

# International Water Scarcity Challenges



## Moderated by Alexander "Sam" G. Fernald, New Mexico Water Resources Research Institute

Alexander "Sam" G. Fernald was appointed director of the New Mexico Water Resources Research Institute (NM WRRI) in July 2013 after having served as interim director since January 2011. As director, he leads the Institute in its mission to develop and disseminate knowledge that will assist the state, region, and nation in solving water resources problems. Dr. Fernald is also the program chair of the Water Science and Management Graduate degree program, where he establishes, initiates, and leads all academic, programmatic, budgetary, administrative, and instructional aspects of the program. Additionally, he is a professor of Watershed Management in the Department of Animal and Range Sciences at New Mexico State University.

Dr. Fernald's earned degrees include a 1987 B.A. in international relations from Stanford University, an M.E.M. in 1993 in water and air resources from Duke University, and a Ph.D. in watershed science from Colorado State University in 1997. He was also a National Research Council Postdoctoral Fellow from 1997-2000 for the U.S. EPA.

*Editor's Note: This panel discussion was transcribed from the speakers' remarks made at the conference. No follow-up was made with the panelists and the editor assumes responsibility for any transcription or editing errors.*

I'd like to introduce the members of this panel and tell you a little bit about what's happening. We have some delivery issues you might have heard about with the United States and Mexico pertaining to the Rio Grande. There will be ongoing discussions about surface water deliveries and future challenges with groundwater in terms of internationally shared water resources. Senator Udall mentioned his support of the Transboundary Aquifer Assessment Program when he spoke earlier. This panel was brought together in an effort to look ahead and consider how we can take some of our research perspectives to meet international water scarcity challenges with science and policy.

First, I will introduce our panelists and then provide discussion questions. Senator Tom Udall has been a U.S. Senator since 2009, after two decades as a U.S. Representative for New Mexico. Senator Udall will be joined by Jeff Jones, who served in the Mexican government as a federal Congressman, a Senator, and the Undersecretary of Agribusiness Development in Mexico's Secretariat of Agriculture. Mr. Jones is from Chihuahua, and we thank him for joining us. Mike Muller is a civil engineering professor at the Wits School of Governance in

South Africa. He was previously a member of the Global Water Partnerships technical committee from 2005 to 2011, and director general of South Africa's Department of Water Affairs from 1997 to 2005. Rubén Chávez Guillén is a civil engineer who has held offices in Mexico in various water resources positions, most recently as director of groundwater for CONAGUA (the National Water Commission) in Mexico. He is now a consultant and working member of the Mexican Geohydrological Association, and also works as a committee member of the Association of Mexican Civil Engineers. Finally, Chris Wilson will round out our panel. Chris is the deputy director of the Mexico Institute at the Woodrow Wilson International Center for Scholars where he leads the institute's programming on regional economic integration and U.S.-Mexico border affairs. He has authored a number of reports on the U.S.-Mexico border.

In the same order as the introductions, our panelists will reflect on some of the questions put together to guide this discussion while also allowing time for open discussion. Starting with Senator Udall: From your perspective, what are the impacts of water scarcity and how has water scarcity affected your work?



## Tom Udall, U.S. Senator

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Tom Udall has earned a reputation as a principled leader who has the integrity to do what is right for New Mexico and our nation. Tom began serving as a U.S. senator in 2009, after two decades of public service as a U.S. Representative and New Mexico's state attorney general. He was reelected to the U.S. Senate in 2014 and is now New Mexico's senior senator.

Tom earned his undergraduate degree at Prescott College and obtained a Bachelor of Laws degree from Cambridge University in 1975. He graduated from the University of New Mexico Law School in 1977. Tom then served as a law clerk to chief justice Oliver Seth of the U.S. Tenth Circuit Court of Appeals and became a federal prosecutor in the U.S. Attorney's criminal division. As chief counsel to the New Mexico Department of Health and Environment, he fought for stronger environmental and health protections.

Tom is married to Jill Cooper, who is a former attorney and a longtime advocate for the arts. They have one grown daughter, Amanda, and they live in Santa Fe.

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Thank you so much for that question, Sam. It's great to be here with all of these panelists. First of all, I think you have to start with water scarcity. It constricts almost everything, not just our present but our future. One of the best ways to put policy into action in that regard is to be frugal with the resource. On the individual level, that means we have to reduce our per-person consumption as much as possible. Our cities are currently doing this. In New Mexico, cities look at per-gallon per-person use and say, "We're doing a better job compared to other cities." It gets a little bit competitive. This is a great thing in the public sector. In the private sector, this means that farmers and companies have to figure out how to operate more efficiently. Government also has to invest in infrastructure,

such as desalination in some cases and, in other cases, pipelines to distribute water.

One of the things that I've seen in our tri-state region of New Mexico, Texas, and Chihuahua, is how dwindling supplies are subject to international treaties. This raises tensions between farmers and the government on both sides of the border between Mexico, the United States and between our bordering states. It's obvious and absolutely clear that we need good science to advise and guide our policy makers to mitigate these tensions and build cooperation. I have tried to aid in this by pushing for funding from Congress to study the impacts of pumping on shared aquifers across international borders.



## Jeffrey Max Jones, Former Federal Senator for the State of Chihuahua

Jeffrey Max Jones has served in the Mexican government as federal congressman (1997–2000), federal senator (2000–2006), and undersecretary of agribusiness development (2006–2009) at Mexico's Secretariat of Agriculture. During this period, he was part of the upswing of the political transition from the 71-year, single-party control over the executive and legislative branches to the current scenario, with its evolved, competitive electoral system.

