Ross: Well, in addition to the water efficiency incentive programs that are in place, part of the executive order was a new requirement for urban and ag water efficiency management plans to instead verify that they have water to get through at least three years of drought. They must now document that they can get through five years of drought. And we're looking at and this will be a requirement for those districts to estimate what their water usage is as part of the total water budget. And the other thing that happened is that previously we had 56 water districts that were required to do an Ag efficiency water management plan and verify how they could get through drought. And that was based on 25,000 acres or more that was being served by them. We have now lowered that to any district that serves at least 10,000 acres or more so we'll have 111 water districts making these kinds of reports, verifying their plans and the state water board will have the opportunity to audit that and verify that it's real and that they have a plan in place. So it's all starting to work together under integrated water management.

Greg Dalton: Noah Diffenbaugh.

Noah Diffenbaugh: Yeah, another one that I'm really interested in, you know, we, in California we've, we use the same dams and reservoirs for both flood control and water storage and we've really relied on snowpack. And Peter can correct me but, you know, something on the order of 30% reliance on snowpack. And what we're seeing with a warmer climate is more rain rather than snow

and earlier melting of the snow that does fall. And what that means is putting more pressure on our reservoirs and that's part of why, you know, we're seeing releases from reservoirs to create more space for flood control. And so one proposal that's been introduced is to give some more flexibility to those water managers by relying more on near term weather forecasts to be able to inform those decisions about whether or not to release water. And I actually think that particularly on the context of reducing snowpack that that actually on a real on the ground basis will give a lot more flexibility.

Greg Dalton: Let's go to our next question at Climate One.

Female Participant: Peter and Karen, could you tell us a little bit about how biodynamic organic farming might help us during drought situations?

Karen Ross: Well, I'll speak specifically. Both of those systems have a very strong emphasis on soil health and really building the organic matter in our soil. And we have good data that shows water retention ability has improved dramatically. So I would use that as one very specific example. And if it's ever funded under the cap and trade proposals that are out there we will be launching under Governor Brown's leadership, he announced that we would have a soil health initiative, so that all farmers will be a part of sequestering carbon and really building the organic matter in their soil. And it will provide some drought resilience, that's the goal of our program.

Greg Dalton: But Peter Gleick, I've had a sustainability executive from Patagonia up here who laments, who says organic cotton stinks because organic itself speaks to fertilizer use, et cetera but not water use.

Peter Gleick: That's right, organic doesn't automatically mean less water. Maybe the general message in addition to the things that Karen has just described is that on farm management practices have an enormous impact on water and soil quality and soil health and carbon emissions and carbon sequestration. So we have to manage the agricultural sector, not just for food production but for sustainability broadly. And I think a lot of what Karen has been describing and she's been a leader in this for a long time, is trying to integrate all those pieces together.

Greg Dalton: We're talking about the drought at Climate One with Noah Diffenbaugh, Peter Gleick and Karen Ross. Let's go to our next question.

Male Participant: Hi, I'm Paul Chapman a long time school teacher and school principal in the Bay Area. I'm now working to promote greener, more environmentally sustainable schools. So I'd like to ask a broader question and that is how you think we can best teach our young people about climate change. When should we do this? How best can we do it in the schools, to what end? Do you have any curricula to recommend?

Greg Dalton: First I'll mention that we did a whole two-part program on Earning and Learning Green. So you can check out a Climate One podcast we did a few months ago on exactly this topic in depth K-12 and college. But who would like to answer that for now? Noah Diffenbaugh, you're an educator.

Noah Diffenbaugh: Well, we had a project at Stanford; it was led by my dean, Pamela Matson and the director of the Stanford teacher education program. They co-led it, and they did develop curriculum materials and piloted those in Bay Area schools. So there was both curriculum development and research on the effectiveness of implementation. So I would point you to that resource.

Greg Dalton: Karen Ross.