A native of Nuevo Casas Grandes, Chihuahua, Mexico, he grew up in a family involved in several agribusiness operations in northwestern Chihuahua. Upon graduating from Brigham Young University in 1982 (international relations), he returned to Mexico as an entrepreneur during the inflationary eighties, and during his business career, he became frustrated with the

government's irresponsible monetary policies leading to a 12-year stint in politics. As senator, Jeff presided over the Border Affairs Committee. As undersecretary at the Ministry of Agriculture, he focused on prospective planning and modeling, market development, and rural finance. Jeff is an avid defender of limited government and the crucial role of open markets in the development of any nation.

He is fluent in English and Spanish, and is currently back in the private sector where he has been involved in a new start-up called Enerlogix Solutions, an energy management company betting on the opening of Mexico's new energy market. Previously he helped two US venture capital and private equity funds get established in Mexico. Jeff is a pilot and enjoys riding horses on his cattle ranch. He and his wife, Michelle, are parents to four daughters and four grandchildren.

**I** think this is one of the critical issues in any of these debates in this region where there is increasing economic activity, particularly in an area like Ciudad Juárez. I think the unclear policy for handling water needs to be addressed to be able to understand what to do about water scarcity.

I first became involved with this issue when I was a federal congressman and senator from 1997 to 2006. There was an issue with the farmers complaining about the cost of electricity that they were paying for their aquifer. They were asking for a very low rate for electricity, it was 14 cents in pesos. The argument I made at that time was that the problem we had was not the price of electricity, because it was, and continues to be, a very minimal cost. It's really the only cost to use water here. In Mexico, it's around two to three cents a kilowatt hour in terms of dollars. The problem, I argued at the time, was that we didn't have control over the aquifers. We were putting more and more wells into these aquifers that were overexploited, and the wells would need to be deeper every year. Going deeper into the aquifer meant an increasing exponential cost to pulling water out from the aquifers. So, my argument was that we needed to regulate aquifers to drop the cost of electricity on water, a scarce resource, otherwise we are not going to have good solutions. At the time, we worked on three basic issues that I felt were important. One was to put more of the decision-making power into the hands of local people. We created what we call the COTAS, (Comités Técnicos de Aguas Subterráneas), which are the groundwater councils, so that local water users would have part of that decision-making power. This is one of the great problems that we have in

Mexico because water is a national issue and there is no local control over it. Of course, the ones really interested in that decision-making process are the local people, but that is an issue that still has not been addressed.

The other thing that we were working on at the time was getting good information to make well-informed decisions. While working to get these COTAS created, we also worked on geohydrological studies for each of the closed aquifers. Getting good, solid information so that you know exactly the capacity of each of these aquifers was a major challenge as well.

The third element that we were working on was to find out exactly how much we were extracting from these aquifers, that is, how many wells there were in these aquifers, so that people were well informed on their resources.

The issue was how you administer a resource. If you don't know how much you have and you don't know how much you're taking out of those aquifers, you've got a serious problem. There were challenges to each of those issues. I'll be glad to comment on those as needed, but these were some of the issues that we were working on.

Generally speaking, I think a problem that we have in Mexico is the lack of democratic institutions in terms of making these types of decisions. The fundamental problem you'll see in the Rio Grande Basin (or the Rio Bravo, as it's called in Mexico) and the water in Chihuahua and Boquillas is the lack of democratic decision-making. Not only with the closed aquifers that are controlled by the COTAS, but also with the waters in the Consejo de Cuenca, or the basin council, which is dysfunctional. It

frustrates a lot of people because there is no good, solid debate over these issues and how to handle them. In the case of the Rio Bravo Cuenca, or basin, it's not an international issue, but an issue of the users that have rights along that river, and that's where it needs to be solved. Some of the root users happen to be on one side of the border, and some of the users happen to be on the other side of the border. But there needs to be a high-quality

debate and good institutions for looking at the technical challenges that there are and for making decisions.

I believe one of the big issues that we have here in Chihuahua in this current crisis is the very centralist perspective of the federal government making decisions without taking into account the perspectives of the people that are the users of this water. That's when you get into trouble.



## Mike Muller, University of the Witwatersand

Mike Muller a professional civil engineer and visiting adjunct professor at the Wits School of Governance, advises many public and private organizations on water and development issues. As a national planning commissioner (2010–2015), he focused on infrastructure, environment, and regional development issues. He chaired the World Economic Forum's Agenda Council on Water (2012–2014) and was a member of the Global Water Partnership's Technical Committee (2005–2011). As Director General of South Africa's Department of Water Affairs and Forestry (1997–2005), Mike led the development of new policies, legislation, and programs in water resources and services that provided safe water to over 10 million people and reached over 90 percent of South Africans by 2012. He was a cofounder of the Mvula Trust (1992) and managed water supply and sanitation programs and utilities, coordinating donor-funded projects and running an innovative urban sanitation program for the Mozambican government (1979–

1988). Current research interests include water governance and management at different scales, the contribution of water to regional development, and challenges of managing climate variability and change.

Good evening to you from Johannesburg. Thank you very much for the invitation.

One always wonders what there is that we can talk about from so far away about something as very complicated and local as water. Listening to Jeff talk about the problems of groundwater basins across communities reminds us that water is a very local issue. What we found in South Africa is that we were able to start from scratch, considering we had the good fortune of having quite a large political change in 1994, and we were able to rewrite a lot of our legislation and our policy. Additionally, we were able to learn from a lot of the efforts and mistakes, as well as the successes, of lots of other people. I think it was one of the water lawyers, Joe Sax, who said, "I wouldn't follow any one particular model from the USA. We can provide you with 50 different examples of the mistakes you can make." We certainly took this to heart and worked quite closely with Bruce Babbitt when he was Secretary for the Interior. I'm also grateful to Ambassador Delano Lewis, who had served two years here as an ambassador ahead of the World Summit on Sustainable Development. We really did learn a lot, and I hope we've actually demonstrated it. What we've managed to do, as opposed to what we wanted to do, is another matter.

Turning to scarcity, I work quite a lot in the sub-Saharan African continent. I'm also involved in the very

contentious Nile dispute. One of the things we learned is that water scarcity is quite a complex issue. The first kind of scarcity we have is the kind you've been discussing, where there really just isn't enough water for the people who are trying to do things with it. You then have to create some sort of arrangement to share water because that's all there is. Physical water scarcity is a concern in many places, but across Africa there are many places that have plenty of water, and yet the farmers can't get reliable irrigation and people can't get reliable drinking water. This is economic scarcity.

Taking a look at the water world maps, we can see places where water is physically scarce, like New Mexico, and those places where water is economically scarce, such as southern and eastern Africa. Southern and eastern Africa have plenty of water, but do not have the resources to move it. Of course, you can have the water and you can have the money, but you also need management, and that includes governance. I understand the challenges of governance in Mexico well after listening to Jeffrey Jones. In fact, we consulted with CONAGUA when we were busy developing water laws. You can have as much money and as much water as you like, but if your institutions aren't working, you won't create any progress. It is important for us to understand that scarcity has these different dimensions: it's physical, economic, and institutional.

We also must recognize the problems that we create for ourselves by scale. By scale, I'm talking about the geography. We use the watershed as a scale for our analyses very often, but there are other scales. Senator Udall, you don't represent a river, you represent the state, a very proud state. The political scale is also important. Yet, there is a third scale also represented on the panel, and that is the *problem shed*. There, you have a set of physical systems that cross a couple of political boundaries, and somehow you need to get the physical system working together with the political boundaries. It is sometimes quite useful to say, "Here's the problem shed. This is the boundary around the people who we are going to have to work with." I have found that concept to be very useful,

particularly in a changing world, because what you find is that the watersheds might stay constant, but the problem sheds are changing all the time, and we need to consider this.

In dealing with scarcity, I always like to think about the different scales and what kind of scarcity we're trying to deal with. I find your challenges there in the southwestern United States very interesting. You have groundwater, you have inter-basin transfers, and you have international cooperation. You've chosen your problem shed well. You can't complain of a shortage of challenges, but you seem to be on your way to dealing with them. So, it's very exciting to listen in.



### Rubén Chávez Guillén, former Groundwater Manager for Conagua (Mexico)

Rubén Chávez Guillén is a civil engineer with a master's degree in hydraulics from the National Autonomous University of México (UNAM). From 1968 to 2018, he held a position at the Department of Water Resources (SRH), Department of Agriculture and Water Resources (SARH), and National Water Commission (CONAGUA), where he participated in the execution and validation of aquifer studies at a national level and collaborated in the development of legal regulations related to water resources. He represented the CONAGUA in national and international events on topics such as climate change, transboundary aquifers, unconventional and geothermal reservoirs, artificial recharge, and others. He taught courses on hydrogeology and related disciplines at the College of Engineering of UNAM (1969–1984), courses in graduate programs in the Mexican States of Chihuahua and Nuevo

Leon Universities, and courses, seminars, and conferences on water resources at Monterrey Institute of Technology and Higher Education (ITESM). He is a consultant and an active member of the Mexican Geohydrological Association and committee member of water resources in the Association of Mexican Civil Engineers (CICM).

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**G**ood day to everyone. Thank you for the invitation to talk about scarcity. As the first speaker already mentioned, there is no doubt that this scarcity is going to affect all sectors, directly or indirectly. All of us absolutely depend on the availability of water. Water is life, and in a scarcity scenario, it's obvious that it is going to be a factor that limits economic development and development in general. And not just in the future, it even compromises current development, especially in regions where the impacts of climate change will accentuate scarcity. In particular, if we look at the northern strip of Mexico bordering the United States, where we share various sources of surface water and groundwater, there is no doubt that it is one of the most problematic zones in the world in terms of water resources. This is because this

area is in one of the largest desert zones in the world. Therefore, we can talk about natural-occurring water scarcity and the fact that groundwater in this northern strip is almost non-renewable. We would have to learn how to regulate this non-renewable resource to a human water consumption scale. Managing this resource would mainly depend on proper administration.

Fortunately, after 40 years of collaborating with the Mexican Hydrologic Authority, one can say that this issue has received some attention. Not as much as one would hope, but some, if only intermittently. Hot spots, or potential areas of conflict that could possibly cause transboundary effects, were identified. Specifically, the Hueco Bolson in Ciudad Juárez/El Paso was identified a long time ago as one of the most problematic zones. At

the same time, the Lower Colorado River Basin, where we have very specific problems in the management of surface water and groundwater, was identified. There we are talking about natural-occurring scarcity because precipitation in Mexico is 100 millimeters per year. Consequently, natural recharge would be almost null if we did not have the water allocation from the Colorado River that pertains to us in accordance to the corresponding international treaty. Therefore, the management of surface water and groundwater is essential. It has presented us with very specific situations, not only technically, but also in administrative, legal, and, of course, political aspects. I believe, in this scenario facing the threat of climate change, it is almost certain that various sections of the border will have accentuated scarcity. Thus, we need to start taking measures to address these growing problems. Yet, here we are faced with divergent perspectives from different sectors. On one hand, you have those who doubt the existence of climate change. Then, you have those who see it as a very futuristic problem, not one that we should worry about right now. And then, you have those who see

it with short-term vision. “Yes, it’s true that it can exist. But it will start affecting us in 30, 40, 50 years, so why do we let it distract us? Let’s solve our current problems.” That’s a great mistake because if we do not learn how to manage this resource, we are going to face gradual scarcity; its effects are already here.