Karen Ross: Can I just add that I know how much teachers have and we always add-on things as opposed to integrating it. And teaching about water and water conservation and how valuable water is, is a great nexus to climate change as well. I just came back from leading a delegation to Israel and that in that country everybody regardless of age, knows how valuable every drop of water is. And they did a very massive education and they continue that in schools from the youngest age possible.

Greg Dalton: Peter Gleick.

Peter Gleick: Yeah, so I would – it's a great question. And I would add that there are great resources in the Bay Area. There's an organization called Community Resources for Science that helps elementary school teachers teach science. And there are new science standards, National Science standards and California has science standards and climate is a piece of that. If we had started teaching climate science 20 years ago or 30 years ago maybe some of our policymakers today would be a little better informed than they are.

[Applause]

Greg Dalton: There's also the National Center for Science Education in Oakland and the Alliance for Climate Education in Oakland. Let's go to our next question at Climate One.

Male Participant: Peter Anderson. I have a background in restoring rivers in the Napa Valley. We're trying to save the steelhead, we lost that battle. I have two friends who are climate scientists who say we're locked into a four degree centigrade rise in temperature in the next few decades. Do you think we can adapt to that?

Noah Diffenbaugh: We're not locked in. We're not locked in, I mean if the Paris agreement is implemented, the carbon budget goals are implemented, we will, you know, we have the very good chance of staying below the two degree target that's outlined in Paris. We are in the period where the decisions that we make now will go a long way to determining whether we see four degrees of warming or whether we see something more like what's in the Paris agreement. So now we have the agreement at the international level and the question now is meeting that agreement.

Greg Dalton: Peter Gleick.

Peter Gleick: So Noah is right. We're not necessarily locked into four. But we are locked into something. There is inevitable unavoidable climate change now. Some of which will be hard to adapt to depending on who you are and where you are. So your question is a valid one, it's a good one. There are going to be bad consequences of the climate changes were not now already able to avoid. And understanding what those are and figuring out how to deal with them is going to be a costly challenge.

Greg Dalton: Last question.

Male Participant: So it's somewhat related to the last questions about whether steelhead or Delta smelt is around the Endangered Species Act. So clearly that's a factor in the distribution of water, but if I look ahead and you look at climate change obviously, that impacts the viability of species. What's the thought of the panel, how is this going to play out?

Greg Dalton: Karen Ross, there's some suggestion that should the Endangered Species Act be relaxed. Farmers obviously don't like it.

Karen Ross: So part of this comes from building great infrastructure 50, 60 years ago and not really

understanding what the impact to nature was. And now we're having to reconcile that. Could there be some flexibility? I think that's the real question. We don't have to throw out an act that's accomplished good things and throw it out. It's about can we create some flexibility, do we have good scientific data to show us how we can manage for species and still have an economy that works. And I think that's the place to focus is on the science; is it just about flows, we also know that for the smelt in particular, it's equally important habitat in the marshes. So I think that we have to be holistic. I know that there are some in the farm community that do believe that the Endangered Species Act has to be dramatically amended. I'm not there but I do think that we should look for flexibility and have a better understanding of how we can meet our coequal goals that we've set for ourselves here in California.

Greg Dalton: And Peter Gleick, a lot of environmentalists are very concerned that if the Endangered Species Act gets tinkered with that it once you open it up, then it'll get basically decimated.

Peter Gleick: Yes, I think that's a real danger. The Endangered Species Act is a line in the sand. You won't let species go extinct if you can prevent it. And Karen's answer was a really good one. We want a healthy ecosystem. We want a healthy agricultural community. We have to figure out how to achieve those things. And it's complicated, but when you have species on the verge of extinction you make a special effort to prevent that.

Greg Dalton: We have to end it there. We've been talking about the drought in California with Noah Diffenbaugh, Professor at Stanford University, Peter Gleick, President Emeritus of the Pacific Institute and Karen Ross, Secretary of California Department of Food and Agriculture. I'm Greg Dalton. You can join the conversation on Twitter using our handle @climateone. And listen to podcasts of this and other Climate One programs on climateone.org. I'd like to thank our guests here in the room and online. Thank you all for joining this conversation.

[Applause]