We need to prevent it from a technical perspective, but society also needs to be aware and informed about the status of their resources because, ultimately, they are the ones that will be affected. Those of us who work in technical studies or regulations sometimes see it as a general, national, and not a local problem. As someone mentioned before, it is the local population who will have to be responsible for the stewardship of this resource. We can get the best research, the most comprehensive research, the most appropriate laws, but if the water users do not comply with the measures, then a sustainable environment would be unattainable. This is my input for now. Thank you.



### Christopher Wilson, Mexico Institute at the Woodrow Wilson International Center for Scholars

Christopher Wilson is deputy director of the Mexico Institute at the Woodrow Wilson International Center for Scholars, where he leads the institute’s research and programming on regional economic integration and U.S.-Mexico border affairs. He is the author and editor of numerous reports, including *Growing Together: Economic Ties between the United States and Mexico* and the *State of the Border Report*. Chris has testified before the United States Congress and is regularly consulted by national and international media outlets regarding U.S.-Mexico relations. He has written opinion columns for the Wall Street Journal, Politico, CNN, and Reuters, among others. Chris previously worked as a contractor doing Mexico analysis for the U.S. military and as a researcher at American University’s Center for North American Studies. In Mexico, he worked at an international trade consultancy and with American students

studying regional political and social issues. He is a member of the Transportation Research Board Committee on International Trade and Transportation, one of the National Academies of Sciences, Engineering, and Medicine technical committees. Chris completed his MA in international affairs at American University, focusing on U.S. foreign policy and U.S.-Mexico relations.

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**T**hank you, Sam, and thank you very much for the invitation. We’re really excited at the Wilson Center to be partnering with you all to try to take on what I consider to be a significant and very complex issue. Thank you, Senator Udall, for being a part of this, and thanks to all of my fellow co-panelists. It is really an honor to share this forum with you all.

For those of you who are unfamiliar, the Wilson Center is a nonpartisan think tank in Washington, D.C. It also serves as the memorial of President Woodrow Wilson, who worked extensively in both academia and public policy. In his memory, the Center strives to bring those worlds together. We were recognized as the number one regional studies think tank by the Think Tanks and Civil Societies

Program of the University of Pennsylvania. I work in the Center's Mexico Institute, which focuses on U.S.-Mexico relations.

Water issues are huge along the U.S.-Mexico border, the region I study. As others have noted, water scarcity is a natural phenomenon, particularly in the desert ecosystem that dominates the region. It's sort of normal and natural, and in some ways is long lasting, but in other ways, it's becoming more pressing than ever. Population growth in border communities is outpacing national averages on both sides of the border. Industrial and agricultural use of water is significant and increasing. Climate change is exacerbating droughts and changing the water flow patterns. The Colorado River rarely reaches the Gulf of California anymore, and the Rio Grande has at times failed to make it to the Gulf of Mexico. These are really serious issues. We have aquifers being depleted faster than they are recharged, affecting both the quality of water and its availability.

At the Mexico Institute, we work with a binational advisory board that includes current and former ambassadors, former leaders of the North American Development Bank, and leading experts in U.S.-Mexico relations. For the last several years, they've been telling us that this set of transboundary water issues is the most important one that is not being talked about enough in Washington and in Mexico City. Our goal is to increase dialogue on the topic and strengthen cooperation by finding ways to improve, not only the way we work across the U.S.-Mexico border, but also the way we communicate. What I've learned is it's going to take a lot more communication than just international cooperation to solve these issues. It's very much about connecting local level end users and stakeholders to the federal process and both interstate and international negotiations. In the United States, we have interstate compacts on water. This is such a complex, multilayered issue that it is very challenging to solve.

We recently saw the complexity of this challenge firsthand. The United States and Mexico have a water treaty going back to 1944. This treaty requires regular transfers of water. We just finished, about a week ago, a five-year cycle. Mexico was behind on its transfer of water as the year closed. The plan was to release water from the Rio Conchos in Chihuahua into the Rio Grande; however, local farmers and activists took over the La Boquilla Dam to stop the transfer from happening. In a conflict with the National Guard in Mexico, one of the protesters was killed. It's kind of a cry for help and an example of the challenge in front of us. The incident highlighted the tensions between local water users and federal authorities, and the importance of maintaining positive relations with both the U.S. federal government and the State of Texas, where

most U.S. water end users reside. These events illustrate a map of all the different levels of not only those actors involved in this really tragic incident, but also those actors that need to be present and involved in the conversation in order to have things end differently. Remarkably, the water transfer issue was solved in a very cooperative fashion. A new agreement was just negotiated, and there was some creativity in terms of how and where the water would be transferred. That was really good to see. We saw that you can solve these problems if you bring together the right set of people. For the Mexican government, that meant negotiating with the State of Texas, not just with the federal government. This is something they're not as accustomed to doing, given the way water is managed in Mexico at a more national level.

With groundwater, I think this becomes even more challenging. There is no treaty for groundwater. We don't have an established framework for cross-border management of this shared resource. The result is a classic tragedy of the commons. Everyone is acting in their own direct interest and is taking as much water as they need. Until what? Until it's all gone? I think we need to act before that happens. This gives us an opportunity, like Mike was mentioning, to learn from all the mistakes as they rewrote laws in South Africa. The fact that groundwater is unregulated right now means that we have the chance to get it right. We have the chance to create structures that address those needs that Jeffrey brought up of having the local level users become a part of the negotiation and the process for management. In the places where we've seen success along the U.S.-Mexico border, there have been some really interesting things happening along the Colorado River demonstrating that bottom-up, stakeholder-driven approaches supported by national governments can lead to meaningful agreements.

Let me stop there for now. I believe this is a really great space to be working in, and I'm really happy to be doing it with the New Mexico WRRI.

**Fernald:** Thanks so much, Chris. Just for your information, this panel won't stop here. Chris is alluding to our proposals for an ongoing four- or five-year project to try and bring universities across the border together to add information and even contribute policy and education to make changes to the situation. This goes back to Senator Udall's idea that we move from information into action. We will be acting on these panelists' great thoughts.

I'd like to conflate our second question since we had eight other questions that we won't have time for. What are the biggest challenges to achieving a less water-scarce future? How do we overcome these challenges? And if I could add question three, how are these exacerbated by climate change? Then, question four in terms of opportunities, are there places for international policy

versus local community action? If you could comment on research areas that we may prioritize or how science might help this situation. Senator Udall, please.

**Sen. Udall:** Thank you, Sam. First of all, I think we all know our biggest challenge in this water-scarce future is climate change and global warming. This is having a huge impact on all of our systems across the board. For us here in the United States, I would say our biggest challenge over the last four to six years is getting the President and Congress on the same page to finally address the threat of climate change. If we don't do that, we know we're going to continue to see droughts and wildfires. All our current models indicate that with the course we're on, we'll see stream flows decline 10 to 20 percent over the next 50 to 70 years. The public really understands this, there's no doubt about that. That's why we need politicians to be bold and to act responsibly, to lead on this issue. I think the pandemic we're in right now has shown us that we better recognize that we're going to need to step up and have that international cooperation when it comes to dealing with these disparities and issues. An individual country can solve climate change within their borders, maybe, but climate change is never going to be solved unless we work around the world.

I will then mention one other issue when you talk about challenges. I think climate change affects the foundation of water supplies such as the amount of precipitation and the amount of snowpack that forms in the spring. We are going to need to look across the board with water at how climate and global warming will impact the foundation of supplies, and then at how we push forward to break through those kinds of issues. I was very interested to hear the talk about how this issue has come between Mexico and the United States and how it led to farmers taking over the dam. We need to work closer together so this kind of tragedy doesn't happen. We need to recognize that individuals may see things differently, but if we share the knowledge, share the science, we can get to the same place and we can cooperate to get things done. Thank you, Sam.

**Fernald:** All right. If we can move on to our next panelist, Jeffrey Max Jones.

**Jones:** Something very important in public policy, and particularly in these types of complex issues, is modeling different scenarios. In this case, it would be our aquifers and basins. It's important to be able to sit down with the water users of our aquifers and government institutions and determine what to do. The role of academia is to bring objectivity to these discussions. My experience in government has been that whenever you get politicians involved in a discussion, be these from the United States, Mexico, or any other country, they tend to speak to their constituents and look to what is the politically correct thing to say, according to their constituency. In other words, their messages tend to be very politicized.

Again, the role of academics and the technical side of this is to bring objectivity to these discussions to ensure they are based on facts. If there were a good model of the transborder rivers, basins, and we had functional councils, really interesting things could be identified. We could then look at various what-if scenarios, their corresponding consequences and how these would affect all the stakeholders and water users. This would give people an improved ability to be empathetic of the other stakeholders and also to be informed regarding the best policies for solving those issues and challenges. What are options A, B, and C and their intended consequences? What do we do about these consequences? If we choose to move deeper into the age of information, we now have an opportunity that wasn't available when these treaties were signed in 1944 and 1906. We now have the ability to insert thousands of variables into an equation, and then ask, what if? If X or Y happened, then what would we do? The unintended consequences could be detected before they happen, and preventive policies could be implemented that would mitigate these consequences before they turn into a crisis, like what has happened recently with the water from the Conchos tributary. If I could make one suggestion, it would be to develop really good modeling for these different aquifers and basins, in order to look at scenarios, and draft possible solutions and policy. If a good model were developed, we would be able to look at various hypothetical scenarios, and then create effective policies to address these challenges. Again, what is needed is good, sound technical information that we would put together in a model, which would allow us to produce varying scenarios in order to develop and consider different possible policy solutions.

**Fernald:** Really nice. Please, Mike.

**Muller:** Listening to you, I think it comes back to what I said. We look different, but our problems are often the same. Tomorrow morning there is a session organized by WaterNet in southern Africa. It brings together the 10 countries of southern Africa and the water resource schools from different universities. We've got a system going where the master's degree programs in some of these water resource schools are shared across countries. For example, one module happens in a country, and another module happens in a separate country. There is a groundwater module that happens in South Africa.

What you get from this is a community of young scholars, and they are going to become practitioners in many cases. They are used to collaboration, have been through the same curriculum, and have a common understanding and a similar approach to different problems. Quite often students come from different countries, but they share the river and talk about it as a common problem. You establish relationships, a bit like what Christopher Wilson had said.

All the old ambassadors, or rather I could say all of the old heads in departments, are my current network. I know all the old heads of departments from water resources across the region. You become a very powerful network that can understand the problem without many conflicts, obviously because you've got politicians and constituencies behind you. Universities are very well placed to be able to build collaborative partnerships with the goal of finding ways of common learning. Let's learn together. Let's look at the same river from different perspectives. Sooner or later in 10 years' time, when we're the heads of departments, or in 20 years' time, when we're senators, we will have a much better understanding of each other and of the problems that we have. This is one area where I think relationships can be very important.

But I'm nervous about this idea that we can inform the discussion objectively. We are in a world in which experts are not particularly valued. They need to be trusted before they become valued. We need to find ways as academic experts—and I'm happy I can wear a practitioner's, academic, and citizen's hat—to have the conversation across different communities, in dialogues people can understand.

Models can help, but often it takes work to explain them to people. We run the water resources of central South Africa on a 14- or 15-dam system that is based on a fantastic model. When I was in Boulder a couple of years ago, people were still talking about our multiyear stochastic model that we use to run our systems. I asked people in the street, "Do you think we're out of water because it is the end of the dry season here?" And they said, "The dam is only 30 percent full." To which I responded with, "The system is 70 percent full, so what is the problem?" They said, "We don't care about the system because our water comes from that dam." It takes quite a lot of work to explain to people that their water security comes not from one dam, but actually multiple dams, which provides more security and more water. It is hard to get that message across. This brings up the question of how do we get the language correct for the right group of people?

I said to Sam that I wasn't going to talk about the Egyptian argument and everything that is happening up in the north end of the continent, which is a long way from where I am. But one of the important bits of language we've learned in the global water discussion is this concept of shared benefits. My colleagues who have done some work on the Nile and I have looked very carefully at the question. How can you develop this water when you have countries of 100 million people short of water and development? How do you convince them that if I use my water, they won't have less? The current project was very carefully conceived. You build a dam on the frontier.

You can't use the water in your own country, you can only generate electricity. You tell the country downstream, "We're going to manage the flooding for you, and we're going to give you cheap electricity." They say, "Hey, that's not bad. We understand those benefits. You mean we don't have to build a new dam to expand our irrigation?" Which is, in fact, the truth in Sudan.

Then, you get to the difficult one. You go and look at Egypt, and they have always had this wonderful river flowing there, and they say, "What's in it for us?" We say, "Well, you can lower your big Aswan Dam, which evaporates about three meters a year in that desert heat, because we can guarantee up on the hill much lower evaporation. We can actually have more water in the system. But by the way, you are going to need to use your water more efficiently." South Africans are now worried because they've discovered the Egyptians using their water efficiently, and instead of growing rice, sugar, and cotton, they're growing oranges. They're competing with South African oranges on the market, and people here are very upset.

I say that this is the best piece of news I've heard for a while. The Egyptians have learned to get more production, more jobs, and why have they done that? Because they realized they were going to have to share the resource. Now they are beginning to find ways of doing it and using that water more effectively, and it all came out of the discussion of shared benefits. That discussion has taken 25 years, by the way. We hosted the ministers of the 10 Nile countries in South Africa back in 1998 to begin on a confidence-building process, and 25 years later, it is a work in progress. If you get the language right and you get the interests understood, you can bring people forward. The language of shared benefits, like 'I'll benefit this way, you'll benefit that way,' can be developed by working together and understanding each other's problems. That would be my contribution at this point.

**Fernald:** Thank you very much. Estimado Chávez Guillén, por favor.

**Guillén:** Thank you. Yes, indeed, it is a growing problem that should be addressed by applying all the aspects of water governance. Of course, this must come from a proper understanding of the resource and its sources. This requires strong binational collaboration, or more, if shared criteria exists with various countries. In our case, and in regards to Mexico's northern border with the U.S., logically, we would have to proceed with this knowledge, which fortunately is considered acceptable by our part. Surely it is even more acceptable in part by the U.S. due to their greater economic capacity, greater resources and greater participation from their border universities.

Nevertheless, Chris Wilson expressed an opinion that suggested we are starting from scratch. In reality,

I disagree with that opinion because, like I said before, since the 1970s, Minute 242 of the International Boundary and Water Commission between Mexico and the U.S. set limits on water extraction between Arizona and Sonora. That same minute included a commitment to exchange information across the border about any projects that could somehow affect the neighboring country. Of course, this minute is not as formal as a treaty. However, under the legal protections of that minute and that commitment, some binational border programs have been carried out intermittently since then, with the cooperation of border universities.

We have identified the most serious cases, as I mentioned before, the Hueco Bolson in Ciudad Juárez/El Paso, the Mesilla Bolson, and the Nogales/Nogales, Santa Cruz, San Pedro, and downstream Piedras Negras, and others. This identification led to focused studies that have progressed, however, they have not led to binational regulations. They have, nonetheless, led to a fairly acceptable, shared understanding that tends to become the models that Mike pointed out. This certainly would be an ideal tool that we could use: have a model of the aquifers we share, or at least, a model of their bordering sections since, in various cases, aquifers are extensive and they cover very large portions of a country. A comprehensive model, perhaps, is not feasible in the short-term. However, a model of the bordering sections would be, certainly, ideal in preventing or correcting transboundary effects.

This is the technical side, and then, we have social participation because, like you all know, governance is more than just the technical side. The knowledge of aquifers should be the basis of management, and I believe it is, but there is more than just the technical aspect. There are socioeconomic, political, environmental and legal aspects that complicate the situation. In the case of climate change, it is obvious that its most immediate effects are on ecosystems. These are the natural outfalls of aquifers and they are the most susceptible to any reduction in water levels. Springs, watersheds, flow rates, base flow of the river and riparian vegetation, are all automatically eliminated. Similarly, sectors with lower economic capacity that depend on very shallow water sources will be sensitive to overexploitation. All of this will be exacerbated by climate change.

On the Mexican side, we can say that there has been much attention to social participation by law. Numerous basin councils and technical groundwater committees have been established, but it has been very difficult for us to provide for them because there's no continuity in their representation. There are representatives from the different user sectors, but over a certain period of time, and with the change of boards, all this continuity is lost. However, they are established, and operate under regulations.

A lot of the achievements in this field are included in the publications of the UNESCO and SARM program, which you are surely familiar with, the Transboundary Aquifers of the Americas. Within the different global programs, one case stood out due to its climate and development level – the border strip between Mexico and the U.S. This is a good reference because it includes the achievements and shared knowledge that was accomplished with the participation of the USGS, CONAGUA, and various transboundary universities. To this date, this program continues to receive attention, and the intention is to formalize certain information exchange projects on the principle of non-intervention to neighboring countries. So, I think that there is something very important ahead, and finally, I think that effective social participation is essential, just like Mike pointed out. Indeed, we can have great, comprehensive research, but these studies will be useless if we, as technical advisors, do not have the ability to explain to the water users in simple, accessible terms what is the status of their water sources and the risks of not complying with technical measures and recommendations. Thank you, Mike.

**Fernald:** Muchas gracias. Chris Wilson.

**Wilson:** Thanks, Sam. Rubén is absolutely right to point out that it's not that there is zero treatment of groundwater at the binational level because there absolutely is. The Transboundary Aquifer Assessment Program is a great tool to be creating data and improving understanding of what is happening in the binational aquifers. I would just suggest that we're far from where we need to be in terms of having transboundary, international management of resources. We have a lot of work ahead of us still. I'll just make a couple of comments about this, how we can do things a bit better from my perspective, and where science fits into that.

It seems to me that the big-picture question here, and it has been talked about a lot already, is making sure that you have the right people in the room when management decisions are being made. That means having local-level voices in the room, having stakeholders be a part of the process, and having a structured process to have their input filter up into higher-level negotiations. But on the part of science, I think it means something important too. It's easy to say, and it's absolutely correct, that scientists need to be providing information and data so that good decisions can be made. We can ask questions: Who are the users? How much water is being lost to evaporation or seepage? How much water is in our aquifers? How are they recharged? What's the quality? There are all sorts of obvious questions that scientists can help us answer, and their findings can be input for good policymaking. I believe it is also important to say that it's not enough to have scientists make contributions and walk away from the conversation; they need to stay in the room as the discussion continues. They need to be a part of the discussion with the policy makers,

because politicians, for all the heat that they get, are really good at balancing the set of interests brought before them.

When industry groups show up and present their concerns, and when cities show up and talk about their concerns, people like Senator Udall can make informed decisions about how to manage that. Let's make sure that those scientists are another group of people that are showing up to be involved in the conversation. It shouldn't be a one-off transfer of the model, do what you want with it, but rather having scientists stay so that when a policy proposal is put forward, they can react to that and say what it might mean.

I'm hopeful this leads us to a cycle that leads to better science as well. The more that the scientists are in the room for policy discussions, the more informed they will be to formulate their next research question. This will lead them when they come back in the room and have an even more useful set of data that is tailored not just to the environmental situation but to the political dimensions of the challenge as well. I think we can have a back and forth that is really useful in this sense. Additionally, I would suggest—and this is something that I'm really excited about in terms of the project that we're embarking on, Sam—that it takes a coming together of not just the hard scientists but also the social scientists to break apart disciplinary boundaries to help understand how decision-making structures meet with scientific or physical realities leading to decision-making and management processes, water use, and everything of this nature. Thanks.

**Fernald:** Wonderful. Thank you so much. We have a question that maybe just one or two people could answer. From Elena Ferdinand: Do you see modeling as a way to combat toxic pollutant plumes in the aquifers and rivers? Jeffrey Jones, I believe you mentioned models, or would somebody else want to address that question?

**Jones:** One of the best experiences I had in the Mexican Senate was being part of the creation of a working group called NAAMIC (North American Agrifood Market Integration Coalition.) Those were, by far, the best bilateral or trilateral meetings that I was ever involved while working in government, both in the executive and the legislative branch. We did precisely this, namely, we brought together stakeholders, government officials, and academicians and technical people from Mexico, Canada, and the USA, to look at different issues regarding the increase of agrifood market integration in North America. We had some extremely good discussions, but today, as I was listening to our discussion, it has occurred to me that this is something that we need to do for water resources and issues. We need to create a "North American Water Resource Coalition" beyond just the border region, though it could begin there. Several different water projects and policies could be identified and discussed, with many possible outcomes.

Of course, the political aspects of this would need to be updated and considered, but there was a project in the 1960s called NAWAPA (North American Water and Power Alliance.) It contemplated bringing fresh water all the way from Canada to the Rio Grande/Rio Bravo Region. I realize that politically speaking, Canada has since established some very restricted water laws, but if we could do some modeling and show the win-win scenarios for different policy decisions related to this, about how to use water better, how to get more water, I believe it would be tremendously effective and mutually advantageous. Factors could be inputted into the model such as the social factors mentioned earlier by Chris Wilson, like the environmental impacts, along with everything else that needs to be considered. When we talk about creating a knowledge-based economy it is absolutely necessary to include academicians who can help bring objectivity to our discussions. In my previous bilateral or trilateral meetings without academia or stakeholders present, but only with politicians from different countries, politics prevailed without objective technical information, and we didn't seem to advance much. However, if we could do something like NAAMIC, again, if we created a North American Water Resource Coalition, and analyzed these issues by modeling different scenarios, and their impacts on the environment, the economy, and society, we would have more intelligent options on the table. This would create more effective discussions and foster additional creative ideas.

**Sen. Udall:** Sam, to follow up on what Jeffrey Jones said, I think part of the question, too, was about pollution plumes and modeling. We've had a lot of experience with this in the Southwest, for example, thousands and thousands of gallons of jet fuel leaked into an aquifer. The pollution plume was moving toward city wells. The Air Force was responsible for remediation and established a model to predict how far the plume would get. The model gave everybody a comfort level. The Air Force was able to show how it was working, how many gallons they were pumping, how fast they were cleaning it up. So, I agree with Jeffrey Jones that modeling can really make a difference. The biggest challenge is getting the population to buy into the model and to understand the science to be willing to go along with it.

**Fernald:** Thank you very much. Panelists, if you could please give a 60-to-90-second vision or parting words of wisdom or inspiration on this topic, starting with Senator Udall.

**Sen. Udall:** I think one of the things that inspires me about this panel, and what we've talked about, is what happened when John Wesley Powell came to the West as an explorer. Of course, Native Americans were here earlier, but he came and stated that this is an arid region, with scarce water, and we need to focus on watersheds;

whether they're international or domestic, we would reap shared benefits, as Mike Muller was talking about. If people share a resource, they then see shared benefits. There is a lot of work that we can do in terms of working together to protect our watersheds and make them last and grow for future generations. Thank you.

**Fernald:** Wonderful. Thank you very much. Next, Jeffrey Jones.

**Jones:** Another successful institution that I followed and participated in while I was in the Senate, was the Energy Council. I believe it started in Texas, and then it expanded to other U.S. energy-producing states, including New Mexico, and it's an institution that continues to be effective. Again, we need to do something like this for water. We need to create an institution where we come together, like the Energy Council comes together, four times a year. They have different issues that they discuss and review. But again, something like this might be very beneficial for institutionalizing water management and looking at different issues from many different perspectives. Water is obviously a complex issue, but it is also the lifeblood of this region, here in the middle of a large desert. We need to have water as a top priority in everything that we do. When we invite decision-makers from government into these discussions, the real reason that they are invited, which we don't say out loud, is to educate them about what the real issues are. Other stakeholders get to participate and get educated as well. I believe Chris Wilson is completely right; you have to have representatives from all sectors sitting at the table looking at the issues more closely. Once everybody is sharing and discussing ideas, and looking closely at what-if scenarios, additional ideas would come forth, ideas never imagined or considered possible. This would be wonderful for this region, and I strongly believe that it's time to do something along these lines for water management.

**Fernald:** Really nice. Thank you. Mike Muller, please.

**Muller:** Sam, thanks very much for having me on. Just as a last thought, we're really pleased always when we hear people in the USA talk about climate change. When I had some engagements with your State Department, they told me that those were two words they could never put together. Having said that, I actually worry in some parts of the world that the focus on climate change is distracting people from the present challenges, and allowing them to say "we can't handle this; we can't do anything." What I'm doing tomorrow, at the southern African meeting, is saying, "Can we please concentrate on managing our

climate variability today? Do we have enough data to do that? Do we have enough understanding? Do we have enough of the models that we need to explain what's happening?" I've been doing some case studies, and I have found where water managers have a really good handle on how they are managing today's variability and today's challenges, they're actually pretty well placed for dealing with those future challenges of climate change. They are sourcing the data they believe is necessary.

In 2020, I would like to see us recognizing that we are pretty good as water managers in many parts of the world at managing climate variability. If we put more effort, get more data, make our models work better, and talk about it more, we'll do two things. First of all, people will understand what we're talking about. Why did it rain so hard last night? We've never had a flood like that. People notice these things, and it enables us to start talking about how things are actually changing, but it also implies that we can do something about it today. That's a last thought from my side. It's always wonderful sharing other people's problems. It makes us feel so good knowing we're not the only ones with them. I appreciate that and good luck to you all because you've got a few challenges across that border.

**Fernald:** Very good. Thank you so much. Estimado Señor Guillén.

**Guillén:** Yes, of course, models are a very important goal. They have progressed, but a lot is still required in order to have representative binational models. A good model would have to rely on highly appropriate and reconciled monitoring programs to have more information on levels, quality, restrictions, relationship with surface sources, etc. It's obvious that no matter how good software is, if we feed it unrepresentative data, we get false results. So, we need to ensure their models are properly validated.

Once we achieve this, we can analyze the different scenarios including the worst-case scenario due to climate change, zero recharge. On the other hand, it is obvious that we need to focus on the development of new water sources like artificial recharge and desalination of sea water and brackish water that exist in the various desert aquifers.

This will allow us to prepare and work in the social and political sectors of this issue. In general, social willpower does not exist. Water users resist extraction controls, they do not comply with official regulations, and political willpower only focuses on the short-term. There is no long-term vision. We need to raise awareness. There is

much left to do. I am grateful for the opportunity to share this with you. Thank you.

**Fernald:** Muchísimas gracias. Chris, in a few words.

**Wilson:** I began speaking about how the rivers hadn't reached the ocean in several of the previous years. Let me end by pointing to what happened with Minute 319, which was a U.S.-Mexico cooperation that allowed the Colorado River to once again reach the Gulf of California in 2014. It showed us what is possible when civil society is involved in the conversation, and when policy makers from both governments work hard together. We've done so many

creative, amazing things across the border, like allowing Mexican water to be stored in U.S. infrastructure. There is no end to the things that we can do if we allow ourselves to think creatively, constructively, and cooperatively. I believe if we simply apply the lessons we've been teaching ourselves over the last several years, there's plenty of space to solve the problems in front of us too. Thank you again for the invitation today.

**Fernald:** Wonderful. What a great panel. Very impressive and really inspirational. Thank you once again.